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Roseville Rail Yard Study

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Roseville Rail Yard Study

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Table of Contents

Contents **Page**

TABLE OF CONTENTS
(CONTINUED)

Contents **Page**

Appendices

TABLE OF CONTENTS
(CONTINUED)

Tables **Page**

TABLE OF CONTENTS
(CONTINUED)

Figures **Page**

Roseville Rail Yard Study Part I: Risk Characterization

Risk Characterization
for the Union Pacific Railroad's J.R. Davis Yard
Roseville, California

INTRODUCTION

The California Air Resources Board (ARB or Board) conducted a health risk assessment of airborne particulate matter emissions from diesel-fueled locomotives at the Union Pacific J.R. Davis Yard (Yard) located in Roseville, California. The results from that evaluation are presented in this report which is comprised of two parts. Part I, Risk Characterization for the Union Pacific Railroad's J.R. Davis Yard Roseville, California, provides a less technical and more easily understood explanation of health risk assessment results. It also is intended to explain what the risk assessment results mean and to put the results in perspective with other related environmental and public health risks. Part II, Health Risk Assessment for the Union Pacific Railroad's J.R. Davis Yard Roseville, California, provides a detailed assessment of the potential health risk near the Yard due to diesel particulate matter (diesel PM) emissions from locomotives.

BACKGROUND

The Placer County Air Pollution Control District (District) requested help from the ARB in determining the potential public health risks from diesel PM emissions due to locomotive activities at the J. R. Davis Yard (rail yard or Yard) in Roseville, California. Roseville is a rapidly growing area and development over the past several years has put more residences in close proximity to the rail yard.   With an increasing population near the Yard, complaints regarding the rail yard operations and concerns about possible health risks have been raised. The rail yard is situated near the heart of Roseville, encompassing about 950 acres on a one-quarter mile wide by four-mile long strip of land that parallels Interstate 80. The Yard is bounded by commercial, industrial, and residential properties. The Yard is the largest service and maintenance rail yard in the West with over 30,000 locomotives visiting annually.

FINDINGS AND RECOMMENDATION

To summarize, the key findings of the study are:

- The diesel PM emissions in 2000 from locomotive operations at the Yard are estimated to be about 25 tons per year.
- Moving locomotives account for about 50 percent, idling locomotives account for about 45 percent, and locomotive testing accounts for about 5 percent of the total diesel PM emissions at the Yard.
- Computer modeling predicts potential cancer risks greater than 500 in a million (based on 70 years of exposure) northwest of the *Service Track* area and the *Hump*

and Trim area. The area impacted is between 10 to 40 acres. To provide some perspective on the size, an acre is about the size of a football field.

- The risk assessment show elevated concentrations of diesel PM and associated cancer risk impacting a large area. These elevated concentrations of diesel PM, which are above the regional background level, contribute to an increased risk of cancer and premature deaths due to cardiovascular disease and non cancer health effects such as asthma and chronic obstructive pulmonary disease. Potential cancer risk and the number of acres impacted for several risk ranges are as follows:
  - ✓ Risk levels between 100 and 500 in a million occur over about 700 to 1,600 acres in which about 14,000 to 26,000 people live.
  - ✓ Risk levels between 10 and 100 in a million occur over a 46,000 to 56,000 acre area in which about 140,000 to 155,000 people live.

- The magnitude of the risk, the general location of the risk, and the size of the area impacted varies depending on the meteorological data used to characterize conditions at the Yard, the dispersion characteristics, and the assumed exposure duration and breathing rate for the proposed population.

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- Given the magnitude of diesel PM emissions and the large area impacted by these emissions, short term and long term mitigation measures are needed to significantly reduce diesel PM emissions from the J.R. Davis Rail Yard.

RISK ASSESSMENT RESULTS

A risk assessment uses mathematical models to evaluate the heath impacts from exposure to certain chemicals or toxic air pollutants released from a facility or found in the air. In order to perform the risk assessment, data was needed on the levels or concentrations of the diesel PM. At this time, there is no monitoring technique that allows scientists to directly measure diesel PM in the air. In order to estimate the concentrations of diesel PM, an emissions inventory was developed and an air dispersion model was then used to estimate the resulting concentration of diesel PM in the air. The air dispersion model uses a variety of information, such as the amount of pollutant emissions, weather or meteorology data, and the location and height of the emissions release, all of which can greatly affect the final results. A detailed description of how the risk assessment was done, including all of the supporting technical data and results, can be found in Part II of this report, *Health Risk Assessment.*

*A **risk assessment** is a tool used to evaluate the potential for a chemical or pollutant to cause cancer and other illnesses.*

In a risk assessment, risk is expressed as the number of chances in a population of a million people who might be expected to get cancer over a 70-year lifetime. However, for informational purposes only, the risk is sometimes reported for other exposure times, such as a 30-year or a 9-year risk. The longer the exposure, the greater the risk will be. In this part, only the 70-year lifetime risk is presented. Information on risk levels associated with 30-year exposures are presented in Part II. This analysis focuses on potential cancer cases due to exposure to diesel PM emissions. However, there is a growing body of scientific data suggesting that exposure to fine particulate matter may be responsible for premature death and morbidity (illness) due to respiratory and cardiovascular disease. The sensitive subpopulations include people with pre-existing cardiovascular disease and respiratory disease, including asthma, particularly those who are also elderly. The overall noncancer mortality from diesel PM exposure may exceed the cancer mortality by a considerable amount. The levels of exposure to diesel PM from the estimated emissions of diesel PM at the Yard were calculated using two meteorological data sets (Roseville and McClellan) and for both urban and rural dispersion characteristics in the air dispersion model. Two meteorological data sets were used because there are no direct meteorological measurements at the yard, and there is some uncertainty about the representativeness of both the Roseville and McClellan data sets. The use of the two sets provides the best estimate of the expected range of levels or concentrations of diesel PM around the rail yard. Dispersion characteristics refer to the type of land use, such as whether there are buildings near-by or open fields. Both urban and rural dispersion characteristics were used because the land uses around the rail yard have properties of both. The predicted diesel PM concentrations near the Yard (within one mile) were estimated using urban dispersion characteristics, while diesel PM concentrations greater than one mile from the Yard were predicted using rural dispersion characteristics. This was done in order to simplify the presentation of the results while still providing a reasonable estimate of possible exposures. In the discussion below, the results based on the various predicted concentrations are presented.

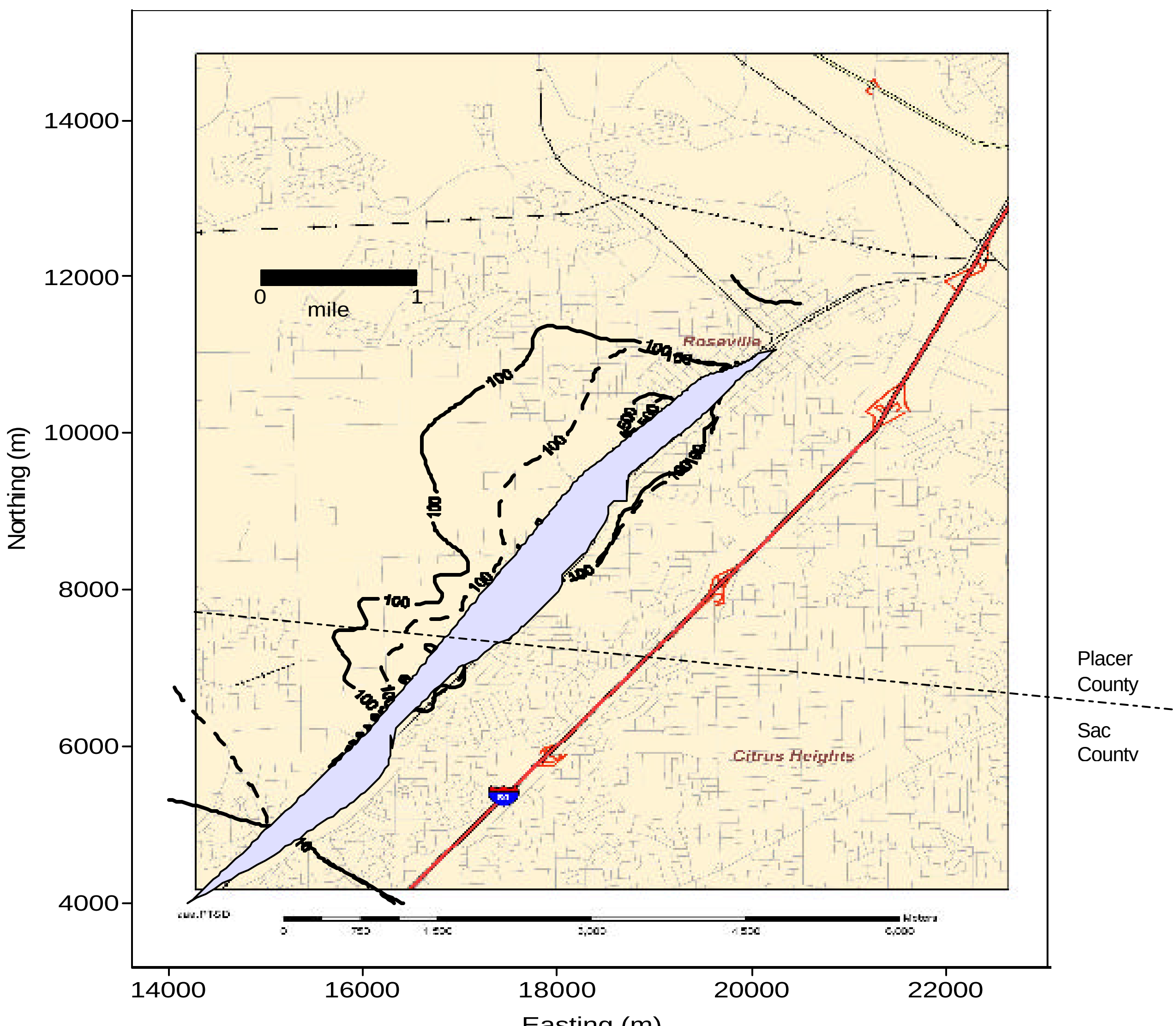
*For **cancer** health effects, the risk is expressed as the number of chances in a population of a million people who might be expected to get cancer over a 70-year lifetime. The number may be stated as "10 in a million" or "10 chances per million". Often times scientific notation is used and you may see it expressed as 1 x 10^{-5} or 10^{-5}. Therefore, if you have a potential cancer risk of 10 in a million, that means if one million people were exposed to a certain level of a pollutant or chemical there is a chance that 10 of them may develop cancer over their 70-year lifetime. This would be 10 new cases of cancer above the expected rate of cancer in the population. The expected rate of cancer for all causes, including smoking, is about 200,000 to 250,000 chances in a million (one in four to five people).*

Estimated Potential Cancer Risk

Figure 1 and Figures 2a and 2b present the estimated potential cancer risk levels due to diesel PM emissions at the Yard. For this analysis, staff elected to present the cancer risk data as risk concentration isopleths focusing on risk levels of 10, 25, 50, 100, and 500 in a million. Figure 1 focuses on the near source risk levels and Figure 2a and 2b focus on the more regional impacts. In each figure, the risk isopleths are overlaid onto a map of the Roseville area surrounding the Yard. The solid isopleth lines are based on the Roseville meteorological data and the dashed isopleth lines are based on the McClellan meteorological data.

Figure 1 shows the 100 and 500 in a million risk isopleths. As shown, the areas with the greatest impact have an estimated potential cancer risk of over 500 in a million. Depending upon the meteorological data set, and using urban dispersion characteristics, the areas exceeding 500 in a million ranges between 10 to 40 acres. The primary area with risks estimated above 500 in a million is shown in the center of Figure 1 toward the top of the Yard on the left. This off-site area is adjacent to the *Service Track* area which includes the maintenance shop. The high concentration of diesel PM emissions is due to the number of locomotives and the nature of activities in this area, particularly idling locomotives. The second area with risk estimates above 500 in a million is shown in Figure 1 just south of the county line and to the left of the Yard. This offsite area is adjacent to the *Hump and Trim* area. Based on the 2000 U.S. Census Bureau's data, between 500 and 700 Roseville residents live in these areas.

Figure 1
Estimated Cancer Risk from the Yard
(100 and 500 in a million risk isopleths)



Notes: Solid Line = Roseville Met Data; Dashed Contour Lines = McClellan Met Data; Urban Dispersion Coefficient, 80th Percentile Breathing Rate, All Locomotive's Activities [23 TPY], Modeling Domain = 6km x 8km, Resolution = 50m x 50m

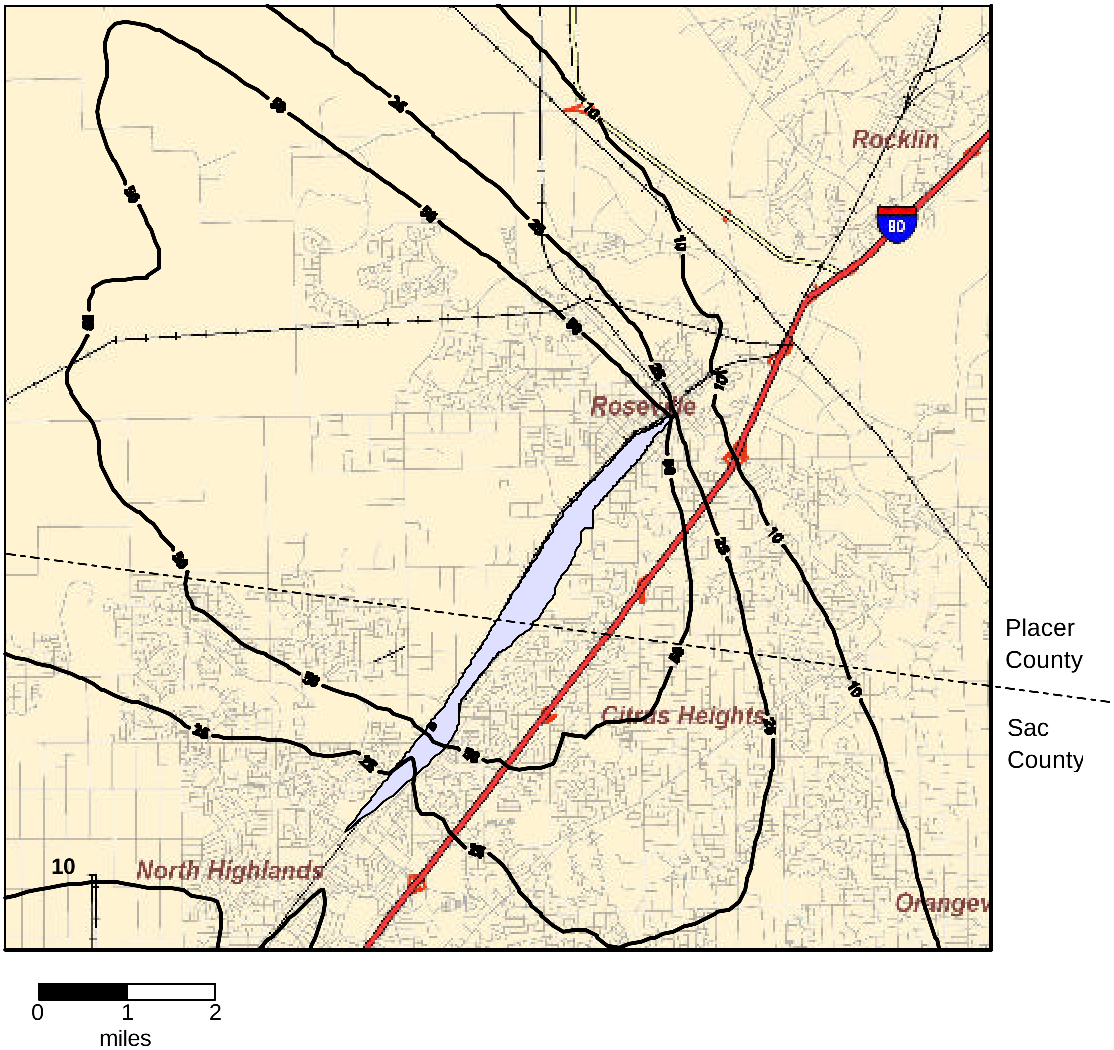
The second area of impact, with an estimated potential cancer risk of 100 to less than 500 in a million, ranges between 700 to 1600 acres. Again, the size of the area of impact is highly dependent upon the meteorological data set used. The area of impact is primarily to the north west of the Yard. Based on the 2000 U.S. Census Bureau's data, between 14,000 and 26,000 residents live in this area.

Figures 2a and 2b show the area where the predicted cancer risk exceeds 10, 25, and 50 in a million. Figure 2a displays the results using the Roseville meteorological data. As shown in figure 2a, the elevated risk levels are primarily to the northwest of the Yard (predominate wind direction) and decreases as the distance from the Yard increases. The largest area of impact has an estimated potential cancer risk of greater than 10 in a million. This area encompasses approximately 46,000 acres. The contour lines of 10 in a million are broken because the risk levels do not fall below 10 in a million within the model domain. In other words, the 10 in a million isopleth goes well beyond the boundaries of the figure. Based on the 2000 U.S. Census Bureau's data, about 140,000 people live in the 10 to 100 in a million isopleth shown on the figure and within the model domain.

Figure 2b shows the risk isopleths using the McClellan meteorological data. Again, the 10 in a million isopleth goes well beyond the boundaries of the figure. The area between the 10 and 100 in a million isopleth encompasses approximately 55,000 acres where an estimated 155,000 residents live.

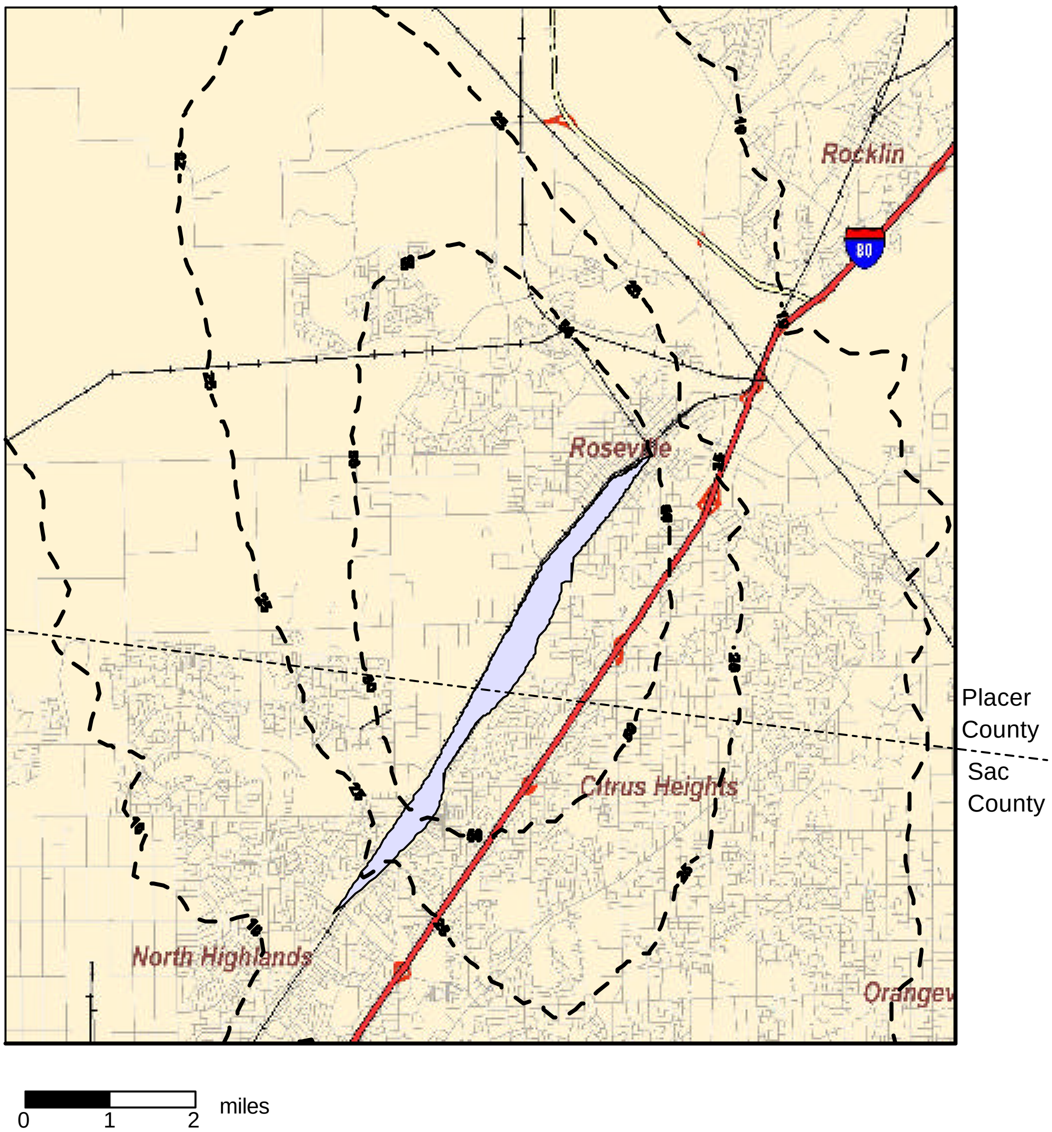
What these results indicate is that the diesel PM emissions from the rail yard are widely dispersed out over the greater Roseville area at levels that pose a cancer risk concern. It is important to understand that these risk levels represent the predicted risk due to diesel PM above the existing background risk levels. For the broader Sacramento region the estimated background risk level from diesel PM is estimated to be 360 in a million for diesel PM and 520 in a million for all toxic air pollutants.

Figure 2a
Estimated Cancer Risk from the Yard Using Roseville Met Data
(10, 25, and 50 in a million risk isopleths)



Note: Roseville Meteorological Data, Rural Dispersion Coefficients, 80th Percentile Breathing Rate, All Locomotives' Activities [23 TPY], 70-Year Exposure

Figure 2b
Estimated Cancer Risk from the Yard Using McClellan Met Data
(10, 25, and 50 in a million risk isopleths)



Note: McClellan Meteorological Data, Rural Dispersion Coefficients, 80th Percentile Breathing Rate, All Locomotives' Activities [23 TPY], 70-Year Exposure

Risk Comparisons

To put the risk assessment numbers into perspective, it is helpful to view them in comparison to other risks due to exposure to air pollution. For example, the estimated risk from toxic air contaminants statewide, based on being exposed to an average annual concentration for 70 years is about 750 chances in a million. This number is based on an average concentration of toxic air pollutants measured by the ARB's monitoring network and the estimated risk for diesel particulate matter based on exposure estimates. The risk in various regions can vary considerably. For example, the average risk in some parts of the Los Angeles area are well over 1,000 chances in a million, while the average regional risk in a less industrialized area like Roseville, is closer to 500 chances in a million.

Top Ten Air Toxics*

Diesel particulate matter
1,3 Butadiene
Benzene
Carbon Tetrachloride
Formaldehyde
Hexavalent Chromium
Para-dichlorobenzene
Acetaldehyde
Perchloroethylene
Methylene Chloride

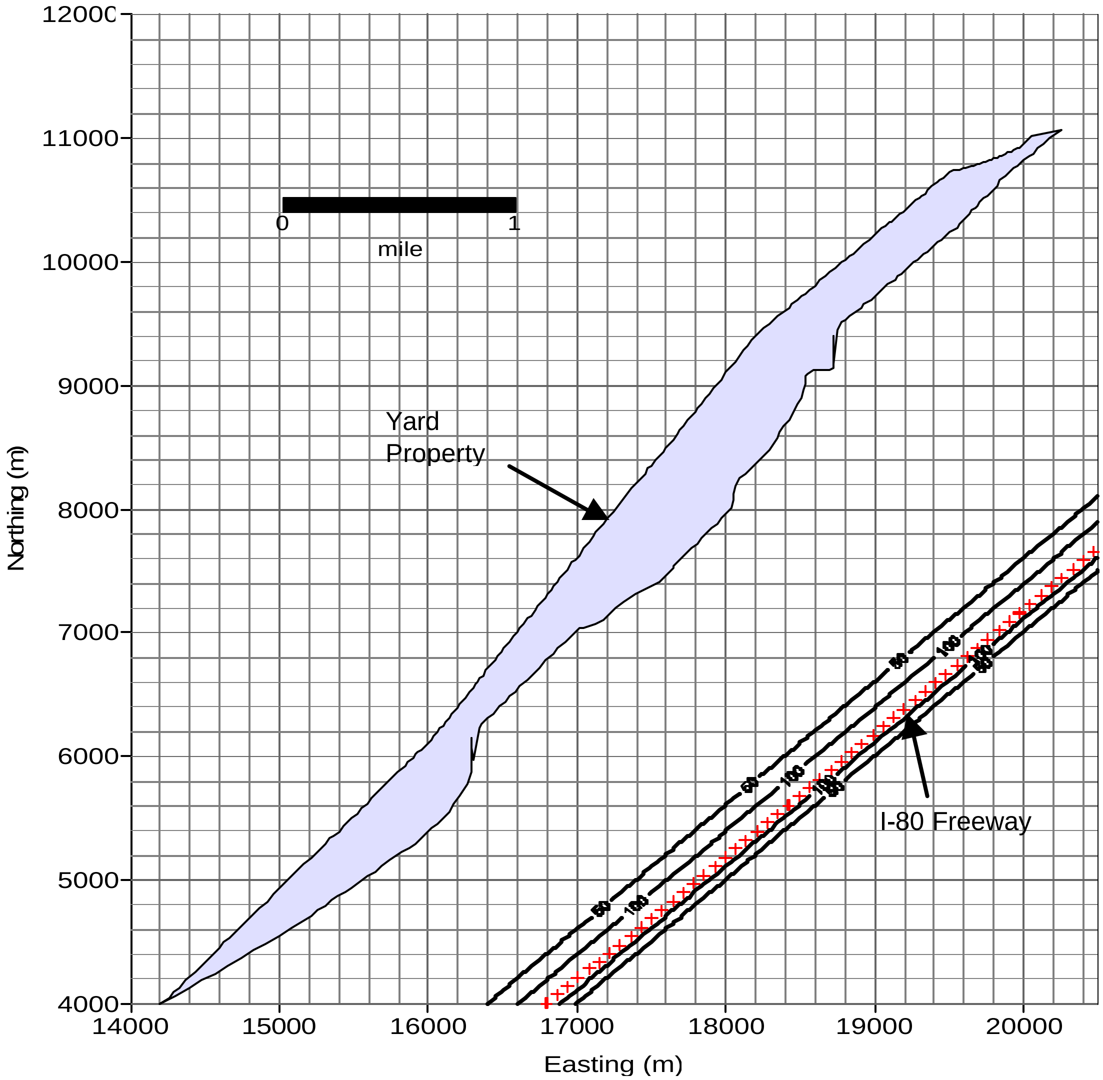
*These are the toxic air pollutants that contribute most to overall statewide risk that is measured in the ARB's monitoring network. Diesel PM is not measured, but is based on estimated values.

In addition, it may be helpful to compare the risk experienced by residents who live in close proximity to various types of facilities where many diesel engines are in use. Diesel PM is an air toxic that is released by a variety of sources. The typical risk from some of these diesel PM sources illustrate the "relative risk" when comparing activities. For example, a truck stop that has a high number of diesel trucks may result in an estimated risk as high as 200 chances in a million for nearby residents.[1] At a big distribution center where hundreds of diesel trucks operate, the risk could be as high as 750 chances in a million.[2]

To put this in a local perspective, the estimated risk from the diesel truck traffic on Interstate 80 in Roseville is shown in Figure 3. The amount of truck traffic driven daily on Interstate 80 is estimated to be about 10,000 heavy-duty diesel trucks per day based on 2002 activity data. The area of risk greater than 10 in a million is about one mile from the freeway (data not shown). The risk level at 300 feet from the edge of the freeway is about 100 in a million.[3]

[1] In July 2004, the ARB adopted an In-Use Diesel Truck Idling regulation that will reduce truck idling by 80 percent.
[2] In February 2004, the ARB adopted a Transport Refrigeration Unit (TRU) regulation that will reduce diesel PM emissions from TRUs by over 90 percent.
[3] The dispersion of diesel PM emissions was treated as an area source with urban dispersion coefficients using the USEPA ISCST3 model.

Figure 3
Estimated Risk from Diesel Truck Traffic on Interstate 80 at Roseville, CA



Note: Estimated Diesel PM Cancer Risk - 50/ and 100/million Contours from Freeway I-80 in Roseville (Roseville Meteorological Data, Urban Dispersion Coefficients, 80th Percentile Breathing Rate, EF = 0.293 g/v-mi [EMFAC2002, Y2004 Fleet], Diesel Truck Traffic = 10,000 vpd, 70-Year Exposure)

Uncertainty in Risk Assessment

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. Therefore, the actual risk calculated by a risk assessment is intentionally designed to avoid underprediction. There are also many uncertainties in the health values used in the risk assessment. Some of the factors that affect the uncertainty are discussed below.

When available, as is the case with diesel PM, scientists will use studies of people exposed at work to estimate risk from environmental exposures. The occupational exposures in these studies are usually much higher than environmental exposures encountered by the general public. In addition, scientists often do not have enough information to be able to predict how a chemical may affect any one person because we are unique and respond differently. Also the actual worker exposures to diesel PM were not measured but were derived based on estimates of emissions and duration of exposure. Different studies suggest different levels of risk. When the ARB's Scientific Review Panel (SRP)[4] identified diesel PM as a toxic air contaminant, they considered a range of inhalation cancer potency factors (1.3×10^{-4} to 2.4×10^{-3} $(\mu g/m^3)^{-1}$) and recommended that a risk factor of 3×10^{-4} $(\mu g/m3)^{-1}$ be used as a point estimate of the unit risk. From the unit risk factor an inhalation cancer potency factor of 1.1 $(mg/kg\text{-}day)^{-1}$ may be calculated.

As mentioned above, there is no direct measurement technique for diesel PM. For this analysis, an air dispersion model was used to estimate the concentrations that the public is exposed. The air dispersion models use a variety of information, all of which can affect the final results. All of these factors make up the “uncertainty” in the risk assessment.

[4] The Scientific Review Panel (SRP/Panel) is charged with evaluating the risk assessments of substances proposed for identification as toxic air contaminants by the Air Resources Board (ARB) and the Department of Pesticide Regulation (DPR). In carrying out this responsibility, the SRP reviews the exposure and health assessment reports and underlying scientific data upon which the reports are based, which are prepared by the ARB, DPR, and the Office of Environmental Health Hazard Assessment (OEHHA) pursuant to the sections 39660-39661 of the Health and safety Code and sections 14022-14023 of the Food and Agriculture Code. These reports are prepared for the purpose of determining whether a substance or pesticide should be identified as a toxic air contaminant.

Roseville Rail Yard Study Part II: Health Risk Assessment

Health Risk Assessment
for the Union Pacific Railroad's J.R. Davis Yard
Roseville, California

I. EXECUTIVE SUMMARY

At the request of the Placer County Air Pollution Control District (District), the California Air Resources Board (ARB or Board) conducted a health risk assessment of airborne particulate matter emissions from diesel-fueled locomotives at the Union Pacific J.R. Davis Yard (Yard) located in Roseville, California. Union Pacific Railroad Company (UP) assisted in the project by providing extensive information on facility operations and emissions.

The purpose of this Roseville Rail Yard Study Part II: Health Risk Assessment, is to provide a detailed assessment of the potential health risk near the Yard due to diesel particulate matter (diesel PM) emissions from locomotives.[5] The risk assessment included developing an inventory of diesel PM emissions at the Yard, conducting computer modeling to predict increases in the ambient air concentrations of diesel PM in the surrounding community due to locomotive activity, and assessing the potential cancer risks from exposure to the predicted ambient air concentrations of diesel PM. As a reminder, Part I of the Roseville Rail Yard Study, entitled "Risk Characterization" explains the results from the risk assessment in less technical and more easily understood terms. Part I also compares the predicted cancer risk from the Yard to other individual sources of diesel PM emissions, as well as to the overall cancer risk produced by airborne toxic compounds in California.

Presented below is a summary of the key findings of the study followed by an overview that briefly discusses how the exposure and risk assessments were performed to evaluate potential cancer risks from exposure to diesel PM from locomotive activities at the J.R. Davis Rail Yard. For simplicity, the overview discussion is presented in question-and-answer format. The reader is directed to subsequent chapters in Part II for more detailed information.

A. Summary of Findings

To summarize, the key findings of the study are:

- The diesel PM emissions in 2000 from locomotive operations at the Yard are estimated to be about 25 tons per year.
- Moving locomotives account for about 50 percent, idling locomotives account for about 45 percent, and locomotive testing accounts for about 5 percent of the total diesel PM emissions at the Yard.

[5] Diesel PM was identified as a toxic air contaminant by the ARB in 1998.

- Computer modeling predicts potential cancer risks greater than 500 in a million (based on 70 years of exposure) northwest of the *Service Track* area and the *Hump and Trim* area. The area impacted is between 10 to 40 acres.
- The risk assessment shows elevated concentrations (= 10 in a million) of diesel PM and associated cancer risk impacting a large area. These elevated concentrations, which are above the regional background level, of diesel PM contribute to an increased risk of cancer and premature deaths due to cardiovascular disease and non cancer health effects such as asthma and chronic obstructive pulmonary disease. Potential cancer risk and the number of acres impacted for several risk ranges are as follows:
  - ✓ Risk levels between 100 and 500 in a million occur over a 700 to 1600 acre area in which about 14,000 to 26,000 people live.
  - ✓ Risk levels between 10 and 100 in a million occur over a 46,000 to 56,000 acre area in which about 140,000 to 155,000 people live.

- The magnitude of the risk, the general location of the risk, and the size of the area impacted varies depending on the meteorological data (Roseville or McClellan), the dispersion characteristics (urban or rural), the assumed exposure duration (70 or 30 years) and the breathing rate (95^{th}, 80^{th}, and 65^{th} percentile).

B. Overview

1. What are exposure and risk assessments?

An exposure assessment is an analysis of the amount (concentration) of a substance that a person is exposed to during a specified time period. This information is used in a risk assessment to evaluate the potential for a chemical to cause cancer or other health effects. Mathematical models are used in both exposure and risk assessments to evaluate the potential health impacts from exposure to chemicals. The input to the mathematical models used to estimate potential health risk for substances emitted in to the air includes data and assumptions regarding:

- the magnitude and duration of the diesel PM emissions,
- the weather, (i.e. meteorology),
- human behavior patterns (i.e. the length of time someone is exposed), breathing rate, body weight
- and the toxicity of the substances.

The predicted concentrations and health impacts (e.g., cancer risk) presented in a site-specific health risk assessment are assumed to exist in excess of background concentrations or resulting health risks. For an individual person, cancer risk estimates are commonly expressed as a probability of developing cancer from a lifetime (i.e., 70 years) of exposure. Cancer risks are typically expressed as “chances per million”.

For example, if the cancer risk were estimated to be 100 chances per million, then the probability of an individual developing cancer would be expected to not exceed 100 chances in a million. If a population (e.g., 1 million people) were exposed to the same potential cancer risk (e.g., 100 chances per million), then statistics would predict that no more than 100 of those million people exposed are likely to develop cancer from a lifetime of exposure (70 years) due to diesel PM emissions from the Yard.

While there are inherent uncertainties in each of the variables, mentioned above, risk assessments are an effective tool to help assess an exposed populations relative risk from exposure to a toxic air contaminant. However, because there are inherent uncertainties in each of the variables that go in to a risk assessment, one needs to recognize that there is considerable uncertainty in estimating the risk for a specific individual or at a specific location. Generally, risk assessment results should not be considered as exact estimates of a specific individual's risk. Risk assessment results are best used to compare the relative risk between one facility and another and for comparing potential risks to target levels to determine the level of mitigation needed. They are also an effective tool for determining the impact a particular control strategy will have on reducing risk.

2. Why did ARB staff conduct an assessment of the J.R. Davis Rail Yard?

The ARB staff conducted an assessment of the J.R. Davis Rail Yard at the request of the Placer County Air Pollution Control District (District). After a recent expansion at the Yard, the District received a significant increase in noise and diesel exhaust emission-related complaints from residents of the City of Roseville that live near the J.R. Davis Rail Yard. To address the growing concerns of nearby residents and to better understand the diesel particulate matter (PM) emission impacts and the related health effects, and to determine if mitigation measures are needed, the District requested the ARB to prepare an exposure assessment of diesel PM emissions and its related heath impacts generated by activities at the J.R. Davis Rail Yard. To the ARB staff's knowledge, no comparable assessment of a similar facility has been prepared and reported in available literature.

3. Why is ARB concerned about Diesel PM?

Diesel engines emit a complex mixture of air pollutants, composed of gaseous and solid material. The visible emissions in diesel exhaust are known as particulate matter or PM, which includes carbon particles or "soot". In 1998, ARB identified diesel PM as a toxic air contaminant based on its potential to cause cancer, premature deaths, and other health problems. Health risks from diesel PM are highest in areas of concentrated emissions, such as near ports, rail yards, freeways, or warehouse distribution centers. 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.

Health impacts from exposure to the fine particulate matter ($PM_{2.5}$) component of diesel exhaust have been calculated for California, using concentration-response equations from several epidemiologic studies. Both mortality and morbidity effects have been associated with exposure to either direct diesel $PM_{2.5}$ or indirect diesel $PM_{2.5}$, the latter of which arises from the conversion of diesel NO_x emissions to $PM_{2.5}$ nitrates. It was estimated that 2000 and 900 annual premature deaths resulted from exposure to either

1.8 $\mu g/m^3$ of direct diesel $PM_{2.5}$ and 0.81 $\mu g/m^3$ of indirect diesel $PM_{2.5}$, respectively, for the year 2000. The mortality estimates are likely to exclude cancer cases, but may include some premature deaths due to cancer, because the epidemiologic studies did not identify the cause of death. Exposure to fine particulate matter, including diesel $PM_{2.5}$ can also be linked to a number of heart and lung diseases. For example, it was estimated the 5,400 hospital admissions for chronic obstructive pulmonary disease, pneumonia, cardiovascular disease and asthma were due to exposure to direct diesel $PM_{2.5}$ in California. An additional 2,400 admissions were linked to exposure to indirect diesel PM (Lloyd. 2001)

4. Where is the J.R. Davis Rail Yard located and what locomotive activities occur there?

The Yard occupies about 950 acres, on a one-quarter mile wide by four-mile long strip of land that parallels Interstate 80, near the City of Roseville, California. Approximately two-thirds of the area of the Yard is located in Placer County with the remaining one-third in Sacramento County. Downtown Roseville and residential neighborhoods are located along the southern side of the Yard. On the northern side are residential areas as well as industrial zones. In the southeast, however, it is predominantly residential neighborhoods. As you move away from the Yard to the northwest, the area becomes more rural in nature. The J.R. Davis Rail Yard has been operating in the City of Roseville since 1905. At the Yard, trains are classified (locomotives and train cars are connected or taken apart) and locomotives undergo routine maintenance, servicing, and repair.

About 31,000 locomotives stopped at the Yard during the year in which UPRR collected statistics for the ARB. Another 15,000 locomotives used the Northside Tracks (through trains) during this period. These locomotives have very large diesel-fueled engines. Locomotive engines generally last 30 to 40 years. Because more effective emission standards for locomotive engines have only recently been promulgated by the U.S. Environmental Protection Agency (U.S. EPA), and are just now being phased in, emissions of both diesel PM and oxides of nitrogen (NOx) from locomotives remain very high relative to many other sources.

5. What are the diesel PM emissions from locomotive activities at the J.R. Davis Rail Yard?

The emissions of diesel PM from locomotive activities at the Yard in 2000 were estimated to be approximately 22 to 25 tons per year. About 50 percent of the diesel PM emissions are from locomotives moving through the different areas in the Yard, about 45 percent are from idling locomotives, and approximately 5 percent are from locomotives undergoing testing.

By area, the *Service Area* (the area around the maintenance shop) had the highest diesel PM emissions, about 8 tons per year. The *Service Area* is located at about the mid-point of the Yard on the northern side (See Figure II-1 on page 20). In the *Service Area*, the predominant source of emissions, about 75 percent of the total, is from idling locomotives. The *Hump Area* and *Trim Area* had the next highest emissions, with 7.5 tons per year diesel PM.

6. How were the diesel PM concentrations near the Roseville Rail Yard estimated?

ARB staff used the U.S. EPA approved computer model (ISCST3) to estimate the annual average offsite concentration of diesel PM resulting from locomotive activity at the Yard. The key inputs to the computer model were the diesel PM emissions information (both magnitude, timing, and location), the meteorological data (wind speed and direction), and the dispersion coefficients (rural or urban). The emissions inventory was developed working closely with Union Pacific Rail Road and the District. This inventory represents the most complete inventory for the J. R. Davis Yard and is based primarily on year 2000 data.

Two different sets of historical meteorological data were used in this analysis to estimate the dispersion and transport of diesel PM emissions from the Yard. One set, the Roseville meteorological set, was from a site about a mile from the Yard. The second set, the McClellan meteorological set, was from a site about 10 miles from the Yard. Since the area surrounding the Roseville Rail Yard has both urban and rural characteristics the modeling was also done using both the urban and rural dispersion coefficients. Based on current land use patterns near the Yard, ARB staff elected to use urban dispersion characteristics within one mile of the Yard and rural dispersion characteristics beyond one mile from the Yard.

7. How were the potential cancer risks from diesel PM estimated?

The potential cancer risks were estimated using standard risk assessment procedures based on the annual average concentration of diesel PM predicted by the model and a health risk factor (referred to as a cancer potency factor) that correlates cancer risk to the amount of diesel PM inhaled.

The methodology used to estimate the potential cancer risks is consistent with the Tier-1 analysis presented in the OEHHA, Air Toxics Hot Spots Program Risk Assessment Guidelines (September 2003). A Tier 1 analysis assumes that an individual is exposed to an annual average concentration of a pollutant continuously for 70 years.[6] A more refined risk assessment (Tier 2) can be performed when additional site specific information concerning the exposed population is available. However, in most cases, adequate site specific information about the exposed population was not available. This was the case in the Roseville Study. The cancer potency factor was developed by the Office of Environmental Health Hazard Assessment (OEHHA) and approved by the SRP as part of the process of identifying diesel exhaust emission as a toxic air contaminant (TAC). Diesel PM was identified as a TAC in 1998 after 10 years of extensive investigation.

[6] According to the OEHHA Guidelines, the relatively health-protective assumptions incorporated into the Tier 1 risk assessment make it unlikely that the risks are underestimated for the general population.

8. What are the results?[7]

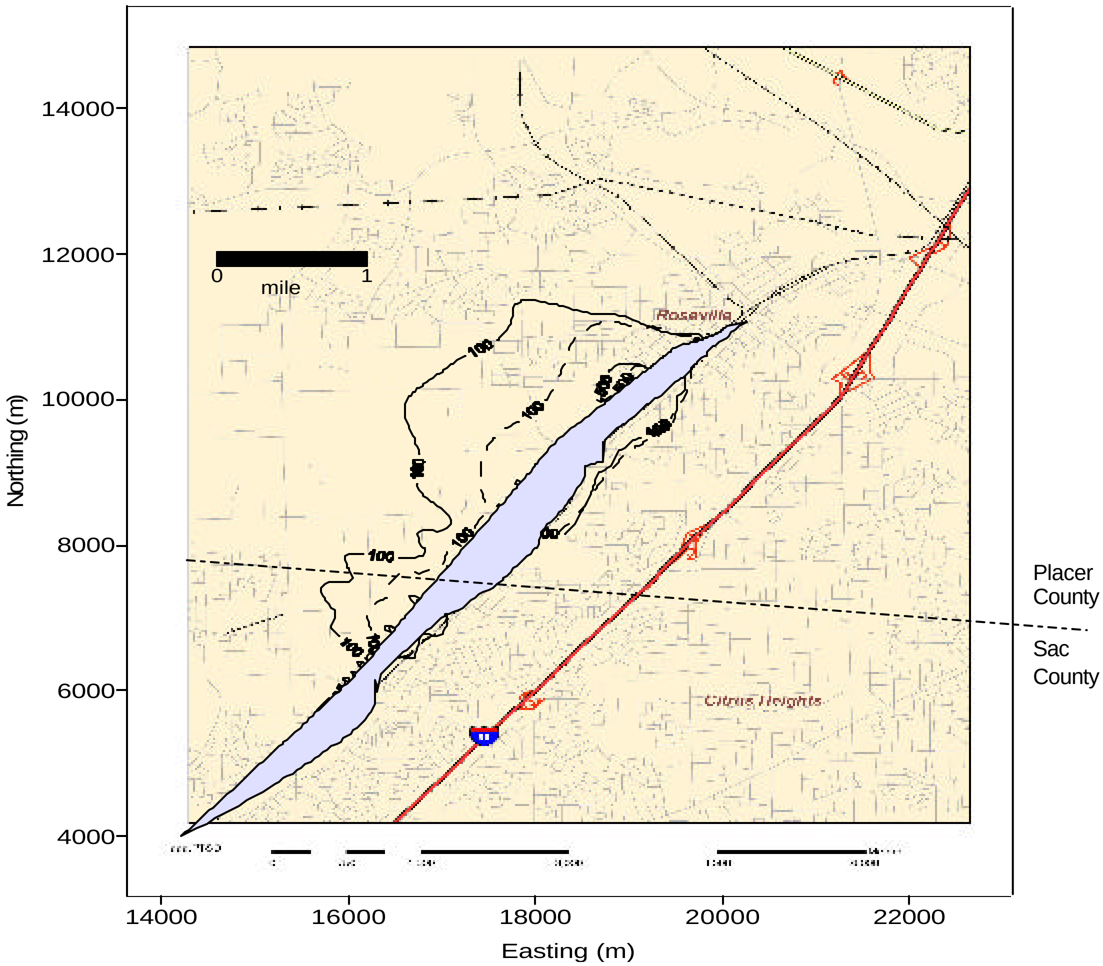
The potential cancer risk from the estimated emissions of diesel PM at the Yard were calculated using two meteorological data sets (Roseville and McClellan) and for both urban and rural dispersion characteristics.[8]

Figure I.1 presents the predicted 100 and 500 in a million cancer risk isopleths for the two meteorological sets (Roseville and McClellan) using the urban dispersion characteristics. ARB staff believes that the urban dispersion characteristics are most appropriate for predicting the near source impacts from the Yard and the rural dispersion characteristics are most appropriate for predicting the area-wide impacts. The solid line represents the 100 or 500 in a million cancer risk isopleth using the Roseville meteorological data. The dashed line represents the 100 or 500 in a million cancer risk isopleth using the McClellan meteorological data. The area inside the isopleth has potential cancer risks estimated to be greater than 100 or 500 in a million depending on the isopleth. For example, the number of acres with predicted cancer risk levels at 100 in a million or more is approximately 1600 acres using Roseville meteorological data and 700 acres using McClellan meteorological data.

[7] All estimated cancer risks reported in the Executive Summary are based on the 80th percentile breathing rate that is the midpoint of the range of risk calculated in the risk assessment. The main body of Part II provides the more detailed information on the entire range of risk, which is calculated using the 65th to 95th percentile breathing rates.

[8] Dispersion coefficients are used in air dispersion models to reflect the land use (rural or urban) over which the pollutants are transported. The rural dispersion coefficient generally results in wider dispersion of the pollutant hence a larger “footprint” whereas an urban coefficient results in less dispersion of the pollutant and a smaller footprint. Because the area around the Yard contained both urban and rural land use types, the model was run with both dispersion coefficients.

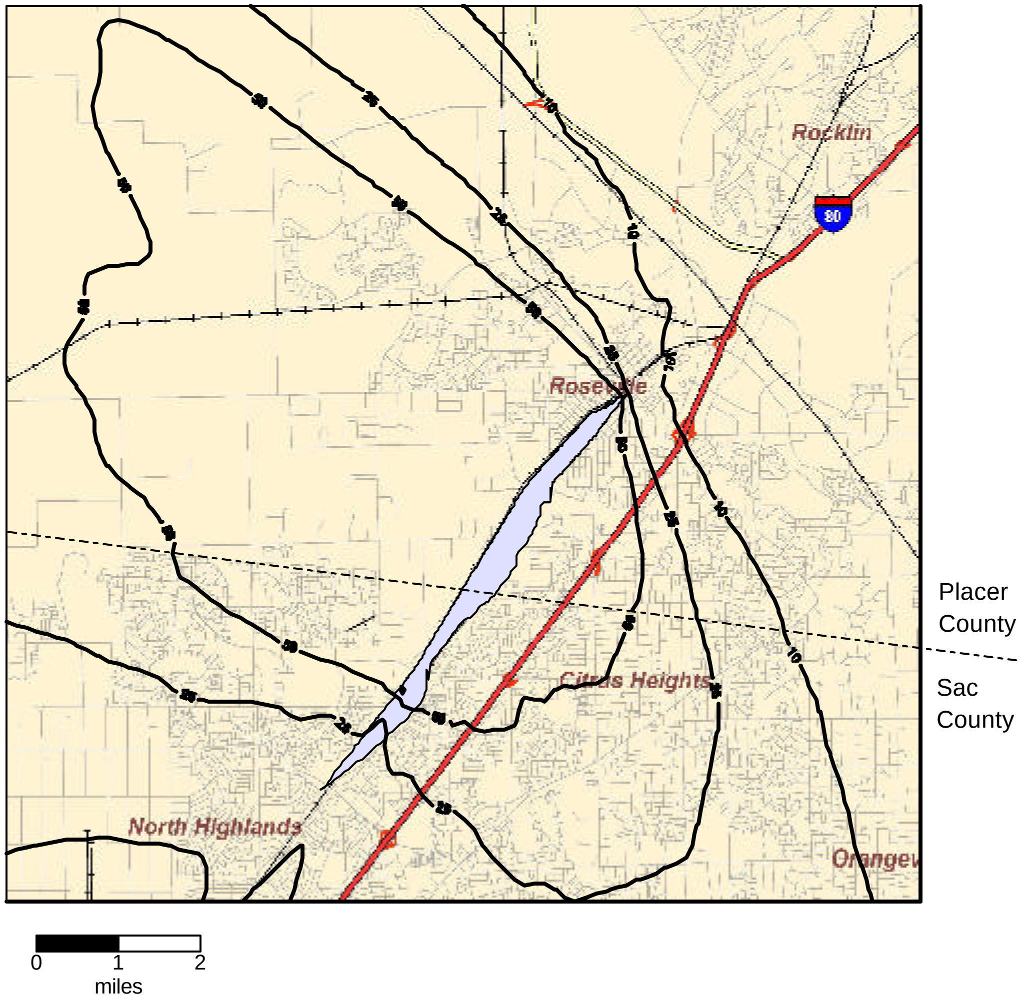
Figure I.1: Estimated Cancer Risk from the Yard (100 and 500 in a million risk isopleths)



Notes: 100/Million Contours: Solid Line – Roseville Met Data; Dashed Line-McClellan Met Data, Urban Dispersion Coefficients, 80th Percentile Breathing Rate, All Locomotives' Activities (23 TPY), 70-Year Exposure

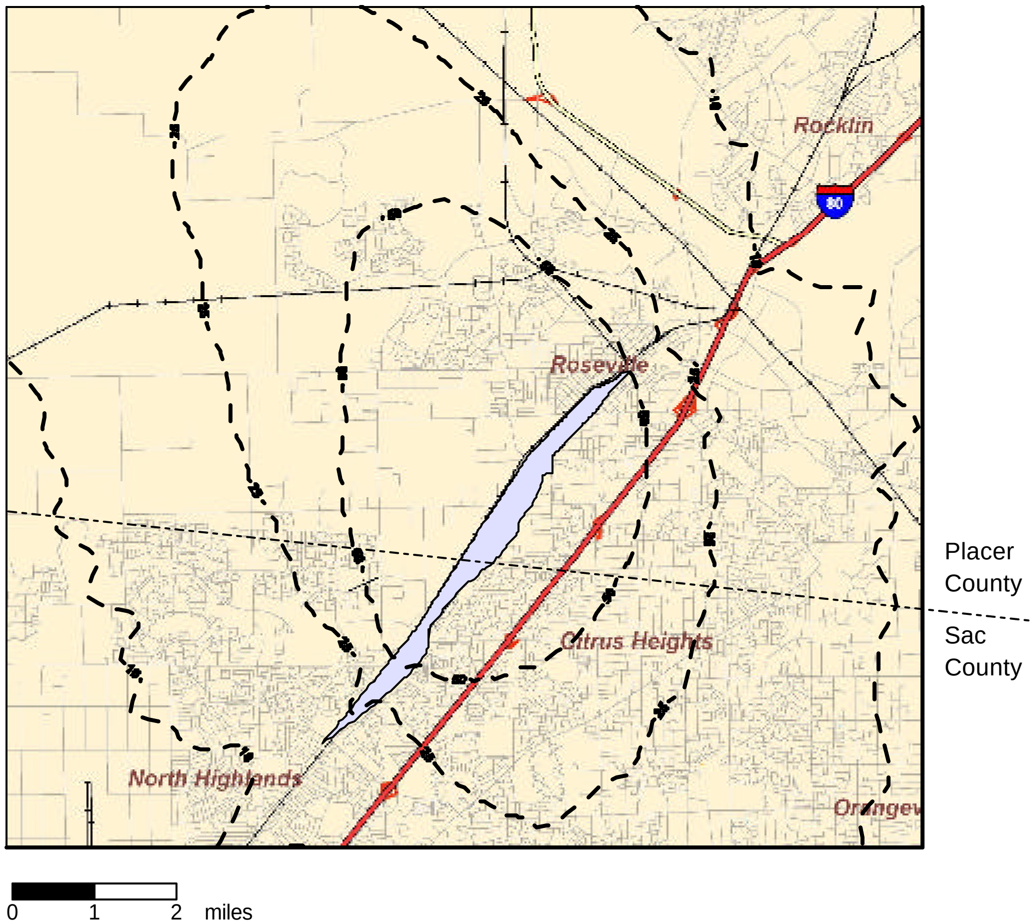
Figures I.2a and 1.2b present the potential risk for the two different meteorological data sets using the rural dispersion coefficient. As stated previously, staff believes that the rural dispersion characteristics are most appropriate for predicting the area-wide source impacts from the Yard. The isopleths for 10, 25, and 50 in a million potential cancer risk are shown. Figure 1.2a provides the estimated cancer risk isopleths using the Roseville meteorological data and Figure 1.2b the results using the McClellan meteorological data. As can be seen in the figures, the area in which the risks are predicted to exceed 10 in a million is very large, covering about a 10 mile by 10-mile area. The estimated number of acres, including areas outside of the modeling area, with a predicted cancer risk of 10 in a million or greater is in excess of 55,000 acres.

Figure I.2a: Estimated Cancer Risk from the Yard Using Roseville Met Data (10, 25, and 50 in a million risk isopleths)



Notes: Roseville Meteorological Data, Rural Dispersion Coefficients, 80th Percentile Breathing Rate, All Locomotives' Activities [23 TPY], 70-Year Exposure

Figure I.2b: Estimated Cancer Risk from the Yard Using McClellan Met Data (10, 25, and 50 in a million risk isopleth)



Notes: McClelln Meteorological Data, Rural Dispersion Coefficients, 80th Percentile Breathing Rate, All Locomotives' Activities [23 TPY], 70-Year Exposure

Using the U. S. Census Bureau's year 2000 census data, we estimated the population within the isopleth boundaries.[9] As shown in Table I.1, over 165,000 people live in the area around the Yard that has predicted risks of greater than 10 in a million. Also shown in Table 1.1 is the average risk level within each risk zone. For example the average risk within the ≥ 500 Roseville risk zone is 645 in a million.

Table I.1: Summary of Average Risk by Risk Zone and Acres Impacted

Meteoro-logical Data Source	**Risk Zone Based on Figures 1.1 and 1.2a and b Isopleth Boundaries** (70 Year Exposure)	Dispersion Characteristic	Average Risk Estimated Based on Years Exposed	Acres Impacted (rounded)	Estimated Year 2000 Population
			70 years		
Roseville	Risk ≥ 500	Urban	645	40	685
	Risk ≥ 100 and < 500	Urban	170	1,600	25,800
	Risk ≥ 10 and < 100	Rural	40	45,900	139,000
	Total			47,500	165,000
McClellan	Risk ≥ 500	Urban	630	10	460
	Risk ≥ 100 and < 500	Urban	156	700	14,200
	Risk ≥ 10 and < 100	Rural	28	55,500	155,000
	Total			56,200	169,000

Notes: Model domain for rural dispersion coefficient is 16km x 18 km with a resolution of 200m x 200m. For the urban dispersion coefficient the model domain is 6km x 8 km with a resolution of 50m x 50m. The 80th percentile breathing rate for adults was used.

Figures I.1 and I.2a and b are based on an exposure duration of 70 years. OEHHA guidelines recommend a 70-year exposure duration for a Tier 1 evaluation. The OEHHA guidelines also provide that a 30-year exposure duration may also be evaluated as supplemental information to show the range of cancer risk based on different residency periods. Table I.2 shows the equivalent risk level for 70- and 30-year exposure duration. Using this table, the 10 in a million isopleth line in Figures I.2 a and b would become 4.3 in a million if the exposure duration was 30 years for an adult.

Table I.2: Equivalent Risk Levels for 70 and 30-Year Exposure Duration

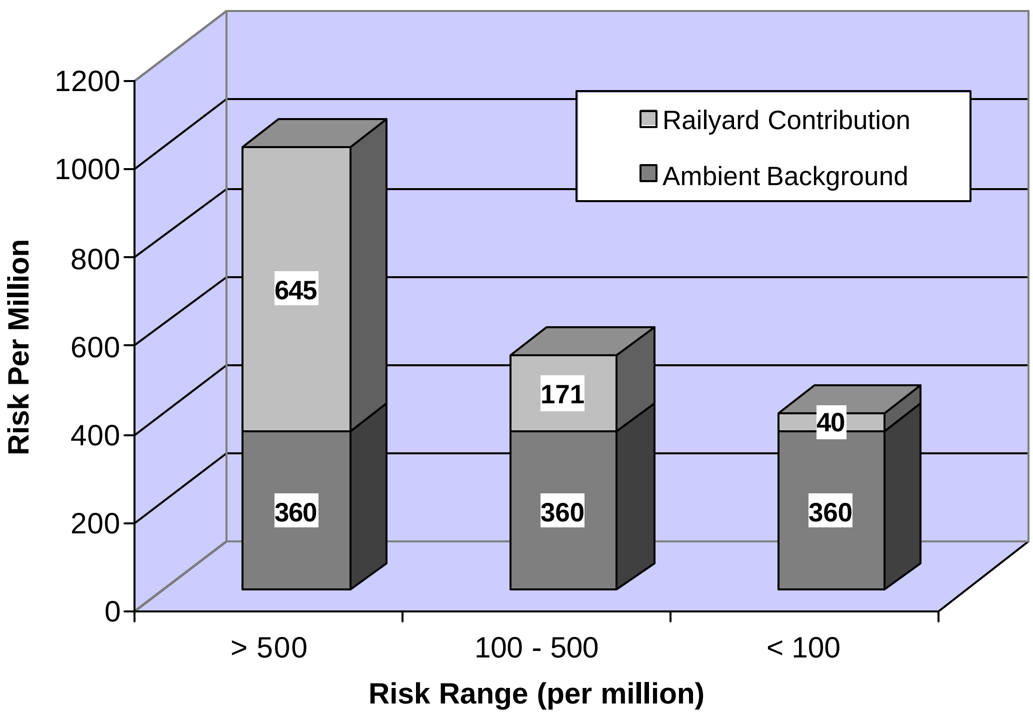
Exposure Duration (years)	Equivalent Risk Level (chance in a million)		
70	10	100	500
30	4.3	43	215

The estimated concentrations of diesel PM due to emissions from the rail yard are in addition to regional background levels of diesel PM. Although emissions from the rail

[9] To estimate the population, a GIS map of the model domain was overlaid with the 2000 census tract boundaries, and the percentage area of a given census tract within an isopleth was determined. The population of the census tract was then weighted with the percentage area of that census tract within the isopleth.

yard also contribute to the regional background, the measurable effect should be small. The regional background risk due to diesel PM emissions has been estimated to be 360 per million for the entire Sacramento Valley in the year 2000. Figure 1.3 provides a comparison of the predicted average potential cancer risk in various isopleths to the regional background risk from diesel PM. For example, in the greater than 500 isopleth or risk range, the average risk above the regional background is 645. Residents living in that area would have a potential cancer risk over 1,000. (645 per million due to rail yard emissions and 360 per million for regional background) (ARB 2004).

Figure 1.3: Comparison of Roseville Rail Yard Risks to the Regional Background Levels in the Sacramento Region for Diesel PM



Note: Roseville Meteorological Data, Urban Dispersion Coefficients for Risk Ranges of > 500 and 100-500, Rural Dispersion Coefficients for Risk Range of < 100.

9. Has monitoring been conducted to verify the model predictions.

No. Currently there is no specific measurement technique for directly monitoring diesel PM emissions in the ambient air. However this does not preclude the use of an ambient monitoring program to measure general air quality trends in a region. However, surrogate tests using elemental carbon can be very expensive. Since cancer risk is based on an annual average concentration, a minimum of a year of monitoring data would generally be needed. A monitoring study to validate the modeling results using elemental carbon would involve numerous monitors operating for at least a year. The cost of such a program is likely to be quite high, ranging from several hundred thousand to possibly several million dollars to complete. Past studies have used black carbon or elemental carbon measurements along with detailed emissions inventories to draw conclusions about the relative contributions of diesel PM emissions. As such, PM 2.5 elemental carbon monitoring can provide general information on combustion-related particulate matter in a region.

10. Have the diesel PM emissions at the Yard changed since 2000, the year for which the health risk assessment was conducted?

Without additional data, it is difficult to determine the emissions trends at the Yard since the year 2000. According to Union Pacific Rail Road, several actions have been taken to modify their locomotive fleet and operations at Roseville in ways that could decrease emissions associated with many locomotive activities. Some of the actions taken include replacing older locomotives with Tier 0 or better locomotives, installation of auto start-stop devices to limit idling, fuel efficiency improvements, modification of load test procedures, and operation efficiency improvements. While the exact diesel PM emissions benefits at the Yard have not been determined, UP indicates that they believe these efforts have resulted in actual emission reductions at the Yard. On the other hand, California has experienced a tremendous increase in the volume of cargo being moved through our Ports that could potentially result in additional rail traffic and diesel PM emissions. For example, based on fuel consumption data provided by the two Class 1 freight railroads operating in California, there was a 4 percent per annum increase in fuel consumption between 1998 and 2002. (BNSF & UP. 2004). Because of this, a more extensive analysis of the projected growth in activity and the impacts from emission reduction strategies is needed to determine if the emissions at the Yard have changed since 2000 and determine the degree to which emission reduction actions have offset the increased emissions due to growth in locomotive activities at the Roseville Yard.

II. INTRODUCTION

This report presents our evaluation of the potential air quality and public health impacts of diesel particulate matter (diesel PM) emissions from locomotive activities at the Union Pacific J.R. Davis Rail Yard (J.R. Davis Yard or Yard) located in Roseville, California. In this chapter, Air Resources Board (ARB) staff provides an overview of the report, the reasons for conducting the exposure assessment, a description of the J.R. Davis Yard, as well as the process used to develop for the exposure assessment.

A. Overview

Exposure or risk assessment is a complex process that requires the analysis of many variables to simulate real-world situations. Three steps were taken to perform the exposure assessment for the J.R. Davis Yard:

- Development of a diesel PM emissions inventory that reflects the amount of diesel PM released annually from locomotive activities at the Yard.
- Air dispersion modeling to estimate the ambient concentration of diesel PM that results from these emissions.
- Characterization of the exposures at nearby residences and estimation of increased potential cancer risk associated with long-term exposures to these concentrations.

The following chapters provide a description of each element of the exposure assessment. Detailed supporting information is included in the appendixes. Specifically, the following information is provided:

- the methodology used in developing the locomotive diesel PM emissions inventory for the J.R. Davis Yard;
- a summary of the estimated diesel PM emissions inventory for the J.R. Davis Yard;
- a discussion on the air dispersion modeling conducted to estimate ambient concentrations of diesel PM;
- the results of the air dispersion modeling and the sensitivity studies; and
- an estimate of the potential impacts (potential cancer risks) to nearby residences due to exposure to ambient concentrations of diesel PM from locomotive activities at the J.R. Davis Yard.

B. Purpose

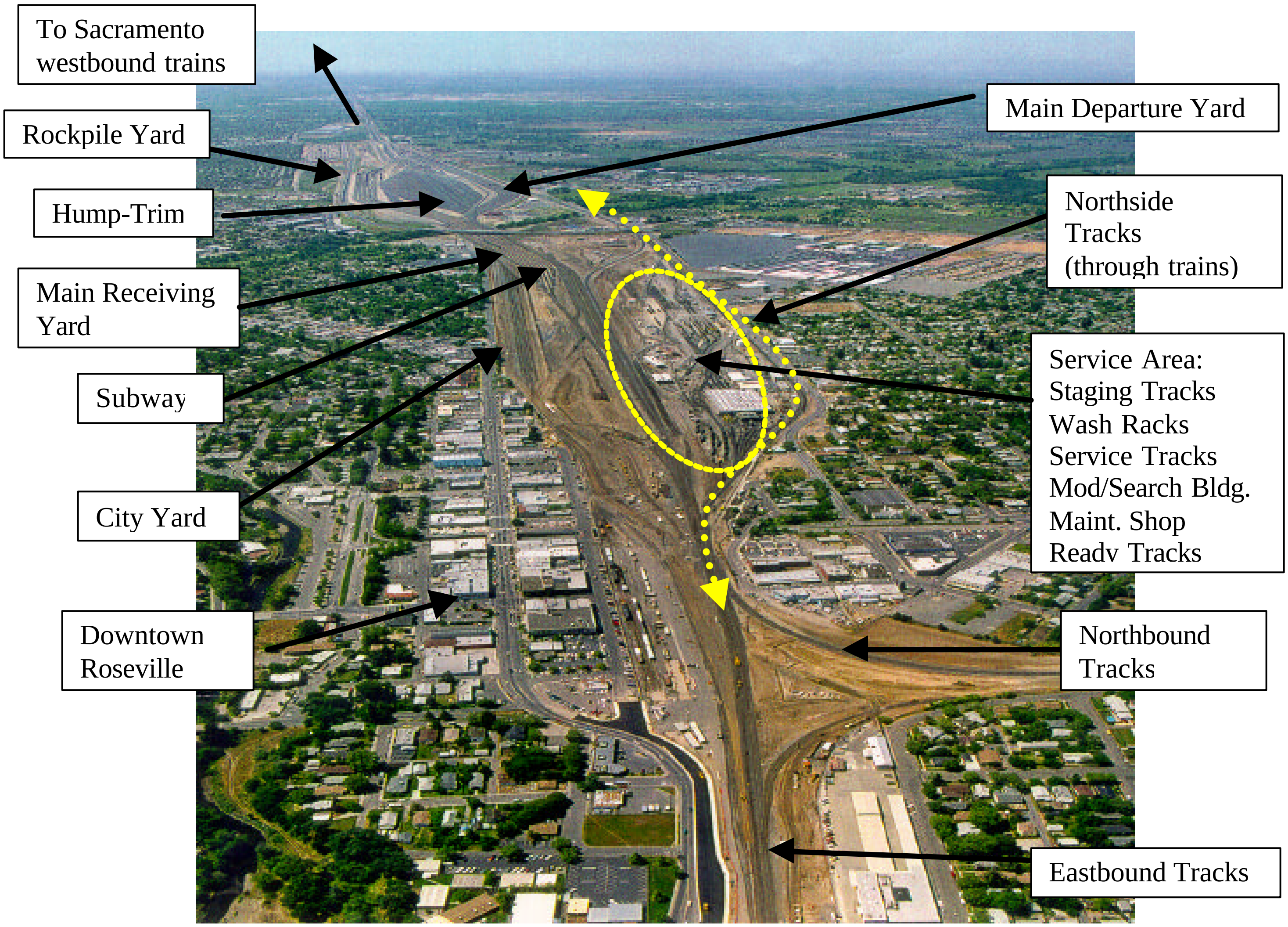
The ARB staff conducted this exposure assessment at the request of the Placer County Air Pollution Control District (District). After a recent expansion at the Yard, the District recognized a significant increase in noise and diesel exhaust emissions related complaints from residents of the City of Roseville that live near the J.R. Davis Yard. To address the growing concerns of nearby residents and to better understand the diesel PM emissions impacts, the District requested the ARB to prepare an exposure assessment of diesel PM emissions generated by activities at the J.R. Davis Yard. (Nishikawa. 2000) In response, the ARB agreed to work with the District to estimate the exposures associated with diesel PM emissions from current and future J.R. Davis Yard operations. (Kenny. 2000)

C. Description of the J.R. Davis Yard

The J.R. Davis Yard operates 24 hours a day, 7 days a week, and 365 days a year. It is Union Pacific's largest, most modern railroad classification yard in the Western United States. The J.R. Davis Yard serves as a classification,[10] maintenance, and repair facility for the Union Pacific Railroad (UPRR). Approximately 98 percent of Union Pacific's Northern California traffic moves through the J. R. Davis Yard.

Figure II.1 is an aerial photo of the J.R. Davis Yard. Various areas within the Yard are identified the photo also shows the interface between the J.R. Davis Yard and the surrounding commercial and residential areas.

Figure II.1: Aerial Photo of J.R. Davis Yard



[10] Classification refers to the building and breaking down of trains.

The J.R. Davis Yard consists of approximately 950 acres situated on a one-quarter mile wide by four-mile long strip of land. Approximately two-thirds of the area of the J.R. Davis Yard is located in Placer County with the remaining one-third in Sacramento County.

A brief summary of the locomotive movements and activities within the J.R. Davis Yard that correspond to the labeled areas in Figure II.1 is provided below. Additional details are presented in Chapter III.

All arriving trains either go to one of the three receiving yards (Main *Receiving Yard, Rockpile Yard or City Yard*) or pass through the Yard on the *Northside Tracks*. For those trains arriving in one of the receiving yards, the locomotives are disconnected from the train and will follow one of two pathways. One pathway is to the *Subway*, which is used for rapid turn-around-fueling operations when full routine service is not required. The locomotives, which are coupled into groups of engines (known as consists), move from the *Subway* to either the *Main Departure Yard* or staging area for the *City Yard or Rockpile Yard.* The locomotives are connected to a train and depart from the Yard.

The other pathway, which the majority (approximately 75 percent) of arriving locomotives travel, has the locomotives moving from one of the receiving yards to the *Service Area* for service or maintenance prior to movement to the *Ready Tracks* where consists are formed. The newly formed consists will move from the *Ready Tracks* to either the *Main Departure Yard* or the staging area for the *City Yard or Rockpile Yard.* From here, the locomotives are connected to rail cars and depart the Yard.

The railcars disconnected from the arriving trains are taken to the H*ump and Trim* area by switcher locomotives for classification (building of trains). Likewise, the railcars are brought to the waiting locomotive (consists) in the departure yards by switcher locomotives for connection prior to leaving the Yard.

D. Development of the Exposure Assessment

To help facilitate and coordinate the collection and interpretation of the technical data necessary for the exposure assessment, a working group was formed with representatives from the ARB, the District and UPPR. The working group established goals and objectives for the project and identified timelines for deliverables of activity data and information on Yard operations. The working group met periodically to review data, identify data gaps and issues, and resolve technical issues.

The key tasks were:

- Develop a diesel PM emissions inventory for the yard
- Conduct air dispersion modeling using the diesel PM emissions inventory
- Conduct an assessment of potential cancer risk using the results of the dispersion modeling.

III. LOCOMOTIVE EMISSIONS CALCULATION METHODOLOGY AND ACTIVITY ASSUMPTIONS

In this chapter, ARB staff summarizes the methodology and development of the locomotive diesel PM emissions inventory for the J.R. Davis Yard. Additional details on the development of the emissions inventory are provided in Appendix B and C.

A. Emissions Calculation Methodology

An air emissions inventory was developed by determining the population and location of locomotives within the yard on an annual basis, establishing the activity (moving, idling, or testing) for the locomotives in each area, and applying emission factors specific to the locomotive model and activity. A simplified equation representing the emissions calculation is provided below with a short description of the approach used to determine the key inputs:

Emissions = ? (Locomotive Population) X (Activity) X (Emission Factor)

- *Locomotive Population*: The population of locomotives is a function of the number of trains arriving and departing the Yard on an annual basis. The number and type of locomotives visiting the Yard annually was determined from data provided by UPRR. UPRR provided detailed information for trains arriving, departing, and passing through the Yard for the period between December 1999 and November 2000. UPRR choose the second week of each month (seven consecutive days of operation) as a representative period from which to collect the data. The data was then extrapolated to represent an entire 1-year period.

- *Activity*: Locomotive activity is a function of what that locomotive is doing – moving at a certain notch throttle setting, idling, or undergoing maintenance testing. The annual, monthly, daily, and hourly locomotive activity in the Yard including locomotive movements and routes for arrival, departure, and through trains, locomotive service and testing activity (number, type, and duration of testing events were determined from the data provided by UPRR. For each activity and location, estimates of the notch setting, locomotive speed, and the time spent in each notch setting were determined.

- *Emission Factors*: The emissions rate for each locomotive is dependent on the locomotive model and what activity the locomotive is engaged in (idling, movement, testing). Emission factors were developed representing the diesel PM emissions rate at idle and at different notch settings for the locomotive models moving through the J.R. Yard. The emission factors for the locomotive models were obtained from the General Motors Electromotive Division (EMD), General Electric Transportation Systems, U.S. EPA's Locomotive Emission Standards Regulatory Support Document, April 1998, and locomotive emissions testing that was conducted by Southwest Research Institute for US. EPA (Fritz, 1995).

In the sections that follow, we provide additional details on the information gathered to support the development of the emissions inventory for the J.R. Davis Yard.

B. Locomotive Engine Population

During the period between December 1999 and November 2000, UPRR collected data for 1,453 individual trains and model information for 5,551 locomotives. This information was used to determine the total number, and the manufacturer and model of locomotives visiting the Yard on an annual basis.

As shown in Table III.1 Approximately 31,000 locomotives stop at the J.R. Davis Yard for service or fueling on an annual basis. Another 15,000 locomotives per year are through trains that use the *Northside Tracks*. The majority of the arriving locomotives, approximately 75 percent, are processed through the *Service Area* where they undergo routine service or maintenance. The other 25 percent are fueled at the *Subway* for rapid turn-around and eventual departure from the Yard.

TABLE III.I: Annual Average Locomotive Traffic at J.R. Davis Yard (Estimated for the Period 12/99 – 11/00)

	12/99 - 11/00	
	Locomotives	**Locomotives**
Arrivals/Departures	31,000	
to Service Area		21,500
to Subway		9,600
Northside Tracks (through trains)	15,000	
Totals	46,000	

Emissions data for all locomotive engine configurations are not available. Therefore, we grouped engines with similar configurations and emissions into classifications. Table III.2 identifies 11 locomotive model classifications that was considered representative of UPRR’s locomotive inventory for J.R. Davis Yard.

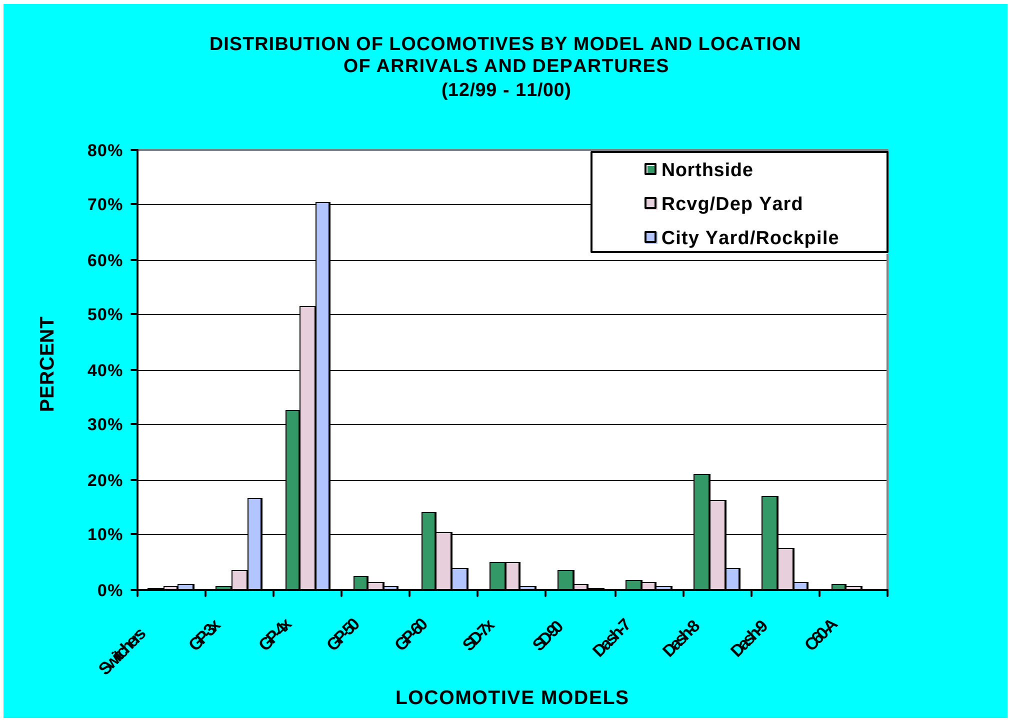
TABLE III.2: Locomotive Model Classifications at J.R. Davis Yard

Model Classification*	Engine Type	Locomotive Models Included in Classification
Switchers	EMD 12-645E	GP-15, SW1500, MP15AC
GP- 3x	EMD 16-645E	GP-30, GP-39
GP- 4x	EMD 16-645E3B	GP-40, GP-45, P42DC, F40PH
GP-50	EMD 16-645F3B	
GP-60	EMD 16-710G3A	
SD- 7x	EMD 16-710G3B	SD- 70, SD-75, SD70M, SD70MAC
SD-90	EMD 16V265H	
Dash-7	GE 7FDL, 12 cyl.	C36-7, B36-7, B30-7, B23-7, U36B
Dash-8	GE 7FDL, 12 or 16	C41-8, C39-8, B40-8, B39-8, B32-8
Dash-9	GE 7FDL, 16 cyl.	C44-9
C60-A (AC 6000)	GE 7HDL	

*EMD GP and SD series models using the same engines are listed with an "x" identifying multiple model numbers within the group.

As mentioned earlier, during the survey period, UPRR recorded locomotive model number for locomotives in each of the three major areas of the yard to allow determination of the fleet composition for each area. Figure III.1 presents the percent distribution of locomotives by locomotive model classification and location of arrival and departure trains. The most common locomotive classifications passing through the Yard are the GP-4X, GP-60, Dash-8, and Dash-9.

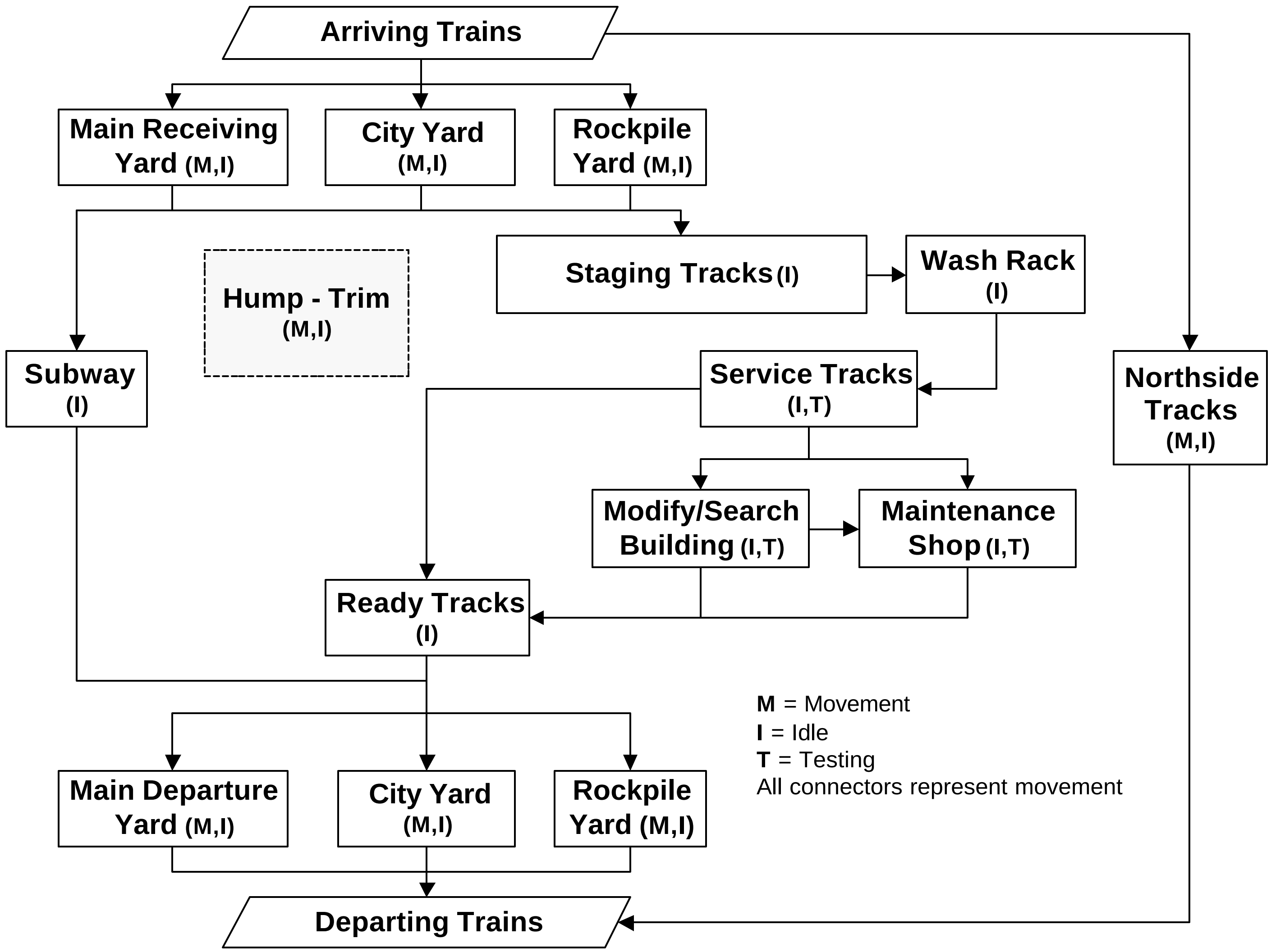
Figure III.1: Distribution of Locomotives at the J.R. Davis Yard



C. Locomotive Activity Assumptions

As shown in Figure III.2, all arriving trains either go to the receiving yards or pass through the Yard on the *Northside Tracks*.

Figure III.2: J.R. Davis Yard Locomotive Activity Schematic



For the locomotives arriving in one of the three receiving areas (*Main Receiving Yard, Rockpile Yard or City Yard*), after the locomotives are disconnected from the train, they will follow one of two pathways.

- One pathway is to the *Subway*, which is used for rapid turn-around-fueling operations. After the locomotives are refueled, the consist will move from the *Subway* to either the *Main Departure Yard* or staging area for the *City Yard or Rockpile Yard.*

- The other pathway, locomotives will move from the receiving yards to the *Service Area* for service and/or maintenance prior to movement to the *Ready Tracks* where consists are formed. The newly formed consists will move from the *Ready Tracks* to either the *Main Departure Yard* or staging area for the *City Yard* or *Rockpile Yard*.

In either pathway, the railcars disconnected from the arriving trains are taken to the *Hump Area* by switcher locomotives for sorting. These recoupled railcars are brought from the *Trim Area* to the departure yards by switchers and ultimately connected to locomotives. Finally, the newly formed train leaves the Yard via one of the departure yards.

Emissions from locomotives can result from locomotive movement along a track segment, idling in one area, or testing activities. As shown in Figure III.2, depending on where a locomotive is in the Yard and the activity that it is engaged in, different emissions levels are assigned to the locomotive.

UPRR provided descriptions of train and locomotive activities in the major areas shown previously in Figure III.2. The activities and locations include:

- Locomotive service activities (number, type, and duration of locomotive activities throughout the Yard.
- Estimates of duration or notch settings for locomotive movements in the Yard, and the nominal notch settings, speed, and distance profiles for departing, arrival, and through trains.

Based on this information, the number and model of locomotives on an hourly and daily basis were estimated for a year for each location in the Yard. Taking into account the estimates of average time spent in each area of activity, the maximum track speed limits between each area, and seasonal variation in activity, we allocated a locomotive "residence time" to each area of activity (including movements between each area).

Based on discussions with UPRR, we developed the following estimates of average times spent in each area:

- One-half to one hour in receiving yards prior to movement to either the *Subway* or *Staging Track* at the *Service Area.*
- Two hours in *Subway*.
- One hour in *Staging Track* (includes time in wash rack area).
- Three to four hours in *Service Tracks* area.
- Two to three hours in *Ready Track*s area.
- Two to four hours in departure yards prior to leaving the Yard.

The detailed assumption on actual locomotive activities in each of these areas are provided in Appendix C.

D. Locomotive Emission Rates

Locomotive engine emission rates were developed based on currently available data. The emission rate for a given locomotive engine will depend on the engine configuration and design, horsepower and the notch setting on the engine.[11] For the development of the diesel PM emissions inventory for the J.R. Davis Yard, ARB staff, in conjunction with UPRR representatives, evaluated available emission rate data. Emission factors for different locomotive models were obtained from the General Motors Electromotive Division (EMD), General Electric Transportation Systems, U.S. EPA's Locomotive Emission Standards Regulatory Support Document, April 1998, and locomotive emissions testing that was conducted by Southwest Research Institute for U.S. EPA (Fritz, 1995). Because emission factors were not available for all locomotive models ARB staff used engineering judgement to assign emission factors to the eleven model classifications for the locomotive engines at the J.R. Davis Yard.

For this analysis, all locomotives were assigned to one of the 11 locomotive model classifications discussed earlier. There was a wide range of emission rates depending on the model. For example, the PM emission factors for the idle mode ranged from about 16 g/hr to 228 g/hr. At a throttle notch of 2, the PM emission rate ranged from 76 g/hr to 201 g/hr. A summary of the emission factors at each notch setting for the different classification is provided in Appendix B.

[11] The power settings for locomotive engines are a series of discrete steady-state operating modes, or commonly referred to as notch settings. There are generally eight power settings (notches one through eight), in addition to low-idle, standard idle, and dynamic brake. These are the only engine power settings at which a locomotive can operate, and the engines can only provide power for propulsion in notch settings one through eight. Exhaust emissions data supplied by the engine manufacturers suggest that emissions can vary significantly by notch setting. One manufacturer's engine may be a relatively low emitter in one notch setting and be a relatively high emitter in another *(reference "Emissions Measurements, Locomotives, Steve Fritz August 1995)*.

IV. LOCOMOTIVE EMISSIONS ESTIMATES

In this chapter, we provide a summary of the diesel PM emissions inventory for the J.R. Davis Yard. Summaries are provided of the total emissions in various areas of the Yard, emissions attributed to different locomotive models and activities. Additional details on the emission inventory are provided in Appendix D.

A. Total Diesel PM Emissions and Distribution

To more easily characterize emissions of diesel PM that result from train or locomotive operations in the Yard, the diesel PM emissions were allocated into five areas based on specific train or locomotive operations. These areas are summarized in Table IV.1 and a detailed schematic and description of the area or activity represented by each area is also included in AppendixA.

Table IV.1: Description of Emissions for the J.R. Davis Rail Yard Diesel PM Emission Inventory

Area	***Description***
1	Movement to/from Yard boundary and receiving and departure yards (*Main Receiving Yard, Main Departure Yard*, *City Yard*, and *Rockpile Yard)* including movement on Northside tracks.
2	Movement/idling within the receiving and departing yards (*Main Receiving Yard, Main Departure Yard, City Yard*, *and Rockpile Yard,* including idling at the *Subway)*.
3	Service Area: Locomotive idling, testing, and movements in *Service Tracks*, *Wash Racks*, *Modsearch Building*, *Maintenance Shop*, and the *Ready Tracks* areas.
4	Hump and Trim operations – Movement of arriving rail cars to reclassification in *Hump Area*. Movement of reclassified cars to departure yards in *Trim Area*. Idling of tradeout locomotives during Hump operations.
5	Movement of locomotives between major locations in Yard (from *Main Receiving Yard*, *Main Departure Yard*, *City Yard*, and *Rockpile Yard* to either the *Subway* or *Staging Area*, and movement of locomotives from *Ready Tracks* or *Subway to Main Departure Yard* and *City Yard/Rockpile Yard* staging area).

Using the data provided by UPRR and the methodology described in Chapter III, the range of diesel PM emissions calculated for the Yard is approximately 22 to 25 tons per year.[12] The emissions ascribed to each area are provided in Table IV.2.

[12] The emissions were also calculated based on a train acceleration-based speed methodology. The results of this approach fell within the range of emissions presented in this chapter. See appendix D for additional details.

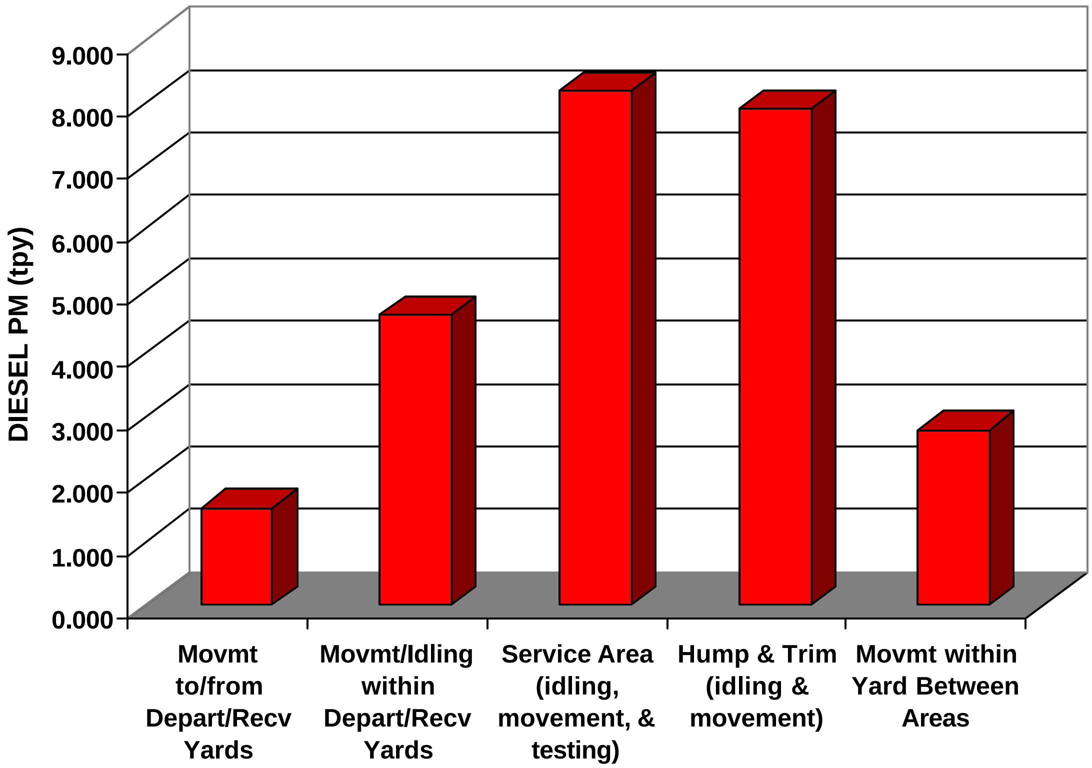
Table IV.2: Estimated Diesel PM Emissions for the J.R. Davis Rail Yard

Location	Total Diesel PM Emissions (tpy)*	Percent of Total
Area 1	1.5	6 - 7%
Area 2	4.6	18 - 21%
Area 3	7.8 - 8.2	31- 36%
Area 4	6.4 - 7.9	29 - 32%
Area 5	1.8 - 2.8	8 - 11%
TOTAL	22.1 - 25.0	

* Due to the uncertainties in locomotive operations in areas 3, 4, 5, and 6 a range of emissions was estimated based on different locomotive models and different potential notch settings.

The emissions estimates in Area 3 are associated with the *Service Area*. The emissions in this area comprise the largest percentage of emissions in the Yard, at approximately 31 to 36 percent of the total. The next highest emission source is the movement and idling of locomotives in the *Hump and Trim Areas* (Area 4) at 29 to 32 percent, followed by Area 2. Area 2 comprises the emissions from the movements of arriving and departing trains within the *Main Receiving* and *Departure Yards*, *City Yard* and *Rockpile Yard* (including idling of locomotives in these areas and at the *Subway*). About 18 to 21 percent of the emissions are from these activities. Figure IV.1 is a graphical depiction of the emissions contribution from the various activities in the Yard.

Figure IV.1: Contribution of Diesel PM by Activity in the Five Areas



Notes:
1. Graph represents high-end only

As shown in Table IV.3, emissions from the testing of locomotives comprise about 6 to 7 percent of the total emissions. The remaining emissions are divided approximately equally between idling and movement of locomotives in the Yard. Idling comprises a larger portion of the overall emissions in the S*ervice Area* (Area 3) and in Area 2, which includes the emissions in the receiving yards and the *Subway*.

Table IV.3: Allocation of Emissions within Each Area to Idling, Movement, and Testing Activities

Area	Diesel PM Emissions Tons per Year (tpy)			
	Total tpy	Idling tpy	Movement tpy	Testing Tpy
1	1.5	0	1.5	0
2	4.6	4.2	0.38	0
3	7.8 - 8.2	5.7 - 5.8	0.5 - 0.8	1.6
4	6.4 - 7.9	0.29 - 0.36	6.1 - 7.5	0
5	1.8 - 2.8	0	1.8 - 2.8	0
Total	22 - 25	10.2 - 10.4	10.3 - 13	1.6

B. Distribution of Emissions by Locomotive Model Groups and Activity

Tables IV.4A and IV.4B illustrate the distribution of diesel PM emissions by locomotive model classification and activity in pounds per day. As can be seen, the GP3X and GP4X locomotive classifications account for the largest emissions at 54 and 51 pounds per day respectively.

Table IV.4A and IV.4B presents two emissions totals for idling and movement of locomotives in the Yard. These emissions totals are due to the uncertainties in locomotive operations in Areas 3, 4, and 5. We've portrayed these differences in activities and the resultant emission totals as a low-end and high-end (i.e., a range in emissions.) The activities (and emissions) identified by Table IV.4A represent the low-end (22 tpy) and the emissions identified by Table IV.4B represent the high-end of our emissions range (25 tpy).

Table IV.4A: Total (Low-End) Annual Average Diesel PM Emissions (Lbs/Day)

TOTAL ANNUAL AVERAGE DIESEL PM_{10} EMISSIONS (LBS/DAY)				
Model	**Idling**	**[1]Movement**	**Testing**	**[1]Total**
Switchers	3.6	24.0	0.2	27.8
GP-3X	6.6	10.2	0.4	17.2
GP-4X	29.4	11.9	4.3	45.6
GP-50	0.5	0.4	0.3	1.2
GP-60	2.1	2.2	1.2	5.5
SD-7X	1.4	0.8	0.3	2.5
SD-90	1.0	0.5	0.1	1.6
DASH 7	0.5	0.3	0.1	0.9
DASH 8	7.6	3.9	1.1	12.6
DASH 9	2.8	1.8	0.8	5.4
C60-A	0.7	0.2	0.0	1.0
Totals	56.2	56.2	8.8	121
			TPY	22

1. Emissions represent idle + TN1

Trim set idling 100% switchers

Table IV.4B: Total (High-End) Annual Average Diesel PM Emissions (Lbs/Day)

TOTAL ANNUAL AVERAGE DIESEL PM_{10} EMISSIONS (LBS/DAY)				
Model	**Idling**	**[1]Movement**	**Testing**	**[1]Total**
Switchers	0.4	0.2	0.2	0.7
GP-3X	10.6	42.7	0.4	53.6
GP-4X	29.4	16.9	4.3	50.5
GP-50	0.5	0.6	0.3	1.4
GP-60	2.1	2.9	1.2	6.2
SD-7X	1.4	0.9	0.3	2.6
SD-90	1.0	0.5	0.1	1.6
DASH 7	0.5	0.3	0.1	0.9
DASH 8	7.6	4.1	1.1	12.8
DASH 9	2.8	2.1	0.8	5.7
C60-A	0.7	0.3	0.0	1.0
Totals	56.9	71.3	8.8	137
			TPY	25

1. Emissions represent idle + TN2

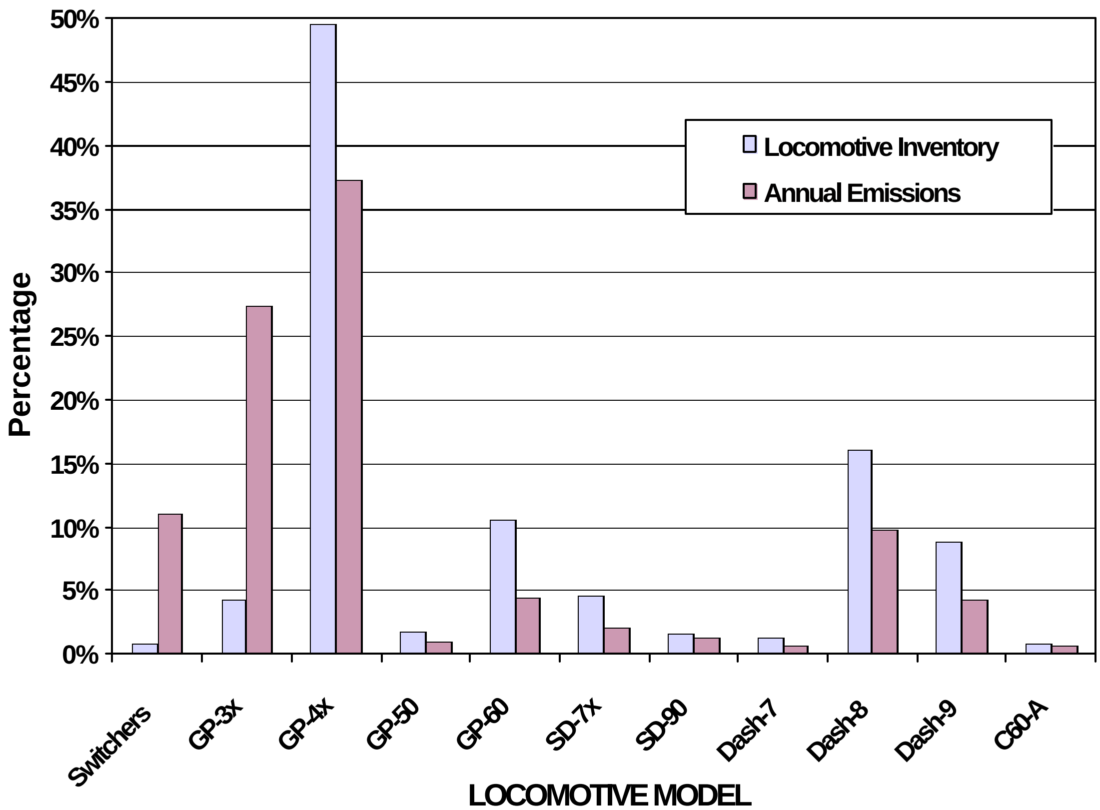
Trim set idling 100 % GP-3x

The differences between the low and high end emissions estimates are due to the assumptions used to estimate emissions in areas 3,4, and 5. For the low end estimate, we assumed locomotive movements in area 3 and 5 were done at notch 1. Notch 2 was assumed for the high end estimate. In area 4, *Hump and Trim*, either switchers or GP-3x locomotives can be used to classify rail cars. The low end estimate was based on assuming only switcher locomotives were used and the high end based on assuming only GP-3x locomotives were used for this activity.

Figure IV.2 presents the percent contribution by each locomotive model classification to the fleet inventory and to the total[13] diesel PM emitted within the Yard. A review of Figure IV.2 shows that switchers, GP-3x, GP-4x, and Dash 8 locomotive model groups contribute approximately 85 percent of the total diesel PM emitted within the Yard. These same model groups represent approximately 70 percent of the locomotive inventory for the Yard. The switchers and GP-3X model classifications account for approximately 5 percent of the locomotive inventory yet are responsible for over 35 percent of the total Yard emissions. This is because these locomotive models are dedicated to the *Hump and Trim* operations.

[13] Total diesel PM represents the average of the low-end and the high-end emissions totals for each locomotive model group.

Figure IV.2: Total Diesel PM Emissions and Locomotive Inventory at J.R. Davis Yard



C. Temporal Distribution of Diesel PM Emissions

The train and locomotive activities that occur in the J.R. Davis Yard occur continuously 24 hours a day. This same pattern of activity is repeated 7 days a week, 365 days a year. Figure IV.3 presents a graphic distribution of the total hourly average diesel PM emissions emitted at the Yard. To verify that the emissions were relatively constant throughout the day and year we investigated the temporal emissions profiles. As shown in Figures IV.3 and IV.4 below, the emissions are relatively constant over a 24-hour period and over the year. The peaks in the annual hourly average emissions are attributed to operational activities that occur at times of shift changes or maintenance activities.

Figure IV.3: Hourly Average Diesel PM Emissions at J.R. Davis Yard

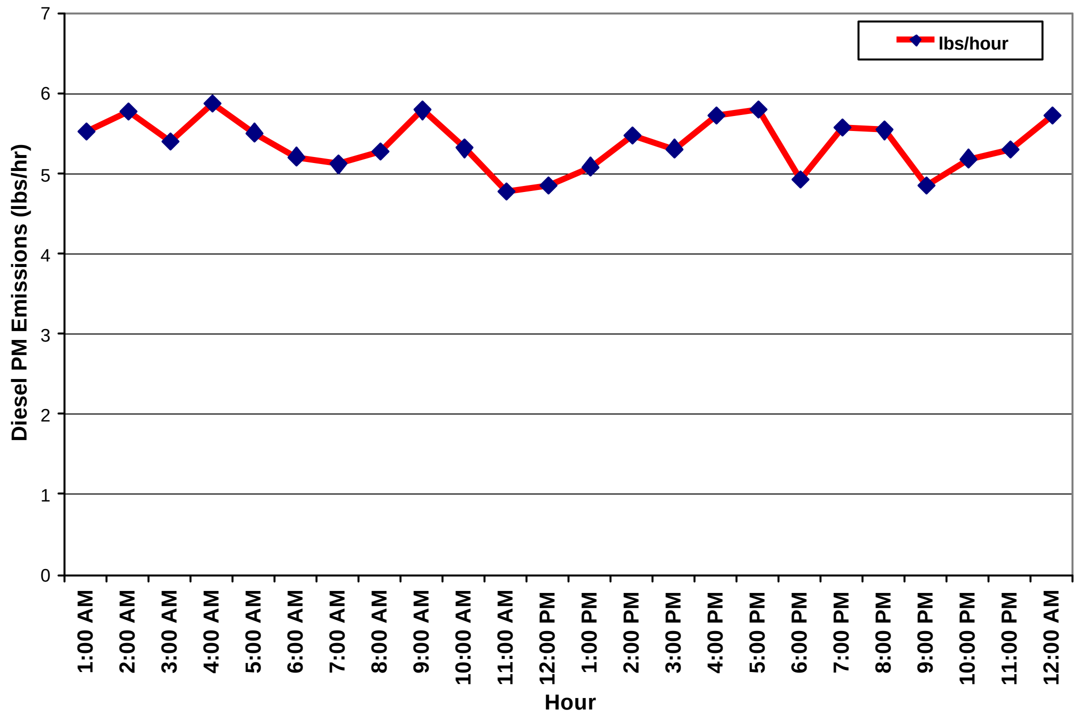
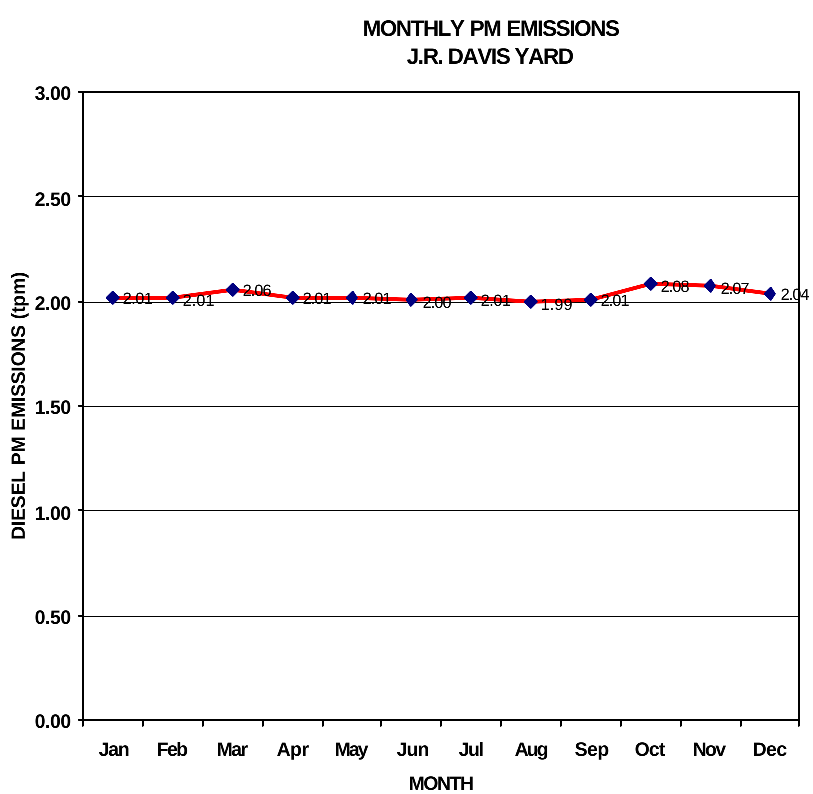


Figure IV.4: Monthly Diesel PM Emissions for J.R. Davis Yard



V. AIR DISPERSION MODELING OF J.R. DAVIS YARD

In this chapter, we describe the air dispersion modeling performed to estimate the downwind dispersion of diesel PM exhaust emissions resulting from the activities at the J.R. Davis Yard. A description of the air quality modeling parameters, including air dispersion model selection, emission source distribution, locomotive stack data, meteorological data selection, model receptor network, and building wake effects, are provided. Model input preparation, output presentation, and uncertainty and sensitivity analyses are also provided.

A. Air Dispersion Model Selection

Air quality models are often used to simulate atmospheric processes for applications where the spatial scale is in the tens of meters to the tens of kilometers. Selection of air dispersion models depends on many factors, such as, characteristics of emission sources (point, area, volume, or line), the type of terrain (flat or complex) at the emission source locations, and source receptor relationships. For the Yard, ARB staff selected the U.S. EPA Industrial Source Complex Model Short Term Version 3 (ISCST3, Version 00101) to simulate impacts at nearby receptors due to diesel PM emissions.[14] The ISCST3 model is a micro-scale, steady-state Gaussian plume dispersion model applicable for estimating impacts from a wide variety of emission release patterns (point, area, line, and volume) such as those found at the Yard for distances up to about 50 kilometers. The model may be used to predict annual average concentrations and account for the effects of building downwash as needed for the Yard. ISCST3 is also able to simulate the dispersion emissions generated from multiple sources and accommodate for both continuous and intermittent sources in flat and complex terrain. The application of ISCST3 follows guidance from the *U.S. EPA Guideline for Air Quality Methods (*40 CFR Part 51, Appendix W*)* (EPA Guidelines). The regulatory default options of ISCST3 were selected, which include (USEPA, 1995a&b):

- Stack-tip downwash (except for Schulman-Scire downwash)
- Buoyancy-induced dispersion (except for Schulman-Scire downwash)
- Final plume rise (except for building downwash)
- Treatment of calms
- Default for wind profile exponents
- Default for vertical potential temperature gradients
- Upper-bound concentration estimates for “super-squat” buildings

[14] ISCST3 Version 02035 was released after modeling studies had begun for the Yard. The changes between version 00101 and version 02035 include the correcting of problems with the SHRDOW emission factor, concatenation of multi-year meteorological files, the area source option of the TOXICS application, and a problem with COMPLEX terrain. Since our application of ISCST3 for the Yard does not use those options that were modified, it was not necessary to re-run the model with the new code.

B. Model Parameters and Adjustments

The emission sources from the locomotives in the Yard are characterized as either a point source or a volume source depending on whether the locomotive is stationary or moving. For stationary locomotives, including idling and load testing, the emissions are simulated as a series of point sources. Model parameters for point sources include emission rate, stack height, stack diameter, stack exhaust temperature, and stack exhaust exit velocity. For moving locomotives, the emissions are simulated as a series of volume sources to mimic the effects of initial dispersion due to plume downwash.

The emission rates for individual locomotive stacks are a function of locomotive type, notch setting, activity time, duration, and operating location. Stack parameters, for the 11 locomotive model classifications at the Yard including stack height, diameter, exhaust temperature, and exhaust velocity, were obtained from the General Motors, Electro-Motive Division and UPRR. Detailed information on the stack parameters is presented in Appendix B. Since the stationary locomotives were not uniformly distributed throughout the Yard, the locations of individual locomotive emission sources which were used for the model inputs were determined based on the detailed locomotive distribution and activity information provided by UPRR (see Appendices C and D).

For "through-trains" and movement of locomotives within the Yard, the emissions are simulated as a series of volume sources with adjusted initial plume release height. Key model parameters for volume sources include initial lateral (σ_{yo}) and vertical (σ_{zo}) dimensions of volumes and source release height. The initial lateral dimensions are estimated by dividing the adjacent source separation distance by a standard deviation of 2.15 as recommended in the ISCST3 User's Guide. Since some rail lines are curved, the source separation distances are not uniform within the Yard.

To consider potential buoyant effects from the exhaust of "through-trains" the volume release heights are adjusted based on a sensitivity study for each of the 11 locomotive model classification. Due to the diurnal variations of ambient air temperature, the adjustment in volume release height are treated separately for daytime (6 am to 6 pm) and nighttime (6 pm to 6 am). Appendix G presents the calculations for the adjustments. The initial vertical dimension of each volume source was determined by dividing the adjusted source height by a standard deviation of 2.15 as recommended in the ISCST3 User's Guide.

C. Emission Sources and Terrain Characterization

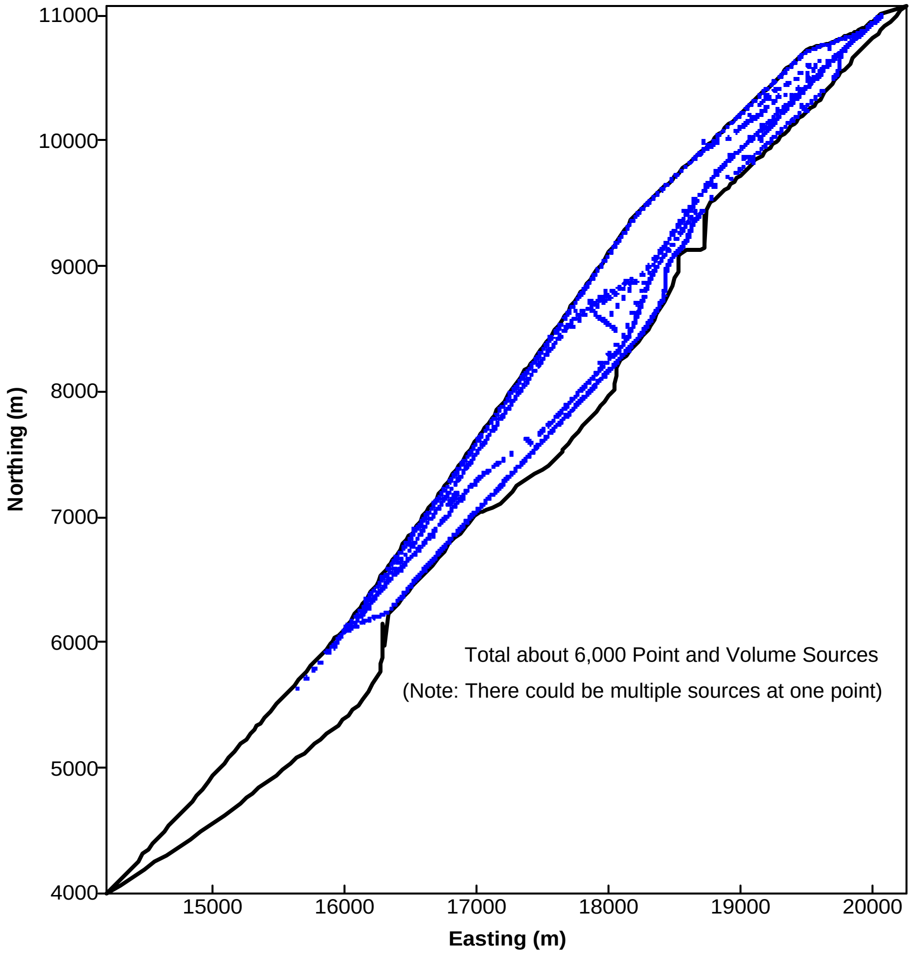
The Davis Yard emissions inventory is a critical input to the ISC3T model. To distribute the emissions into individual emission sources suitable for modeling, the Yard was divided into the following areas:

- *Main Receiving Yard*
- *Rockpile Yard*
- *Subway*
- *Staging Tracks*
- *Service Tracks*
- *Main Departure Yard*
- *Northside Tracks*
- *Ready Tracks*
- *Hump Operation*
- *City Yard*
- *Mod/Search Building*
- *Maintenance Shop*
- *Trim Operation*

For each area, there are numerous rail lines with lengths of several hundred meters to several kilometers. For simplicity, it is assumed that the emissions are emitted from certain rail lines and locations. For example, there are seven rail lines over three kilometers long in the *Main Receiving Yard*. In this case, we assumed that the emissions are generated from individual points along the center rail line. The coordinates for these emission sources were obtained from the confidential digitized two-dimensional associative electronic map (AUTOCAD format) provided by the UPRR. The distance between the two adjacent sources ranges from 50 to 150 meters. Since each locomotive type has different emission rates, notch settings, and stack data; for each point, there could be a maximum of 99 stacks (11 locomotive types x 9 settings). Figure V.1 presents a graphical representation of each emitting source evaluated in the modeling exercise. Note that in Figure V.1, each point could represent a maximum number of 99 independent point sources.

Local terrain variations are not considered for sources and receptors in the modeling domain. The local terrain is relatively flat.

Figure V.1: The Distribution of Emission Sources within the Yard



D. Meteorological Data

The ISCST3 model requires hourly meteorological data as input. The critical meteorological parameters include wind speed, wind direction, atmospheric stability, ambient temperature, and mixing height. These parameters have significant impact on the modeling predictions. Wind speed determines how rapidly the pollutant emissions are diluted. It also influences plume rise, thus affecting downwind concentrations of pollutants. Under low wind conditions, the plume's initial buoyancy and inertia will cause the emissions to go higher into the air than during high wind conditions. Wind direction determines where pollutants will be transported.

Atmospheric stability determines the rate of mixing in the atmosphere and is typically characterized by the atmospheric vertical temperature profile. The difference of ambient temperature and the stack exhaust exit temperature determines the initial buoyancy. In general, the greater the temperature difference, the higher the plume rise. Mixing height defines the vertical depth of the atmosphere through which pollutants are allowed to mix by dispersion processes. The greater the mixing height, the larger the volume of atmospheric available to dilute the pollutant concentration.

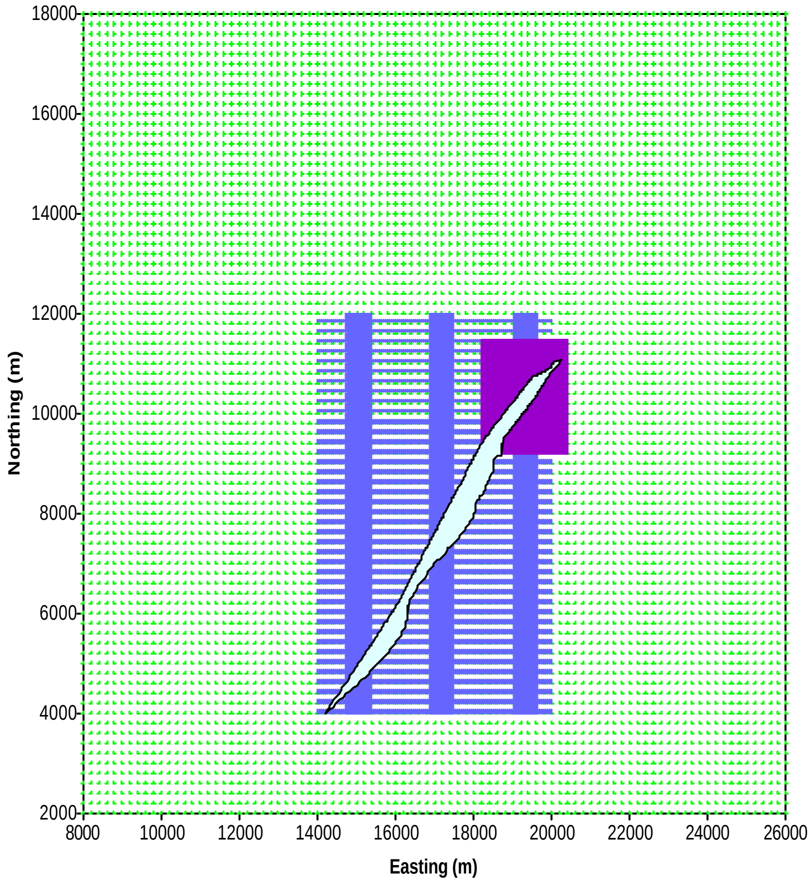
Meteorological data should be selected on the basis of spatial and temporal representativeness. The spatial representativeness of the data is dependent upon the proximity of meteorological monitoring site to the facility location. The temporal representativeness of the data is a function of the yearly variations in weather conditions. The ARB air quality monitoring (AQM) station at Roseville is within one mile of the Yard. The most recent year of meteorological data for this site is 1999. Although the use of five years of meteorological data is strongly recommended by U.S. EPA and CARB, one year (1999) of representative meteorological data was thought to be sufficient based on an analysis of five years of data, which indicated that there were little variations between the years. Even though the ARB AQM station at Roseville is near the Yard, it has limitations. The wind speed collected at this station is a vector averaged wind speed. U.S. EPA Guidelines specify scalar winds speeds should be used for Gaussian plume modeling. Scalar average winds are generally greater than vector averaged winds and as a result, there may be a bias in the estimated concentrations.

Because of the limitation in the Roseville AQM meteorological data discussed above, the meteorological data for 1996 from McClellan AFB was also selected and used as a sensitivity study. McClellan AFB is about 10 miles southwest of the Yard. Although further from the Yard than the Roseville AQM data, the McClellan AFB data are scalar averaged wind speeds. The detailed procedures of meteorological data preparation and the QA/QC are presented in Appendix F. The statistically analysis and windrose plots for the meteorological data are also presented in Appendix F.

E. Model Receptors

Receptors are the locations where concentrations are estimated by the model. A Cartesian grid receptor network is used in this study where an array of points are identified by their x (east-west) and y (north-south) coordinates. This network is convenient to identify the emission sources within the Yard with respect to the receptors in the nearby residential areas. Initial screening analyses indicate that higher off-site potential cancer risks should be located adjacent to the *Service Area* (or Area 3 which includes the *Staging Tracks*, *Service Tracks*, *Mod/Search Building*, *Maintenance Shop*, and *Ready Tracks*). To better define concentrations in this area, a fine grid receptor network of 20m x 20m is used in the modeling domain of 1km x 1km surrounding the *Maintenance Shop Area*. A medium grid receptor network of 50m x 50m is selected for the modeling domain of 6km (easting) x 8km (northing), which covers the whole Yard and the surrounding residential areas. A coarse receptor network of 200m x 200m is selected in the large modeling domain of 18km x 16 km, which covers the whole the City of Roseville and part of the County of Sacramento. Figure V.2 shows the grid receptor networks of fine (20m x 20m), medium (50m x 50m), and coarse (200m x 200m). Note that the receptors within the Yard are included in the network, but the risks from these on-site receptors are excluded from final risk analyses.[15] As stated above, all receptors are assumed to be at the same base elevation as the emission sources (i.e., flat terrain).

Figure V.2: Distribution of Receptors around the Yard [Black(Purple) for 20m x 20m, Dark Gray(Blue) for 50m x 50m, and Light Gray(Green) for 200m x 200m]



F. Building Wake Effects

If pollutant emissions are released at or below the "Good Engineering Practice" (GEP) height as defined by EPA Guidance (USEPA, 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 ISCST3 model has the option to simulate the effects of building downwash. To do so,

[15] Due to the complexity of operations within the yard, a number of simplifying assumptions were made in preparing model inputs. For example, the emissions of moving locomotives were represented by emissions at a fixed location. For this study, such simplifications are intended to estimate off-site concentrations only.

“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 (PBW) along with the building height (BH), and they are prepared by the Building Profile Input Program (BPIP). The BPIP calculates 36 pairs of BH and PBW values for input to ISCST3 (USEPA, 1995c).

In this study, two types of building or structures are considered: locomotives and actual buildings in the *Mod/Search Building* and *Maintenance Shop Area*. For each locomotive, it is assumed that the stack is on top of the locomotive roof. It also is assumed that each locomotive has the same physical height, length, and width.

G. Model Inputs

ISCST3 requires four types of inputs: control, source, meteorological, and receptor. Control inputs are required to specify the global model options for the model run. The control options include dispersion coefficients (rural vs. urban), averaging time, pollutant type, exponential decay, terrain, and receptor elevations. The regulatory default option as described previously is also control input.

Source inputs require source identification and source type (stack, area, volume, or open pit). Each source type requires specific parameters to define the source. For example, the required inputs for a point source are emission rate, release height, exhaust exit temperature, exhaust exit velocity, and stack diameter. In addition, other parameters for building downwash, variable emission rates, dry and wet deposition can be specified.

The requirements for meteorological and receptor inputs have been discussed in the Meteorological Data and Model Receptors. Table V.1 lists the model options used in ISCST3. In order to generate the inputs for the large number of sources needed to simulate emissions at the Yard, several Fortran programs were developed.

Table V.1: Modeling Input Parameters and Description

Modeling Parameters	**Values or Description**
Model Used	ISCST3(Version 00101)
Source Type	Point and Volume
Dispersion Setting	Urban and Rural
Receptor Height	1.5 m
Stack Information*:	
Stack Diameter	Dependent upon locomotive type
Stack Height	Dependent upon locomotive type
Stack Exhaust Temperature	Dependent upon locomotive type and notch setting
Stack Exhaust Flow Rate	Dependent upon locomotive type and notch setting
Emission Rate	Dependent upon locomotive type, notch setting, location, and operation time
Time Emissions Emitted	24h/d with variable emission rate, 365d/y
Meteorological Data	Roseville (1999) and McClellan AFB (1996)
Release Height	Dependent upon source type, locomotive type, and operation time
Building Downwash	Yes for stack sources
Modeling Domain	1km x 1km, 6km x 8km, 18km x 16km

*Detailed stack information is provided in Appendix B.

H. Model Output Presentation

The concentrations of diesel PM estimated by the modeling are presented as 2-D isopleths and zone averages. The 2-D isopleths are used to display the plume ranges and to visualize the rate at which the diesel PM concentrations change with distance. Zoned average concentration is introduced to quantitatively determine concentrations in specific areas. The point of maximum impact (PMI) in the vicinity of the Yard (outside of the yard fence) was first identified and a series of circles with different radii $r_1,\ldots,r_N$ centered at the PMI was drawn. The zoned average concentration located between r_1 and r_2 is calculated as the follows:

$$Zoned\ average\ concentration = \frac{\sum_{i=1}^{N} R_i A_i}{\sum_{i=1}^{N} A_i} \qquad (1)$$

where R_i is the diesel PM concentration in the grid cell i in the ring-shaped region defined by $r_1 < r < r_2$, and A_i is the corresponding area, N is the number of grid cells in the ring-shaped region of $r_1 < r < r_2$. The N varies and increases with radium r. Note that the concentrations of diesel PM within the Yard are omitted from the zone average. This was done to minimize modeling artifacts because in certain cases the distance between the receptor and the assumed source location have been simplified.

I. Uncertainty and Sensitivity Analysis

There are two kinds of uncertainties: inherent and reducible. Inherent uncertainty is caused by the model's (e.g., ISCST3) inability to accurately simulate a complex wind flow field. Air dispersion models simulate pollutant transport in the air with known conditions that are input to the models (e.g., wind speed, mixing height, and emission release characteristics). However, there are variations in the transport, such as the turbulent flow in the air, which are not simulated by the models. As a result, deviations in pollutant concentrations estimated by the models may occur. Nevertheless, inherent uncertainty is beyond our study scope. Reducible uncertainty is a result of uncertainties in the input values of the known conditions, which include source characteristics (emissions, stack parameters, etc.) and meteorological inputs.

Uncertainties of emission estimates may be attributed to many factors such as locomotive engine type, throttle setting, level of maintenance, operation time, and emission factor estimates. Evaluating individual uncertainties is difficult and may in itself introduce new uncertainties. We conducted sensitivity studies to evaluate how the uncertainty of model input parameters affect the estimated concentrations. The sensitivity studies are conducted by considering variations in the following parameters:

emission rate, stack exhaust temperature, stack exhaust velocity, meteorological data selection, and dispersion coefficient selection. The ranges of the parameters for the sensitivity studies are defined as follows:

Emission rate:	Base case ± 20%
Stack exhaust temperature:	Base case ± 50K
Stack exhaust velocity:	Base case ± 50%
Meteorological data:	Roseville and McClellan AFB
Dispersion coefficient:	Rural vs. Urban

The impacts of these variables on the resultant concentrations and exposures are discussed in Chapter VI.

VI. EXPOSURE ASSESSMENT OF J. R. DAVIS YARD

In this chapter, we briefly describe the Office of Environmental Health Hazard Assessment (OEHHA) guidelines on health hazard risk assessment and how we used the guidelines to characterize potential cancer risks associated with exposure to diesel exhaust from the Yard. We also present detailed air dispersion modeling results for the Yard and discuss the results from sensitivity studies conducted to provide perspective on the uncertainties in the modeling results.

A. OEHHA Guidelines

The Air Toxics Hot Spots Program Risk Assessment Guidelines: The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments (OEHHA guidelines) published as a final draft by OEHHA in 2003[16], (OEHHA 2002a and ARB 2003) outlines a tiered approach to risk assessment, providing risk assessors with flexibility and allowing for consideration of site-specific differences. Tier 1 is a standard point-estimate approach that uses a combination of the average and high-end point-estimates. Tier 2 utilizes site-specific information for risk assessment when site-specific information is available and is more representative than the Tier 1 point-estimates. Tier 3 is a stochastic approach for exposure assessment when the data distribution is available. Tier 4 is also a stochastic approach but allows for utilization of site-specific data distribution.

The OEHHA guidelines require that all health hazard risk assessments use Tier 1 evaluation for the Hot Spots Program. For Tier 1, OEHHA recommends that two values, one representing an average and another representing a defined high-end value, be used for key exposure pathways (e.g., breathing rate). The average and high-end of point-estimates are defined in terms of the probability distribution of values for that variate. The mean (65th percentile) represents the average values for point-estimates and the high end (95th percentile) represents the high-end values for point-estimates from the distribution identified in OEHHA (2000).[17] In addition to using an estimate of average and high-end consumption rates, potential cancer risk evaluations for 9, 30, and 70-year exposure durations can be utilized. Nevertheless, all hazard risk assessments must, at a minimum, present the potential risks based on a 70-year exposure.

B. Exposure Assessment

Exposure assessment is a comprehensive process that integrates and evaluates many variables. Three variables can have significant impacts on the results of a health risk assessment – emissions, meteorological conditions, and human exposure information. The emissions affect the risk levels linearly, as emissions increase so does the risk.

[16] The final guidelines were augmented on October 9, 2003 with the "Air Resources Board Recommended Interim Risk Management Policy for Inhalation-Based Residential Cancer Risk."
[17] The 65th percentile breathing rate is 271 L/kg-day and the 95th percentile breathing rate is 393 L/kg-day, which differ by approximately 30 percent.

Meteorological conditions can have a large impact on the resultant ambient concentration of toxic pollutant with higher concentrations found along the predominant wind direction and under calm wind conditions. The key variables in human exposure are a person's proximity to the emission plume, how long he or she breathes the emissions (exposure duration), the person's breathing rate, and body weight. The longer the exposure time, the greater the potential risk.

To examine the potential cancer risks associated with exposure to diesel exhaust emissions from locomotive activities in the J. R. Davis Yard, we used the Tier-1 methodology presented in the OEHHA guidelines. The OEHHA guidelines, and this assessment, use health and exposure assessment information that is contained in the Air Toxics Hot Spot Program Risk Assessment Guidelines, Part II, Technical Support Document for Describing Available Cancer Potency Factors (OEHHA 2002b); and the Air Toxics Hot Spot Program Risk Assessment Guidelines, Part IV, Technical Support Document for Exposure Analysis and Stochastic Analysis (OEHHA 2000). We assumed nearby residents would be exposed to diesel exhaust PM for 70 years. The potential cancer risk is estimated by multiplying the inhalation dose by the cancer potency factor (CPF) of diesel PM (1.1 $(mg/kg\text{-}d)^{-1}$). Additional details on the risk characterization are provided in Appendix I.

C. Risk Characterization

Risk characterization is defined as the process of producing a quantitative estimate of risk, including a discussion of its uncertainty. The risk characterization process integrates the results of air dispersion modeling and relevant toxicity data (i.e., diesel exhaust PM Cancer Potential Factor) to estimate potential cancer or noncancer health effects associated with contaminant exposure.

For this study, exposures are assumed to occur through the inhalation pathway only. The potential cancer risks are characterized based on the 80^{th}, mean (65^{th}) and 95^{th} percentile breathing rates. Noncancer chronic health effects are not evaluated in this study because inhalation cancer risk due to diesel exhaust emissions from the Yard outweighs the noncancer chronic health impacts from diesel PM. Currently, there is no acute reference exposure level to quantify the (short-term) one-hour health impacts. Diesel PM risk is evaluated by the inhalation pathway only. There is not an oral slope factor to assess the risk from pathways other than inhalation. It is important to note that no background or ambient diesel PM concentrations are incorporated into the risk quantification. In the following sections, we present predicted cancer risk levels using two different meteorological data sets and dispersion coefficients.

To characterize the risk, three modeling domains were used in this modeling exercise: fine (1km x 1km, or 0.6mi x 0.6mi with a resolution of 20m X 20 m), medium (6km x 8km, or 4mi x 5mi with a resolution of 50m X 50m), and coarse (18km x 16km, or 11mi x 10mi with a resolution of 200m X 200m). The risks are presented graphically as 2-D isopleths and zoned averages.[18] The 2-D isopleth contours were used to display the

[18] As discussed in Chapter V, for this risk assessment, the concept of zoned average risk was introduced to help portray the risk from the Yard. Zoned average risk represents the average risk in a given area, in

risk's plume ranges with distances in all wind directions. This approach is a deviation from the traditional approach of focusing on cancer risk at the point of maximum impact or at the maximum exposed individual. Staff elected to use this alternative approach due to the complexity of the modeling, the need for numerous simplifying assumptions, and the uncertainties with respect to the location of emission sources (the exact location of idling locomotives is often unknown). We also provide a discussion on the relationship of risk with downwind distance, and the temporal and spatial effects of risks associated with activities in the Yard.

1. Estimated Exposures[19]

The potential cancer risk from the estimated emissions of diesel PM at the Yard were calculated using two meteorological data sets (Roseville and McClellan) and for both urban and rural dispersion characteristics.[20] Figures VI.1a and b present the potential risk for the two meteorological data sets using the rural dispersion coefficient. Staff believes that the rural dispersion characteristics are most appropriate for predicting the area-wide impacts i.e. those impacts further away from the yard, and the urban dispersion characteristics are most appropriate for predicting the near source impacts from the Yard.

For simplicity, only the isopleth for 10 in a million potential cancer risk is shown in each figure. In Figure VI.1a the solid line represents the 10 in a million cancer risk isopleth using the Roseville meteorological data and in figure VI.1b the dashed line represents the 10 in a million cancer risk isopleth using the McClellan meteorological data. Inside the isopleth the potential cancer risk is estimated to be greater than 10 in a million. Outside the line the potential cancer risk is estimated to be less than 10 in a million. As can be seen in the figure, the area within which the risks exceed the district's significant risk threshold of 10 in a million is very large, extending about 8-10 miles in the North-South direction.

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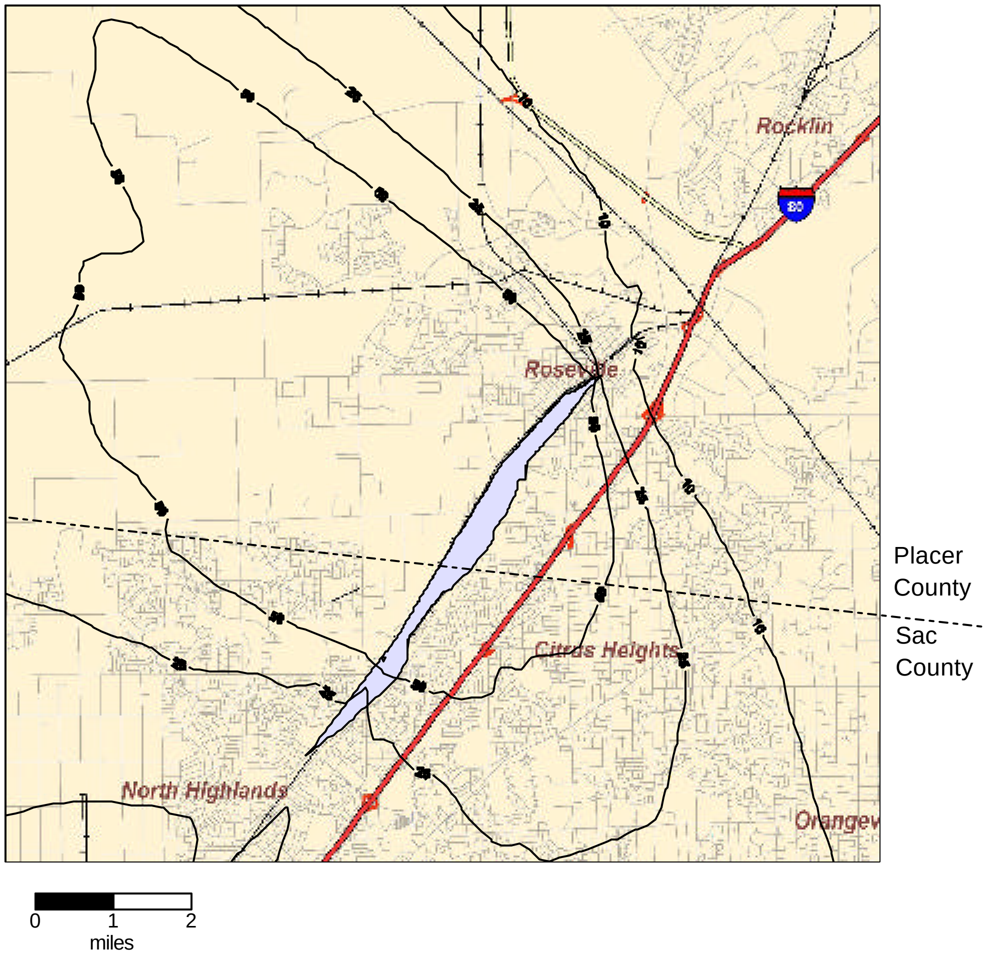
this case, concentric rings were drawn around the point of maximum impact in the outside of the yard fence and the risk within the rings were averaged to generate a "zoned average concentration."

[19] The results based on the 80th percentile breathing rates are presenting in this subsection and those for the mean and 95th percentile breathing rates are provided in Appendix H.

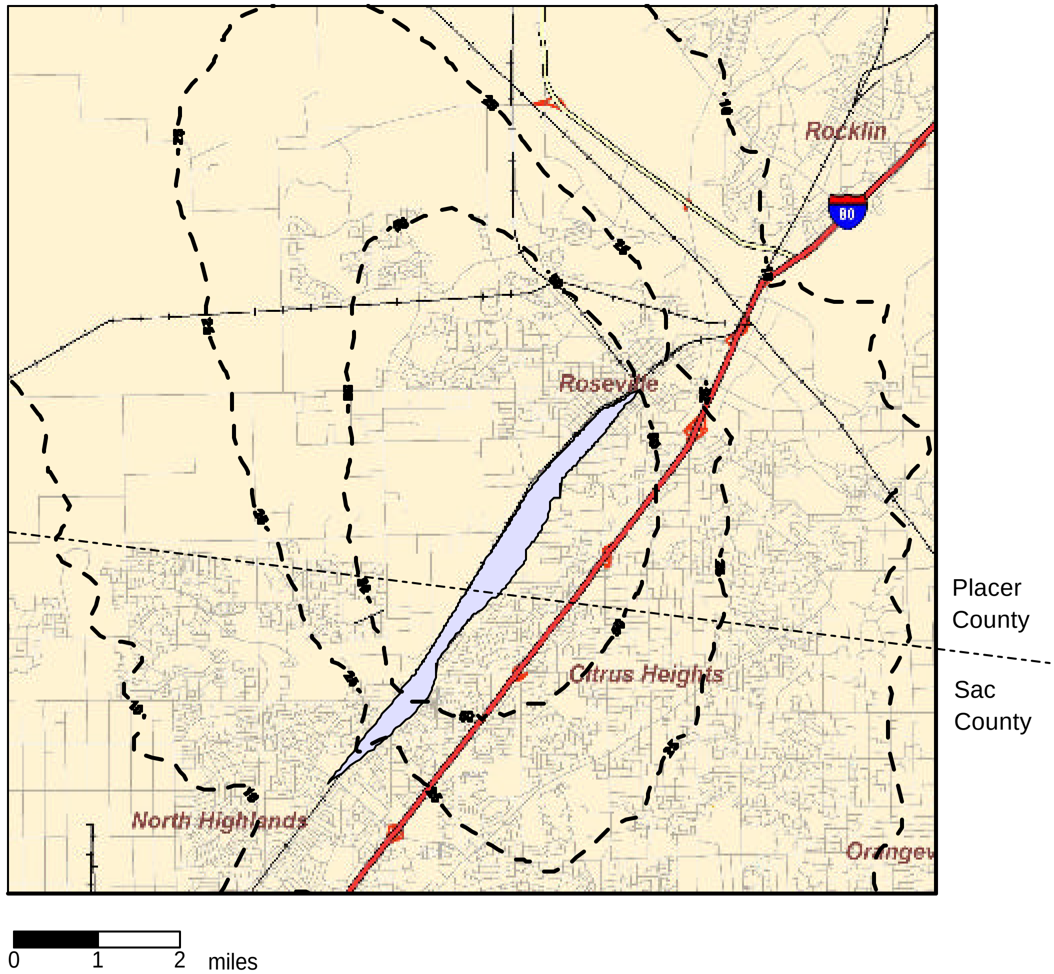
[20] Dispersion coefficients are used in air dispersion models to reflect the land use (rural or urban) over which the pollutants are transported. The rural dispersion coefficient generally results in wider dispersion of the pollutant hence a larger "footprint" whereas an urban coefficient results in less dispersion of the pollutant and a smaller footprint. Because the area around the Yard contained both urban and rural land use types, the model was run with both dispersion coefficients.

Figure VI.1a: Estimated Cancer Risk from the Yard Using Roseville Met Data (10, 25, and 50 in a million isopleths)



Note: Roseville Meteorological Data, Rural Dispersion Coefficients, 80th Percentile Breathing Rate, All Locomotives' Activities [23 TPY], 70-Year Exposure

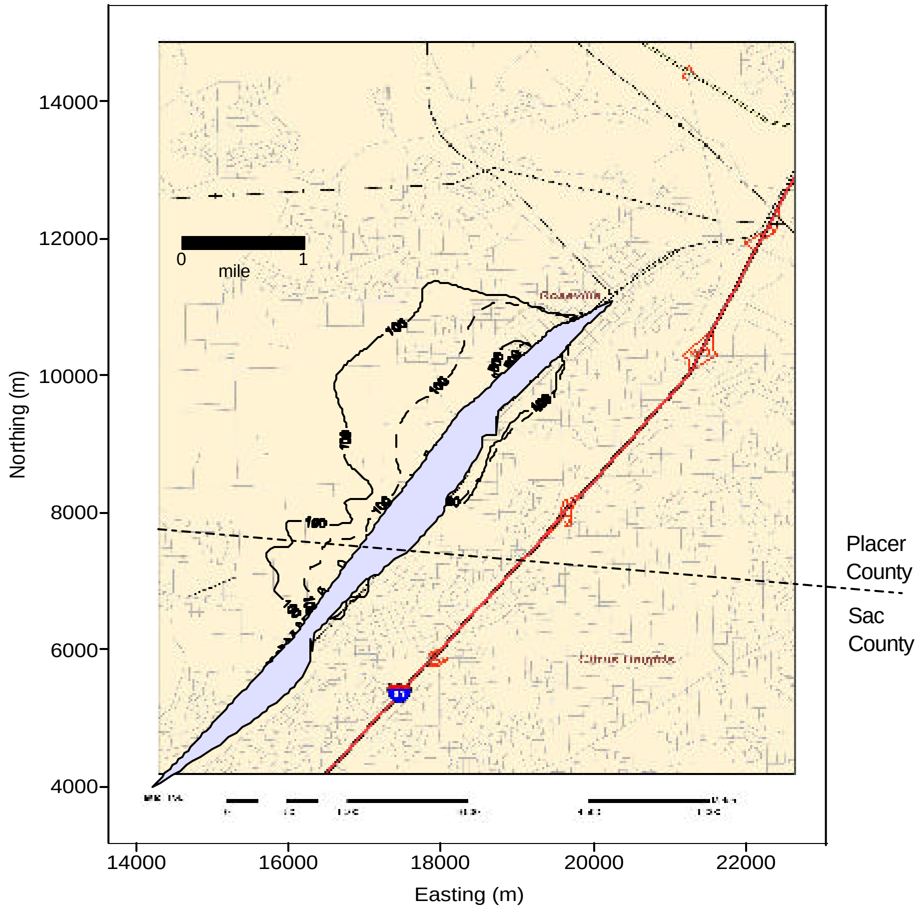
Figure VI.1b: Estimated Cancer Risk from the Yard Using McClellan Met Data (10, 25, and 50 in a million isopleths)



Note: McClellan Meteorological Data, Rural Dispersion Coefficients, 80th Percentile Breathing Rate, All Locomotives' Activities [23 TPY], 70-Year Exposure

Figure VI.2 presents the 100 and 500 in a million cancer risks contour lines (isopleth) for the two meteorological sets (Roseville and McClellan) using the urban dispersion characteristics. Staff believes that the urban dispersion characteristics are most appropriate for predicting the near source impacts from the Yard. The solid line represents the 100 and 500 in a million cancer risk isopleths using the Roseville meteorological data. The dashed line represents the 100 and 500 in a million cancer risk isopleths using the McClellan meteorological data. The area inside the isopleth has potential cancer risks estimated to be greater than 100 or 500 in a million.

Figure VI.2: Estimated Cancer Risk from the Yard (100 and 500 in a million risk isopleths)



Notes: 100/Million Contours: Solid Line – Roseville Met Data; Dashed Line – McClellan Met Data, Urban Coefficients, 80th Percentile Breathing Rate, All Locomotives' Activities [23 TPY], 70-Year Exposure

As can be seen by these figures, the magnitude and the extent (size of area) of the predicted cancer risk levels are highly dependent on the meteorological data selected, and the use of urban or rural dispersion coefficients. However, in either case the potential cancer risk level is significant. Additional details for the isopleths are provided in Table VI.1. As is shown, a very large area, between 47,500 and 55,500 acres have predicted concentrations of diesel PM that result in a risk of greater than or equal to 10 in a million, the District's threshold for significant risk. About 9,000 acres have PM concentrations that result in risks between 10 and 100 in a million, about 700-1,600 acres have risks between 100 and 500 in a million, and approximately 10-40 acres could have risks of greater than 500 in a million[21].

[21] Modeling inputs placing idling emissions at specific locations (e.g., at the west end of the Departure Yard), may cause modeling artifacts that are not representative of actual conditions. Such artifacts appear as high estimated concentrations in localized areas near the Yard boundary that is less than 100m across. Since such idling emissions actually occur at locations along a longer section of the track, the peak off-site concentrations may be lower.

Table VI.1 provides information on the average risk with the three risk zones based on two exposure durations as well as the number of acres in each of the risk zones. For example, in the ≥ 100 and < 500 risk zone (see Figure VI.2) the average cancer risk in that area is 170 in a million assuming a 70-year exposure duration and 73 in a million assuming a 30 year exposure duration. The number of acres estimate to be in this risk zone is in the last column is 1600.

It should be noted that the 70-year exposure duration is recommended in the OEHHA guidelines for a Tier 1 evaluation. A 70-year exposure ensures a conservative risk estimate is predicted and is a "historical benchmark for comparing facility impacts on receptors and for evaluating the effectiveness of air pollution control measures." The OEHHA guidelines also provide that a 30-year exposure duration may also be evaluated as supplemental information to show the range of cancer risk based on different residency periods. However, the OEHHA guidelines also caution that as the exposure duration decreases the uncertainties can increase since the cancer potency factors are derived from long term studies (OEHHA 2002a).

Table VI.1: Summary of Average Risk by Risk Zone and Acres Impacted

Meteoro-logical Data Source	**Risk Zone Based on Figures VI.1 and VI.2a and b Isopleth Boundaries** (70 Year Exposure)	Dispersion Characteristic	Average Risk Estimated Based on Years Exposed		Acres Impacted (rounded)
			70 years	30 years	
Roseville	Risk ≥ 500	Urban	645	275	40
	Risk ≥ 100 and < 500	Urban	170	73	1,600
	Risk ≥ 10 and < 100	Rural	40	17	45,900
	Total				47,500
McClellan	Risk ≥ 500	Urban	630	270	10
	Risk ≥ 100 and < 500	Urban	156	67	700
	Risk ≥ 10 and < 100	Rural	28	12	55,500
	Total				56,200

Notes: Model domain for rural dispersion coefficient is 16km x 18 km with a resolution of 200m x 200m. For the urban dispersion coefficient the model domain is 6km x 8 km with a resolution of 50m x 50m. The 80^{th} percentile breathing rate for adults was used.

The OEHHA guidelines require that for health risk assessments, the cancer risk for the maximum exposed individual or at the point of maximum impact (PMI) be reported. The PMI is the offsite location closest to the emission source that shows the highest modeled concentration of diesel PM, or highest risk. The maximum off-site diesel PM cancer risks from the Yard range from 900 to 1,000 in a million based on the urban dispersion, 80^{th} percentile breathing rate, and 70 years of exposure. The location of the PMI varies, depending upon the meteorological data set (McClellan or Roseville), air dispersion coefficients (urban or. rural) and how the emissions are allocated in the Yard.

The estimated concentrations of diesel PM due to emissions from the Yard are in addition to regional background levels of diesel PM. Although emissions from the Yard also contribute to the regional background, the measurable effect should be small. The regional background risk due to diesel PM emissions has been estimated to be 360 per million for the entire Sacramento Valley in the year 2000. In those areas around the Yard, the potential risks can be significantly above the regional background levels. For example, within the ≥ 500 Roseville risk zone, the average risk is 645 in a million due to emissions only from the Yard. Taking into consideration both the regional background emissions and the Yard impacts, residents living in that area would have a potential cancer risk over 1,000 (645 per million due to Yard emissions and 360 per million for regional background). (ARB 2004).

2. Variation of Diesel PM Concentration with Time of Day

Since meteorological conditions and emissions vary with time, the hourly contributions to annual average diesel PM concentration exhibit diurnal and seasonal patterns. Figures VI.3 (a & b) present the diurnal contributions to the concentrations over a year with different receptor distances in the predominant wind direction for Roseville meteorological data with rural and urban dispersion coefficients, respectively. The receptors used in the Figures VI.3 (a & b) are selected in the predominant wind direction at the distances of 200, 500, 1000, and 5000 meters from the Yard boundary near the *Service Area*. Although the hourly emission profile does not show much variation over a period of 24 hours (see Chapter IV, Section B), the hourly contribution to annual average concentration exhibit strong diurnal effects and the effects are greater closer to the Yard boundary.

Figure VI.4 shows the bimodal contribution to the concentration for daytime (6am to 6pm) and night-time (6pm to 6am) emissions as a function of downwind distance. As seen in Figure VI.4, the contribution to the concentration for receptors, kilometers away is greatest for nighttime conditions. This phenomenon is not surprising because the vertical dispersion is relatively strong during the daytime due to warming of the ground by the sunlight and causes unstable atmospheric conditions. In addition, a sensitivity study (the results not shown here) indicated that there is greater plume rise and as a result the PMI is located further downwind during the nighttime conditions. This condition helps us to better understand why the risk does not decrease as rapidly with distance from the source as with other conventional sources such as a freeway for example. In the freeway example, the diurnal emissions reduce the contribution to annual average from nighttime situations.

The monthly contribution to the concentration is shown in Figure VI.5 for various downwind receptor distances. The summer season has higher contributions to annual average, predominantly for shorter receptor distances. This is likely due to the longer daylight hours during the summer time, which results in more unstable atmospheric condition due to solar radiation. This in turn results in less plume buoyancy. Temporal annual average diesel PM concentration variations for McClellan AFB meteorological data exhibit the similar patterns and can be found in Appendix H (see Figures H5-H8).

Figure VI.3a: Diurnal Contribution to Annual Avg. Conc. Vs. Receptor Distance (Annual Average: 1.74 μg/m^3 at 200m, 1.18 μg/m^3 at 500m, 0.80 μg/m^3 at 1km, and 0.25 μg/m^3 at 5km. Roseville Met Data, Rural Dispersion Coefficient)

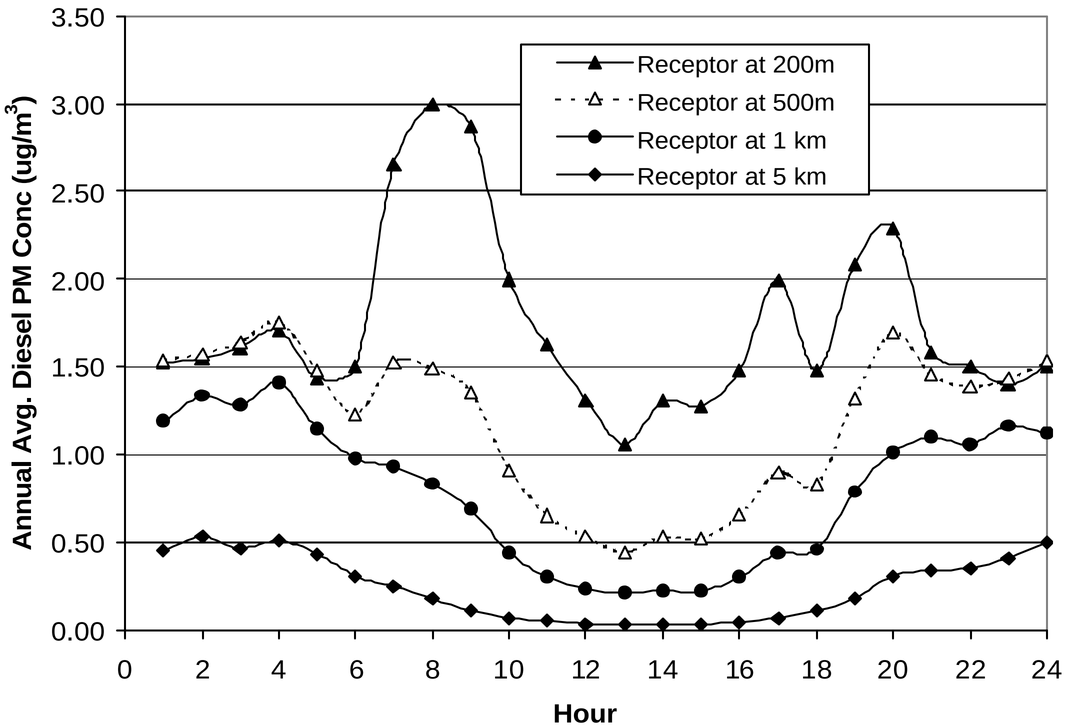


Figure VI.3b: Diurnal Contribution to Annual Average Conc. vs. Receptor Distance (Annual Average: 1.55 μg/m^3 at 200m, 0.80 μg/m^3 at 500m, 0.40 μg/m^3 at 1km, and 0.09 μg/m^3 at 5km. Roseville Met Data, Urban Dispersion Coefficient)

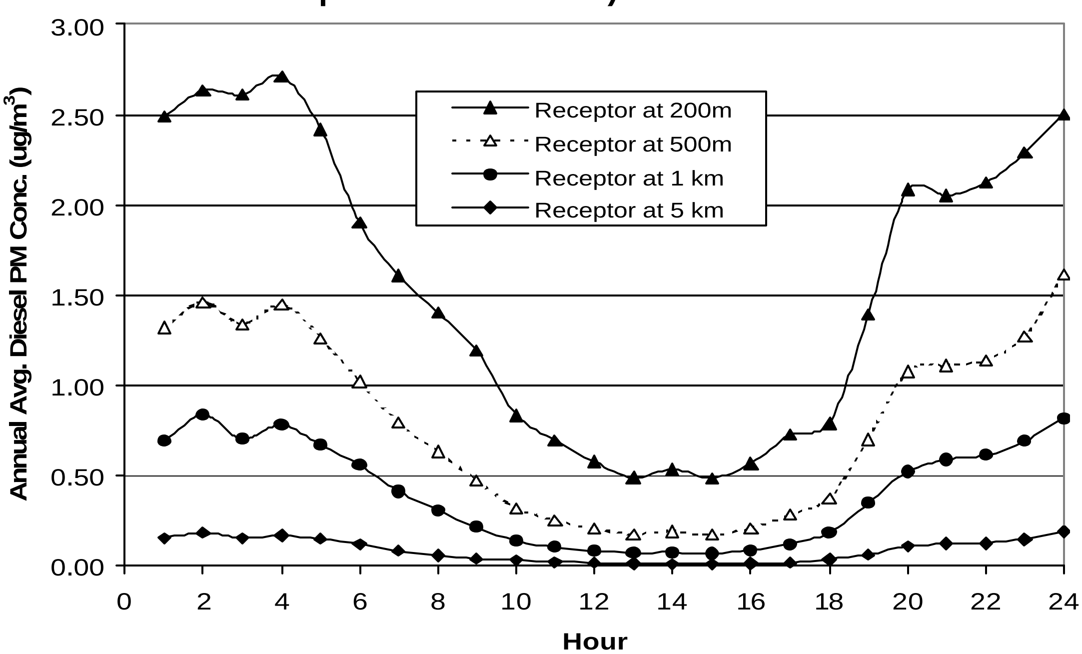


Figure VI.4: Contribution to Annual Avg. Conc. (%) from Day Time (6am – 6pm) and Night Time (6pm – 6am) Emissions vs. Receptor Distance (Roseville Meteorological Data (1999))

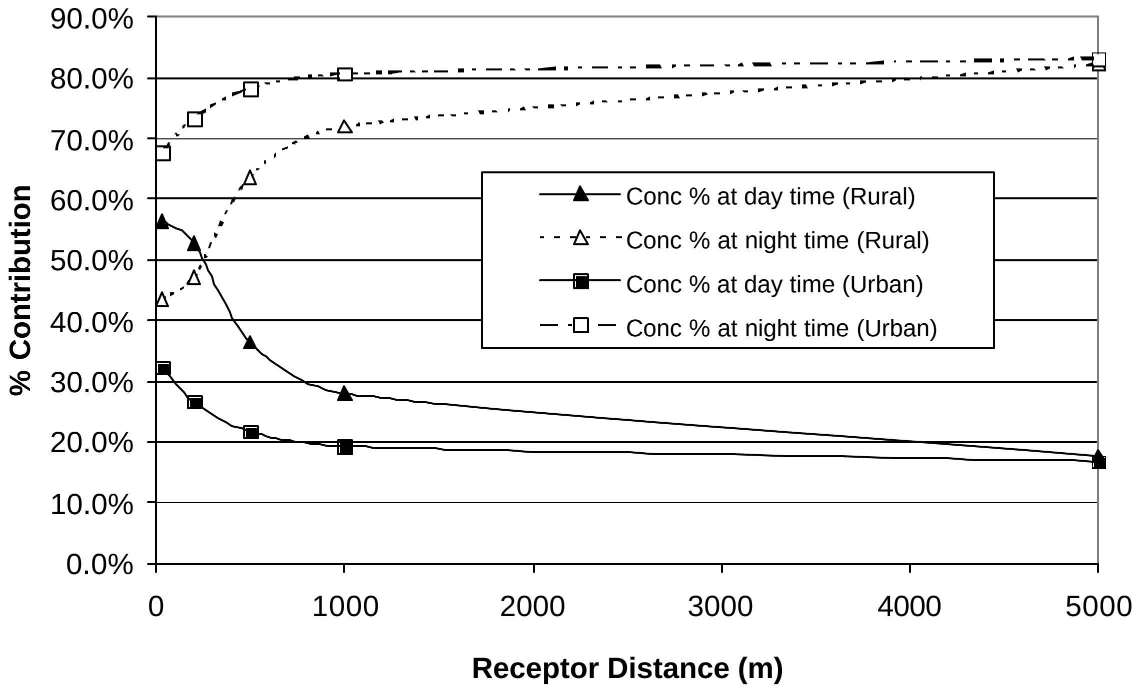


Figure VI.5a: Monthly Contribution to Conc. for Various Receptor Distances (Roseville Meteorological Data, Rural Dispersion Coefficient)

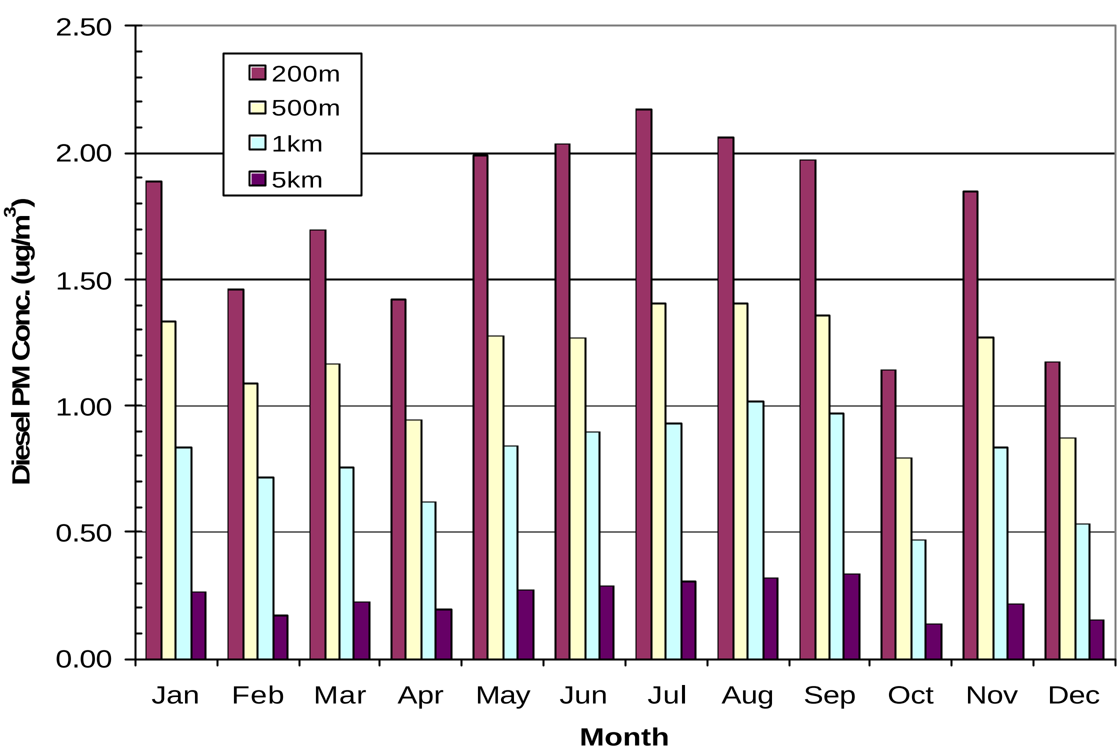
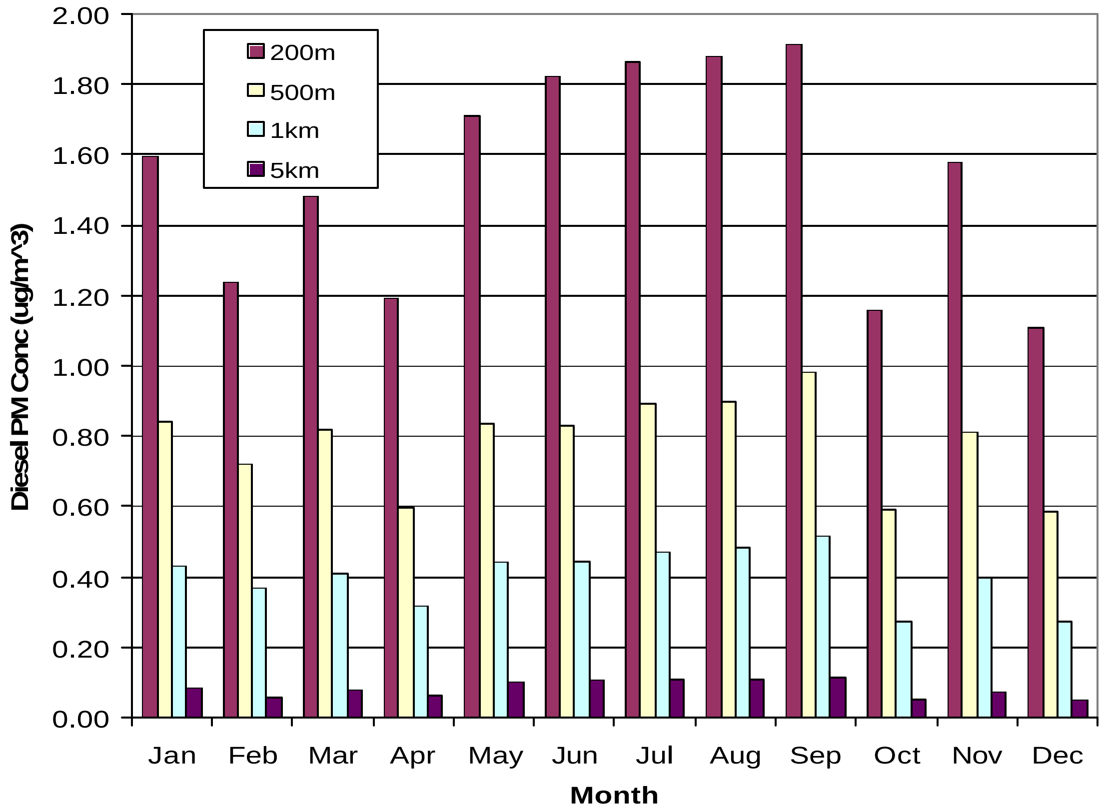


Figure VI.5b: Monthly Contribution to Conc. for Various Receptor Distances (Roseville Meteorological Data, Urban Dispersion Coefficient)



3. Risk Associated with Movement and Idling Activity

In this section we take a closer look at the impacts associated with two types of sources within the Yard, movement activity and idling activity. As stated in Chapter III, there are three kinds of activities in the Yard: movement, idling, and testing. The emissions for these activities are approximately 10.3, 10.5, and 1.6 tons per year, respectively. For simplicity of discussion, we include the emissions of testing into the idling activity. The modeling results for the movement and idling activities are presented in Appendix H (see Figures H9 and H10).

Based on the analysis, there are two relatively small offsite areas where the estimated risk exceeds 500 cases in a million. The first is adjacent to the *Service Area* and the second is adjacent to the *Hump and Trim* area. It is possible that the 500 in a million estimates adjacent to the *Hump and Trim* operation are an artifact of how emissions from the *Ready Track* were modeled. However, without additional field observation and analysis, ARB staff cannot make a definitive finding. However, we do not believe that this additional work would significantly change the results or conclusions of the report.

4. Risk Associated with Individual Activities/Areas

As documented in Chapters III and IV, the locomotive activities occur in many areas of the Yard, e.g., the *Northside Tracks*, *Main Departure Yard*, *Main Receiving Yard*, *City Yard*, *Rockpile Yard*, *Subway*, *Service Area* (*Staging Tracks, Service Tracks, Mod/Search Building, Maintenance Shop and Ready Tracks*), and *the Hump and Trim Operations*. We conducted individual air dispersion modeling runs for all Diesel PM emissions resulting from locomotive activities in these areas. Each activity has a different contribution to the overall cancer cases per million (risks) attributed to emissions of diesel PM from locomotives within the Yard.

The greatest contribution to risks is due to emissions in the *Service Area*, where cancer risk levels are estimated to exceed 500 in a million in the residential area nearby the *Service Area* (see Figure H-11 in Appendix H). Three factors help explain these estimates:

1. Diesel PM emissions generated at the *Service Tracks* and *Ready Tracks* account for about 31 to 36 percent of the total diesel PM emissions within the Yard.
2. The areas where the emissions are generated within the *Service Area* are relatively small (concentrated source of emissions) and located close to the Yard boundary.
3. The predominant emissions activity in this area is idling, which results in localized areas of elevated concentration because of lower plume rise caused by lower exhaust temperature and lower exhaust exit velocity.

The second largest contributor to estimated risk is locomotive activity in *the Hump and Trim Operations* area, which account for about 29 to 32 percent of total diesel PM emissions emitted within the Yard. The offsite locations adjacent to the *Hump and Trim Operations* (Area 4) are predicted to have 70-year cancer risk levels exceeding 500 cases per million (see Figure H12 in Appendix H).

The emissions from departure yards and receiving yard, (Area 2), contribute to the third largest risk impact offsite. The risk greater than or equal to 100/million extends to about one mile in the downwind direction (see Figure H-13 in Appendix H). The total emissions from *Main Departure Yard* and *Main Receiving Yard* account for about 18 to 21percent of total diesel PM emitted within the Yard.

While a comparison of emissions (Chapter 4, Table IV.2) and the estimated risks associated with the three main contributors of emissions and risk (Areas 2, 3, and 4) are similar in magnitude, the potential health impacts are at different offsite areas and the modeling domains are different.

D. Uncertainty, Variability, and Model Sensitivity

To better understand the extent of uncertainty and variability in the modeling results, we conducted sensitivity studies using variable values for the modeling parameters, including modeling domain and resolution, emission rate, stack exhaust temperature and flow rate, meteorological data selection and dispersion coefficients, and building downwash. To reflect the uncertainties and variabilities, the modeling results are presented as spatial average range.

1. Modeling Domain and Resolution

As stated in the previously, three modeling domains are used in this modeling exercise: fine (1km x 1km, or 0.6mi x 0.6mi), medium (6km x 8km, or 4mi x 5mi), and coarse (18km x 16km, or 11mi x 10mi). The first domain (fine) is used to capture the levels of elevated concentration around the *Service Area* where there are the busiest activities. The second domain (medium) covered the whole Yard and nearby residential areas. The third domain (coarse) is utilized to include the estimated risk for in the whole City of Roseville and part of the County of Sacramento. Three modeling resolutions are used for the fine, medium and coarse domains: 20m x 20m, 50m x 50m, and 200m x 200m, respectively. The modeling domain average risks presented here for the purpose of comparing of variables only. Table VI.2 summarizes the effects of the modeling domain on the spatial average risks, Table VI.3 summarizes the effects of the modeling resolution on the spatial average risks. As expected, the smaller the modeling domain, the larger the spatial average risk. On the other hand, as the modeling resolution increases (moves from coarse to medium to fine), the spatial average risks are increased by less than 5 percent. The effect of modeling resolution on the spatial average risk is not significant.

Table VI.2: Effect of Modeling Domain on Spatial Averages

Met. Data	Disp. Option	Risk in Domain 1 (1km x 1km)	Risk in Domain 2 (4mi x 5mi)	Risk in Domain 3 (11mi x 10mi)
Roseville	Rural	360 – 530 (1.280)	110 – 160 (0.384)	40 – 55 (0.135)
Roseville	Urban	285 – 410 (1.000)	55 – 80 (0.191)	15 – 22 (0.053)
McClellan	Rural	300 – 430 (1.050)	80 – 115 (0.278)	27 – 40 (0.094)
McClellan	Urban	180 – 260 (0.625)	35 – 50 (0.123)	11 – 16 (0.039)

Note: (1) The values in the parenthesis are diesel PM concentrations, in $\mu g/m^3$, and
(2) The modeling resolutions for domain 1, domain 2 and domain 3 are 20m x 20m, 50m x 50m, and 200m x 200m, respectively.

Table VI-3. Effect of Modeling Resolutions on Spatial Average Risks in the Domain of 4mi x 5mi (Unit in Potential Cancer Cases per Million)

Met. Data	Disp. Option	Average Risk (50m x 50m)	Average Risk (200m x 200m)
Roseville	Rural	110 – 160 (0.384)	105 – 155 (0.374)
Roseville	Urban	54 – 79 (0.191)	52 – 75 (0.181)
McClellan	Rural	77 – 112 (0.270)	75 – 105 (0.254)
McClellan	Urban	35 – 50 (0.121)	33 – 48 (0.116)

Note: The values in the parenthesis are spatial averaged diesel PM concentrations, in $\mu g/m^3$.

2. Effects of Uncertainty in Diesel PM Emissions

Uncertainties of emission estimates can be attributed to many factors, which include variations in locomotive engine type, throttle setting, number of locomotives, operation time, and emission factor. Assessing or evaluating individual uncertainties is difficult and may itself introduce new uncertainties. From the perspective of modeling inputs, if locomotive engine's stack diameter, height, exhaust temperature, and exhaust velocity are fixed, uncertainties related to the factors mentioned above can be incorporated into a lumped modeling input parameter – emission rate.

As explicitly stated in the Gaussian plume dispersion equation, which is used for this analysis with ISCST3, the downwind concentration is linearly proportional to the emission rate. This means that uncertainty of the estimated concentrations resulting from uncertainty of emission rates can be estimated by linearly scaling the model outputs. For example, if the emission rate increases or decreases from the base case by 20 percent, the estimated risks due to emissions from the Yard can be scaled by 20 percent. Correspondingly, the spatial average risks in the fine modeling domain (4mi x 5mi) for base case $\pm$ 20% are about 130 – 190 and 90 - 130 cases per million, respectively, based on Roseville meteorological data with the rural dispersion coefficients and the 65th to 95th percentile breathing rate.

3. Effects of Stack Data

The stack data includes stack height, stack diameter, stack exhaust temperature, and stack exhaust exit velocity. The stack height and diameter are a function of locomotive type and they are considered to be constant. The stack exhaust temperature and exhaust exit velocity are a function of locomotive type and throttle setting. Generally speaking, the lower the exhaust temperature and the lower the exhaust exit velocity, the higher the estimated concentrations at downwind receptors. In order to investigate the sensitivity of the effects of exhaust temperature and exhaust velocity on the diesel PM concentrations and risks, we conducted four sensitivity studies. The modeling conditions, the spatial average risks, and the maximum diesel PM concentrations at the PMI are listed in Table VI.4.

Table VI.4: Effect of Exhaust Temperature and Velocity on Spatial Average Risks

Case	Variable	Spatial average risk and Diesel PM Concentration.	Compared with base case	Diesel PM Concentration at PMI $\mu g/m^3$	Compared with base case
Base	Base T, V	105 – 155 (0.372)	-	3.72	-
1	T-50K	123 – 179 (0.416)	+11.8 %	5.12	+37.6 %
2	T + 50K	104 – 151 (0.351)	-5.6 %	3.14	-15.6 %
3	V – 50%	130 – 189 (0.440)	+18.2 %	4.74	+27.4 %
4	V + 50%	96 – 139 (0.323)	-13.1 %	3.00	-19.3 %

Note: (1) Roseville meteorological data with rural dispersion coefficients is used,
(2) The modeling domain = 4mi x 5mi and modeling resolution = 200m x 200m, and
(3) T = exhaust temperature, V = exhaust velocity, Q = emission rate.
(4) Diesel PM concentrations and locations of PMIs are a function of stack exhaust temperature and velocity.

As expected, when we reduce the exhaust temperature or exhaust velocity (cases 1 and 3), the estimated diesel PM concentration and risks increases. Conversely, the reverse is true when the exhaust temperature or velocity increases. In addition, variation in stack temperatures and velocity can affect the location of the PMI. The effects of changing exhaust temperature and exhaust velocity on the concentration of diesel PM at the PMIs are the same as the spatial average diesel PM concentrations or risks. Nevertheless, changing exhaust temperature and velocity has a greater effect on the diesel PM concentration and risks at the PMI than on the spatial average risks. In other words, stack exhaust data poses more effects on the nearby receptors than on the far-away receptors in the predominant downwind direction.

4. Effects of Meteorological Data

The modeling results using Roseville and McClellan AFB meteorological data have been presented and discussed in Section C of this chapter. The general finding is that the estimated risks based on the McClellan AFB meteorological data show lower spatial average risks and has relatively steep slope of risk change with the downwind distance. The spatial average risk within the fine modeling domain (1km x 1km) is about 430 potential cancer cases per million, which is lower than that based on the Roseville meteorological data (530 cases per million), based on 95th percentile breathing rate and the rural dispersion coefficients. For the modeling domain of 4mi x 5mi, the spatial average risk based on the McClellan AFB meteorological data is about 110 cases per million, which is lower than the risk based on the Roseville meteorological data (160 cases per million) for the same modeling domain.

Intuitively this makes sense because the annual average wind speed from the Roseville meteorological data is lower than the average speed from the McClellan AFB. Based on the Gaussian model formulation, the downwind concentration is inversely proportional to the wind speed. The annual average wind speeds for the Roseville and McClellan AFB meteorological data sets are 2.39 and 3.52 m/s, respectively.

The dispersion coefficients have a significant effect on risks. The proper selection of dispersion coefficients is difficult for this analysis. As we can see from Table VI.2, the rural dispersion coefficients produce about a 28 percent greater spatial average risk than the urban dispersion coefficient in the fine domain (1km x 1km). By selecting both urban and rural dispersion coefficients and evaluating the results for both, we can bracket the appropriate dispersion conditions in the modeling domain.

5. Effect of Building Downwash

The sensitivity study on building downwash indicated (data not shown) that the buildings located in the Diesel Shop area do not have significant effect on the spatial average risk (less than 1 percent). The effect of building downwash resulting from the locomotive dimensions on the spatial average risks is about 10 percent based on Roseville meteorological data with the rural dispersion coefficients in the modeling domain of 4mi x 5mi.

E. Summary of Modeling Results

The estimated offsite diesel PM concentrations and associated potential cancer risk due to locomotive activities at the J.R. Davis Yard in Roseville are significant. The magnitude and the extent (size of area) of the predicted cancer risk levels are highly dependent on the meteorological data selected, and the use of urban or rural dispersion coefficients.

We conducted four base-case modeling simulations, i.e., Roseville and McClellan AFB meteorological data coupled with rural and urban dispersion coefficients. Computer modeling predicts potential cancer risks greater than 500 in a million (based on 70 years of exposure) northwest of the *Service Track* area and the *Hump and Trim* area. The area impacted is between 10 to 40 acres. Potential cancer risk and the number of acres impacted for several risk ranges are as follows:

- Risk levels between 100 and 500 in a million occur over about 700 to 1,600 acres in which about 14,000 to 26,000 people live.
- Risk levels between 10 and 100 in a million occur over a 46,000 to 56,000 acre area in which about 140,000 to 155,000 people live.

The magnitude of the risk, the general location of the risk, and the size of the area impacted varies depending on the meteorological data (Roseville or McClellan), the dispersion characteristics (urban or rural), the assumed exposure duration (70 or 30 years) and the breathing rate (95^{th}, 80^{th}, and 65^{th} percentile).

Even though hourly emissions from locomotive activities in the Yard did not have much variation, the simulated risks exhibit strong temporal pattern. The daytime (6am to 6pm) activity contributes most to risks at nearby receptors. The nighttime (6pm to 6am) activity contributes most to risk for the far-away receptors. For seasonal variations of the risks, the summer season contributes most for receptors nearest the Yard.

Diesel PM emissions from the Yard are split between idling (including load testing) and movement approximately, 12 tpy and 10 tpy, respectively. Individually, idling emissions contribute most to offsite risks for receptors near the *Service Area* (Area 3) and receptors near the *Hump and Trim Operations* (Area 4). Estimated risks attributed to emissions from movement are distributed to receptors near the boundary throughout the whole Yard and therefore have less of a "hot spot" impact.

The simulated risks also exhibit spatial variations. Among the twelve activity areas within the Yard, it is estimated that *Service Area* contributes the most to the estimated risk for residential receptors near the Yard. The *Hump and Trim Operations*, *and Departure* and *Receiving Yards* (*Main Receiving* and *Departure Yards*, *City Yard*, *Rockpile Yard*, and idling in *Subway*) are identified as the second and third largest contributors to the estimated cancer risks to the nearby residential receptors.

The model sensitivity to various modeling input parameters, including diesel PM emission rate, exhaust temperature, exhaust flow rate, meteorological data selection, dispersion coefficient selection, and building downwash, were investigated.

Uncertainty and variability of emission estimates are a direct result of many factors, such as locomotive engine type, throttle setting, operation schedule, and emission factor. The uncertainty in the emission rate is linearly related to the concentration and subsequently, the risk.

The lower the exhaust temperature and stack exhaust velocity, the higher the risk. For the modeling domain of 4mi x 5mi and Roseville meteorological data with rural dispersion coefficients, if the exhaust temperature is decreased by 50 Kelvin or increased by 50 Kelvin, the domain spatial average risk is increased by 10 percent or decreased by 5 percent, respectively. Similarly, if the stack exhaust velocity is decreased by 50 percent or increased by 50 percent, the corresponding domain spatial average risk would increase by 18 percent or decrease by 13 percent, respectively.

The selection of meteorological data and choice of dispersion coefficients effect the estimated concentrations and risk. For the modeling domain of 4mi x 5mi, the spatial average risk resulting from the most conservative selection (Roseville meteorological data with rural dispersion coefficients) is about three times higher than that resulting from the most dispersive selection (McClellan AFB meteorological data with urban dispersion coefficients). Since the most ideal choice of meteorological conditions are not available, the above selections are believed to bracket the most ideal selections.

The effect of building downwash from the buildings in the *Service Area* on the spatial average risk is negligible (less than 1 percent). Including downwash effects due to the dimensions of the locomotives increases the spatial average risk by about 10 percent for the Roseville meteorological data with rural dispersion coefficients in the modeling domain of 4mi x 5mi.

The sensitivity studies are useful to evaluate the effects of uncertainties and variabilities in the model inputs on the estimated downwind concentrations, and subsequently risks. The modeling techniques used to evaluate downwind concentrations of diesel PM emissions are based on the best available information and following OEHHA Risk Assessment guidelines. Where uncertainties arise, sensitivity studies are used to establish a range of possible downwind concentrations. To derive more refined estimates of potential risk, more site-specific data may be used.

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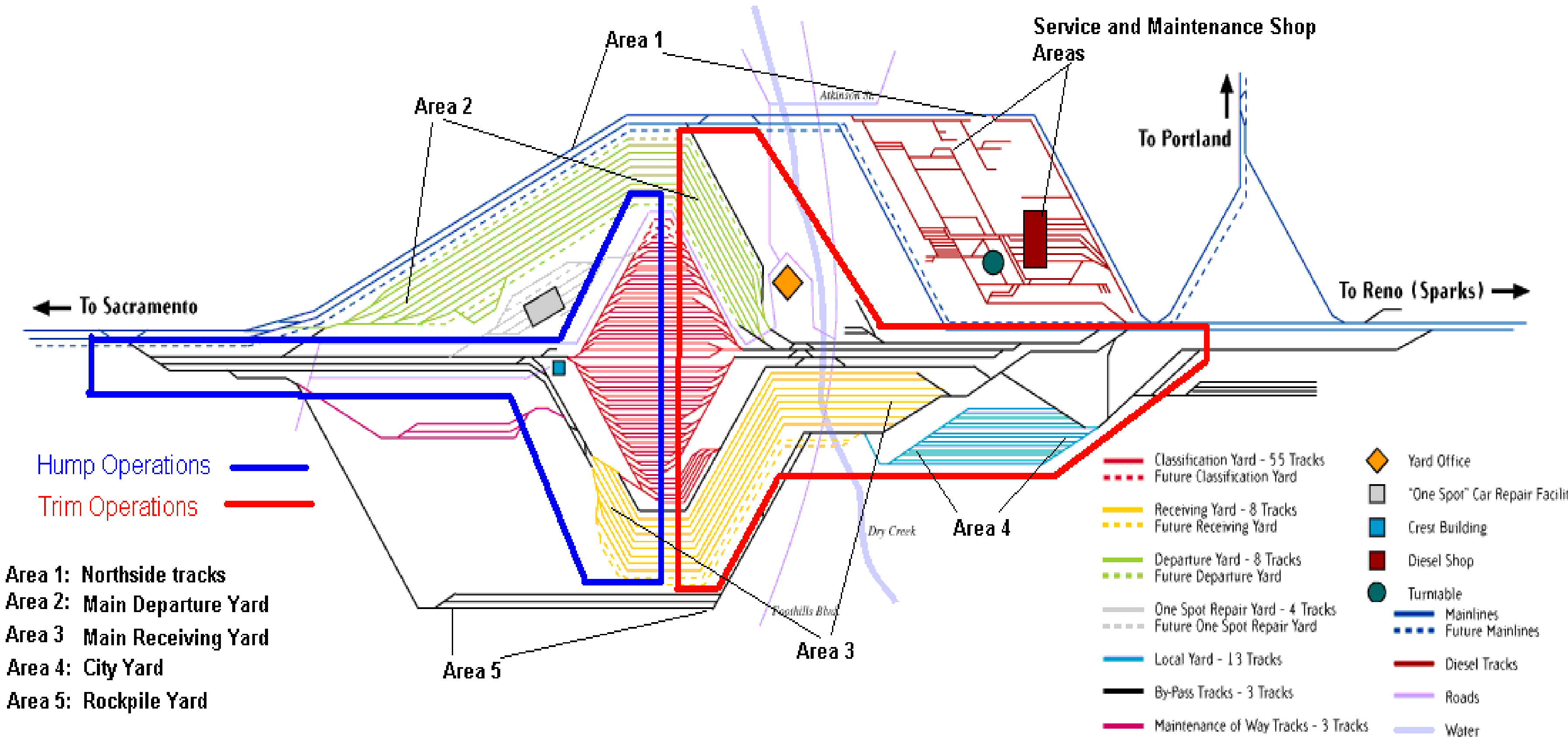
APPENDIX A

J.R. Davis Yard
Schematic of Major Areas of Activity

Schematic of Major Areas of Activity



Major Activities or Areas

Area 1: Movement from/to boundary of Yard to/from Main Receiving Yard, Main Departure yard, City Yard, and Rockpile Yard. Movement on Northside of yard is included in this area.

Area 2: Idling and movement within the Main Receiving and Departure Yards, City Yard, and Rockpile Yard. Idling at the Subway.

Area 3: Idling at Service Tracks, Mod/Search Building, Maintenance shop, and Ready Tracks.

Movements of locomotives from Service Tracks to Mod/Search building to Maintenance shop, or Ready tracks.

Locomotive testing at Service Tracks, Mod/Search building, and Maintenance shop (East and West sides).

Area 4: Hump and Trim Operations – switchers used to move arriving rail cars to reclassification (forming new trains) in Hump and Trim areas, and the movement of these reclassified cars to departure yards. Idling of tradeout locomotive sets during Hump operations.

Area 5: Movement of locomotives from Main Receiving and Departure Yards, City Yard, and Rockpile Yard to either the Subway or Service Area.

Movement of locomotives from Ready Tracks and Subway to Main Departure Yard or City Yard staging area.

APPENDIX B

Diesel Particulate Matter
Emission Factors and Stack Parameters for
Locomotives

Appendix B provides the diesel PM emissions factors and stack parameters for locomotive models observed on trains entering and leaving J.R. Davis Yard in Roseville, California. As discussed in Chapter 4 and Appendix C, 11 different locomotive model classifications were identified based on the diesel engines they used.

The Electro-Motive Division (EMD) of General Motors provided the locomotive engine exhaust gas parameters for the locomotive models. This information was used as inputs for air dispersion modeling, e.g., a g/hr emission factor, stack exit velocities, stack dimensions, stack heights, and stack temperatures.

The following in a brief description of the data presented in the tables contained in Appendix B.

Table B-1: This table presents diesel PM emission factors (EFs) for locomotives and the source of the data. This data was compiled from all available emissions data for locomotives with the majority of the data obtained from U.S. EPA's Locomotive Emission Standards Regulatory Support Document, April 1998. It also identifies additional locomotive model groups that were included in the 11 different locomotive model groups based on similar engine configurations.

Tables B-2 through B-8: These tables contain stack parameters by notch setting for specific EMD locomotive models that were considered in UPRR's locomotive fleet. Approximately 66 percent of UPRR's locomotive fleet are comprised of locomotives manufactured by EMD.

Table B-1: Diesel PM Emission Factors for Locomotives

Model Number	Engine Type		Idle	Dynamic Brake*	Throttle Notches 1	2	3	4	5	6	7	8	DATA REFERENCES
Switchers (1)	EMD 12-645E	g/bhp/hr	2.07	0.80	0.32	0.33	0.31	0.24	0.23	0.28	0.25	0.28	EPA RSD APPENDIX B, 12/17/97
		hp	15	70	72	233	440	669	885	1109	1372	1586	
		g/hr	31	56	23	76	138	159	201	308	345	448	SWITCHERS
GP-60	EMD 16-710G3A	g/bhp/hr	3.18	4.09	0.25	0.31	0.30	0.23	0.21	0.25	0.21	0.23	EPA Locomotive Emissions Regulation
		hp	5.00	23.00	198.00	430.00	975.00	1351.00	1817.00	2637.00	3496.00	4035.00	RSD, Appendix B, 12/17/97
		g/hr	15.90	94.07	49.50	133.30	292.50	310.73	381.57	659.25	734.16	928.05	LINE-HAUL LOCOMOTIVE
SD-70	EMD 16-710G3B	g/bhp/hr	1.67	2.41	0.26	0.23	0.24	0.20	0.19	0.21	0.24	0.25	EMISSIONS MEASUREMENTS -
Table 14, BN# 9457, avg Part #3 (SD70MAC)		hp	10.80	13.90	202.00	435.00	978.00	1514.00	2003.00	2876.00	3640.00	4187.00	LOCOMOTIVES BY STEVEN G. FRITZ
		g/hr	18.00	33.50	52.12	99.62	229.83	298.26	388.58	603.96	880.88	1030.00	FINAL REPORT AUGUST 1995
GP-40 (3)	EMD 16-645-E3	g/bhp/hr	2.82	1.16	0.34	0.34	0.33	0.25	0.23	0.28	0.24	0.26	EPA RSD APPENDIX B
		hp	17	69	105	395	686	1034	1461	1971	2661	3159	LINE-HAUL LOCOMOTIVE
		g/hr	47.94	80.04	35.7	134.3	226.38	258.5	336.03	551.88	638.64	821.34	EMD 16-645-E3
GP-50	EMD 16-645F3B	g/bhp/hr	2.89	1.78	0.25	0.30	0.30	0.23	0.21	0.24	0.21	0.24	EPA RSD APPENDIX B
		hp	9	36	205	475	1005	1353	1876	2766	3454	3866	LINE-HAUL LOCOMOTIVE
		g/hr	26.01	64.08	51.25	142.5	301.5	311.19	393.96	663.84	725.34	927.84	
GP-38 (4)	EMD 16-645E	g/bhp/hr	2.53	0.88	0.32	0.33	0.32	0.24	0.23	0.28	0.26	0.29	EPA RSD APPENDIX B
		hp	15	82	98	333	589	871	1161	1465	1810	2124	LINE-HAUL LOCOMOTIVE
		g/hr	38.00	72.00	31.00	110.00	186.00	212.00	267.00	417.00	463.00	608.00	
GE Dash 9	GE 7 FDL, 16 cylinde	g/bhp/hr											RECEIVED FROM GENERAL
		hp											ELECTRIC (Cert data)
		g/hr	45.872	47.641	59.3804	115.0184	232.4322	253.4752	430.6692	596.216	671.6898	643.2664	Tier 0 DASH 9 (BNSF 5419) & AC 4400
GE Dash 8	GE 7 FDL, 12 or 16	g/bhp/hr	2.48	1.63	0.45	0.32	0.31	0.21	0.16	0.14	0.14	0.15	RECEIVED FROM GENERAL
	cylinder	hp	14.9	90.5	191.2	416.2	940.2	1396	2048.4	2668	3352.9	4100.6	ELECTRIC (Cert data)
		g/hr	36.952	147.515	86.04	133.184	291.462	293.16	327.744	373.52	469.406	615.09	DASH 8 MFI TIER 0
GE Dash 7	GE 7 FDL, 12 cylinde	g/bhp/hr	9.12	5.32	0.67	0.67	0.35	0.45	0.24	0.18	0.18	0.18	EPA RSD APPENDIX B
		hp	25.00	117.00	150.00	300.00	700.00	1050.00	1550.00	2050.00	2600.00	3000.00	LINE-HAUL LOCOMOTIVE
		g/hr	228.00	622.44	100.50	201.00	245.00	472.50	372.00	369.00	468.00	540.00	
C60-A	GE HDL	g/bhp/hr											RECEIVED FROM GENERAL
		hp											ELECTRIC (Cert data)
		g/hr	67.8019	147.869	108.765	168.545	337.9375	305.4352	500.4864	604.6515	713.461	1063.981	TIER 0 AC6000 UP 7555
SD-90MACH	EMD 16V265H	g/bhp/hr											RECEIVED FROM GENERAL MOTORS
		hp											Emissions test data
		g/hr	61.05	108.50	50.10	99.06	255.85	423.70	561.60	329.28	258.15	933.60	EMD

Locomotives Groups
(1) Includes GP15-1, SW1500, MP15, MP15-AC
(2) Includes SD70, SD75, SD70M & SD70MAC
(3) Includes GP40, GP40-2, SD40-2, SD45-2, GP45, P42DC, F40PH
(4) Includes GP38-2, GP38-2L, GP39-2, GP39-2L, GP38-3L, SD38-2
(5) Includes C44-9, C44-9W, C44-AC, C44AC/60AC
(6) Includes B32-8, C39-8, B39-8, B40-8, C40-8, C41-8
(7) Includes B23-7, C30-7, C36-7, B30-7, B36-7, U36B

EMD Engine Exhaust Gas Information

Air intake Temp 90 ^{o}F Barometer 29.4 In Hg

Table B-2

Switcher, Engine: 12-645E, Stack Diameter: 12", 2 Stacks.						
T/N	**Exhaust Flow (cfm)**	**Exhaust (m^3/s)**	**Diameter (m)**	**Exhaust Velocity (m/s)**	**Exhaust Temp (^{o}F)**	**Exhaust Temp (^{o}K)**
8	12225	5.7696	0.3048	39.54	830	716
7	10697	5.0484	0.3048	34.59	747	670
6	8735	4.1225	0.3048	28.25	655	619
5	7293	3.4419	0.3048	23.59	577	576
4	5909	2.7887	0.3048	19.11	499	532
3	4673	2.2054	0.3048	15.11	421	489
2	3353	1.5824	0.3048	10.84	325	436
1	2423	1.1435	0.3048	7.84	222	379
Idle	1742	0.8221	0.3048	5.63	156	342
DB-1	4261	2.0110	0.3048	13.78	214	374

Table B-3

GP-3X, Engine:16-645E, Stack Diameter: 12", 2 Stacks.						
T/N	**Exhaust Flow (cfm)**	**Exhaust (m^3/s)**	**Diameter (m)**	**Exhaust Velocity (m/s)**	**Exhaust Temp (^{o}F)**	**Exhaust Temp (^{o}K)**
8	16580	7.82	0.3048	53.62	820	711
7	14262	6.73	0.3048	46.12	747	670
6	11647	5.50	0.3048	37.67	655	619
5	9724	4.59	0.3048	31.45	577	576
4	7879	3.72	0.3048	25.48	499	532
3	6230	2.94	0.3048	20.15	421	489
2	4470	2.11	0.3048	14.46	325	436
1	3231	1.52	0.3048	10.45	222	379
Idle	2323	1.10	0.3048	7.51	156	342
DB-1	5681	2.68	0.3048	18.37	214	374

Table B-4

GP-4X, Engine: 16-645E3B, Stack Diameter:36" X 15", 1 Stack.						
T/N	**Exhaust Flow (cfm)**	**Exhaust (m^3/s)**	**Diameter (m)**	**Exhaust Velocity (m/s)**	**Exhaust Temp (^{o}F)**	**Exhaust Temp (^{o}K)**
8	19850	9.37	0.666	26.89	730	661
7	16604	7.84	0.666	22.49	728	660
6	13363	6.31	0.666	18.10	650	616
5	11143	5.26	0.666	15.10	592	584
4	8926	4.21	0.666	12.09	522	545
3	7160	3.38	0.666	9.70	448	504
2	5057	2.39	0.666	6.85	353	451
1	3543	1.67	0.666	4.80	233	385
Idle	2752	1.30	0.666	3.73	173	351
DB-1	6985	3.30	0.666	9.46	237	387

EMD Engine Exhaust Gas Information

Air intake Temp 90 ^oF Barometer 29.4 In Hg

Table B-5

GP-5X, Engine: 16-645F3B, Stack Diameter: 36" X 15", 1 Stack.

T/N	Exhaust Flow (cfm)	Exhaust (m^3/s)	Diameter (m)	Exhaust Velocity (m/s)	Exhaust Temp (^oF)	Exhaust Temp (^oK)
8	23851	11.26	0.666	32.31	634	607
7	20977	9.90	0.666	28.42	759	677
6	15293	7.22	0.666	20.72	767	681
5	12520	5.91	0.666	16.96	641	611
4	9306	4.39	0.666	12.61	552	562
3	6998	3.30	0.666	9.48	450	505
2	5110	2.41	0.666	6.92	382	467
1	3716	1.75	0.666	5.03	317	431
Idle	2446	1.15	0.666	3.31	174	352
DB-1	5517	2.60	0.666	7.47	197	365

Table B-6

GP-6X, Engine: 16-710G3A, Stack Diameter: 34" X 14", 1 Stack.

T/N	Exhaust Flow (cfm)	Exhaust (m^3/s)	Diameter (m)	Exhaust Velocity (m/s)	Exhaust Temp (^oF)	Exhaust Temp (^oK)
8	22867	10.79	0.6253	35.14	645	614
7	19818	9.35	0.6253	30.46	678	632
6	16212	7.65	0.6253	24.91	740	666
5	11442	5.40	0.6253	17.58	650	616
4	11206	5.29	0.6253	17.22	565	569
3	8501	4.01	0.6253	13.06	495	530
2	6498	3.07	0.6253	9.99	348	449
1	5165	2.44	0.6253	7.94	275	408
Idle	2036	0.96	0.6253	3.13	192	362
DB-1	2281	1.08	0.6253	3.51	204	369

Table B-7

SD-70, Engine: 16-710G3B, Stack Diameter: 34" X 14", 1 Stack.

T/N	Exhaust Flow (cfm)	Exhaust (m^3/s)	Diameter (m)	Exhaust Velocity (m/s)	Exhaust Temp (^oF)	Exhaust Temp (^oK)
8	23807	11.24	0.6253	36.59	600	589
7	21525	10.16	0.6253	33.08	670	627
6	16565	7.82	0.6253	25.46	710	650
5	14822	7.00	0.6253	22.78	695	641
4	11726	5.53	0.6253	18.02	630	605
3	8838	4.17	0.6253	13.58	550	561
2	6647	3.14	0.6253	10.22	371	461
1	5171	2.44	0.6253	7.95	296	420
Idle	1995	0.94	0.6253	3.07	195	364
DB-1	2224	1.05	0.6253	3.42	205	369

EMD Engine Exhaust Gas Information

Air intake Temp 90 °F Barometer 29.4 In Hg

Table B-8

SD-90, Engine: 16V265H, Stack Diameter: 36" X 15", 2 Stack.						
	Exhaust	**Exhaust**	**Diameter**	**Exhaust Velocity**	**Exhaust**	**Exhaust Temp**
T/N	**Flow (cfm)**	**(m^3/s)**	**(m)**	**(m/s)**	**Temp (°F)**	**(°K)**
8	35511	16.76	0.666	24.05	840	722
7	29605	13.97	0.666	20.05	900	755
6	23710	11.19	0.666	16.06	1054	841
5	19049	8.99	0.666	12.90	1050	839
4	12705	6.00	0.666	8.61	1050	839
3	9523	4.49	0.666	6.45	840	722
2	5337	2.52	0.666	3.62	760	677
1	3538	1.67	0.666	2.40	670	627
Idle	2441	1.15	0.666	1.65	530	550
DB-1					620	600

APPENDIX C

Train and Locomotive Activity and Assumptions

(Note: Union Pacific Rail Road representatives reviewed a draft version of Appendix C and indicated that several data points are considered confidential. Throughout this appendix, the confidential data has been redacted and is replaced with XXXX.)

Appendix C provides detailed information on the assumptions used for train and locomotive activity. The majority of the train and locomotive data was provided by UPRR. UPRR provided detailed information for working trains terminating, originating, and passing through J.R. Davis Yard for the period between December 1999 and November 2000. The second week of each month (seven consecutive days of operation) was chosen to avoid including any unrepresentative peaks in activity resulting from holidays that occur at the beginning and end of months.

UPRR also provided estimates of spatial and temporal distributions for arrival and departure trains for the major areas of activity in the Yard. Assumptions for locomotive idling and movements in the Yard were developed based on additional information provided by UPRR and discussions with the Director of Yard Operations and the Managers of the Service Tracks and Maintenance Shop. This information allowed us to determine:

- Paths of arrival and departure trains, as well as, locomotive movements through the Yard.
- The distribution of trains by month and hour of the day for the major areas of the Yard.
- Notch position (throttle settings), time spent in each notch, estimated speed or time spent for each activity, and movements of different types of trains or locomotives along different segments of track.
- The fractions of locomotives from each of eleven the locomotive model groups.
- The average numbers of locomotives per consist assigned to trains.

Train activity can vary from year-to-year, seasonally, and day-to-day due to a variety of factors and there is no guarantee that the patterns observed in the data used for the exposure assessment will recur in future years. However, staff believe the total arrival and departure train activity, their spatial and temporal distributions, and the resultant calculations of diesel PM emissions represent the current "best estimates" of train or locomotive activities at the Yard available for the exposure assessment.

Train Activity by Location and Direction

UPRR provided detailed information on the trains arriving and departing the J.R. Davis Yard for the12-month period from December 1999 through November 2000. As mentioned previously, the second week of each month was selected to represent the trains for each month and to avoid peak periods. UPRR extrapolated the data to represent an entire 1-year period.

According to UPRR, during the period between December 1999 and November 2000 they collected data for 1,453 individual trains and model information for 5,551 locomotives. The data for each of the trains were tabulated to provide:

- aggregate annual activity estimates (trains per year) for the different types of train activity (arrivals, departures, and through trains), directions, and locations within the yard;
- the fraction of total activity occurring in each month, and during each hour of the day; and
- the fleet composition (fraction of locomotives by model number) in use by different types of trains (based on the portion of the yard they pass through). (Add Reference)

In Table C-1 below, the aggregate annual activity estimates for the different types of train activity or train for the major areas of activity in the Yard by location and direction are shown. There are three types of train events – arriving at the yard, passing through the yard, and departing the yard. The total number of "through trains" also includes AMTRAK and Burlington Northern Santa Fe train activity. The number of train events does not equal the number of locomotives.

<u>Determination of the Number and Model of Locomotives by Location</u>

Trains using different portions of the J.R. Davis Yard have different types of load and destinations. As a result, the distributions of different locomotive models as well as the number of locomotives pulling each train are different. Multiple locomotives or power units that are connected to pull a train are referred to as consists. Typically two locomotives per consist are used for local and work trains and three locomotives per consist are used for long-haul trains. During the survey period, UPRR counted the number of locomotives by model number for each of the following areas. The *Northside tracks* (primarily through freight and passenger); the *Main Receiving Yard* and *Main Departure Yard* (primarily high horsepower, long-haul freight); and the *City Yard* and *Rockpile Yard* (lower horsepower, local, and UPRR work trains).

Table C-2 below presents an estimated average number of working locomotives per train. As is shown, the typical train has about 3 locomotives per consist. The information in Table C-2 was estimated by UPRR from the total number of working locomotives arriving or departing from an area, divided by the total number of trains arriving or departing from the area. These numbers represent an annual average. On occasion, there may be a greater number of locomotives per train. This is due to the movement of "power" from one location to another due to seasonal variation in shipping or equipment breakdown.

<u>Locomotive Fleet Composition</u>

There are a wide variety of locomotive models in the in-use locomotive fleet. These models can be grouped in eleven classifications with locomotive models within each classification having similar engine configurations. Table C-3 below identifies the eleven locomotive model classifications representative of UPRR's locomotive inventory for the J.R. Davis Yard.

TRAIN AND LOCOMOTIVE DISTRIBUTIONS

Table C - 1	Train Activity by Location and Direction				
Trains Direction/Event	Number of Trains in Each Area December 1999 through November 2000*				
	Northside	Main Receiving	Main Departure	City Yard	Rockpile
EB Arrivals	XXXX	XXXX	XXXX	XXXX	XXXX
EB Departures	XXXX	XXXX	XXXX	XXXX	XXXX
EB Through	XXXX	XXXX	XXXX	XXXX	XXXX
WB Arrivals	XXXX	XXXX	XXXX	XXXX	XXXX
WB Departures	XXXX	XXXX	XXXX	XXXX	XXXX
WB Through	XXXX	XXXX	XXXX	XXXX	XXXX
Totals	XXXX	XXXX	XXXX	XXXX	XXXX

*Numbers may not add up due to rounding

Table C - 2	Average Number of Locomotives per Train		
	Location		
	Northside	Main Receiving & Departure Yards	City Yard & Rockpile
Locomotives per train	2.68	3.05	3.01

Table C - 3	Classification of Locomotive Models at J.R. Davis Yard	
Model Classification*	Engine Type	Locomotive Models Included in Classification
Switchers	EMD 12-645E	GP-15, SW1500, MP15AC
GP- 3x	EMD 16-645E	GP-30, GP-39
GP- 4x	EMD 16-645E3B	GP-40, GP-45, P42DC, F40PH
GP-50	EMD 16-645F3B	
GP-60	EMD 16-710G3A	
SD- 7x	EMD 16-710G3B	SD- 70, SD-75, SD70M, SD70MAC
SD-90	EMD 16V265H	
Dash-7	GE 7FDL, 12 cyl.	C36-7, B36-7, B30-7, B23-7, U36B
Dash-8	GE 7FDL, 12 or 16	C41-8, C39-8, B40-8, B39-8, B32-8
Dash-9	GE 7FDL, 16 cyl.	C44-9
C60-A (AC 6000)	GE 7HDL	

*EMD GP & SD series models using the same engines are listed with an "x" identifying multiple model numbers within the group

Monthly and Hourly Distribution of Trains

The data provided by UPRR were analyzed to determine the monthly temporal distribution (i.e. the fraction of annual total activity occurring in a month) and the hourly distribution (i.e., the fraction of daily total activity occurring during a specific hour) of the trains passing through the Yard. Figure C-1 and Table C-4 present the percent distribution of trains in each month by location in the Yard. The percentages represent the fraction of the annual totals, which were calculated by dividing the one-week data set for each month by the total number of trains in the twelve-week data set. The month to month variation was not very significant. In most cases, the variation between months was less than 5 percent at all locations.

Figure C-2 and Table C-5 present the distribution of trains by the hour of the day. These activities were calculated by dividing the number of trains arriving or departing during any given hour by the total number of trains. Similar to the month to month variation, the distribution of trains by the hour of the day did not vary significantly. Overall, the hour to hour variation in activity was less than 5 percent. The peaks in train activity during the hours of 5:00 a.m. and 8:00 a.m. reflect increases in Northside “through train” activity, and UPRR crew changes. The peaks in train activity during the hours of 9:00 a.m. and 10:00 a.m. reflect Maintenance of Way work trains, locals, and industry trains that have scheduled start times. UPRR has a Transportation Plan that is adhered to for day-to-day operations and peak times for scheduled trains.

Figure C - 1: Monthly Distributions of Trains by the Month

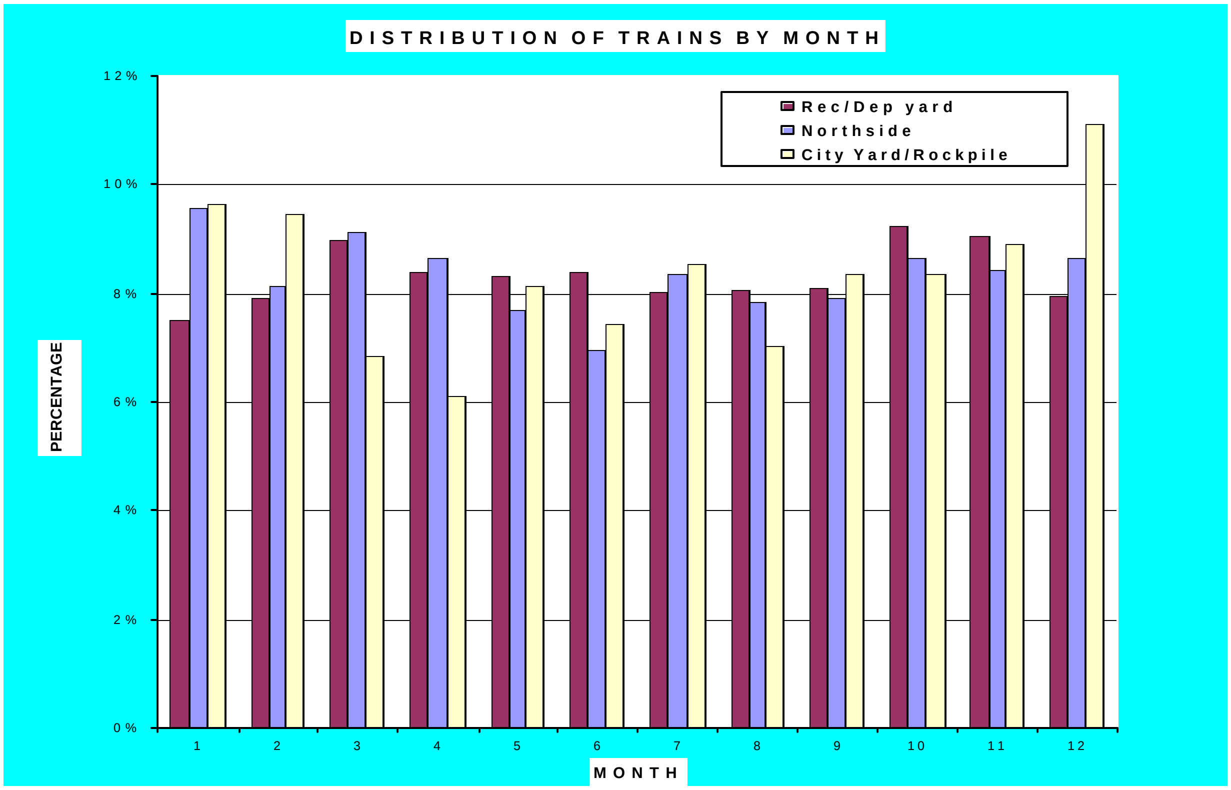


Table C - 1: Distribution of Trains by Month			
Month	Northside	Main Receiving & Departure Yards	City Yard Rock pile
January	9.56%	7.54%	9.65%
February	8.14%	7.92%	9.46%
March	9.11%	8.99%	6.86%
April	8.66%	8.41%	6.12%
May	7.69%	8.31%	8.16%
June	6.95%	8.41%	7.42%
July	8.36%	8.01%	8.53%
August	7.84%	8.04%	7.05%
September	7.92%	8.11%	8.35%
October	8.66%	9.26%	8.35%
November	8.44%	9.04%	8.91%
December	8.66%	7.94%	11.13%
Total	100.00%	100.00%	100.00%

Figure C - 2: Hourly Distribution of Trains at the J.R. Davis Yard

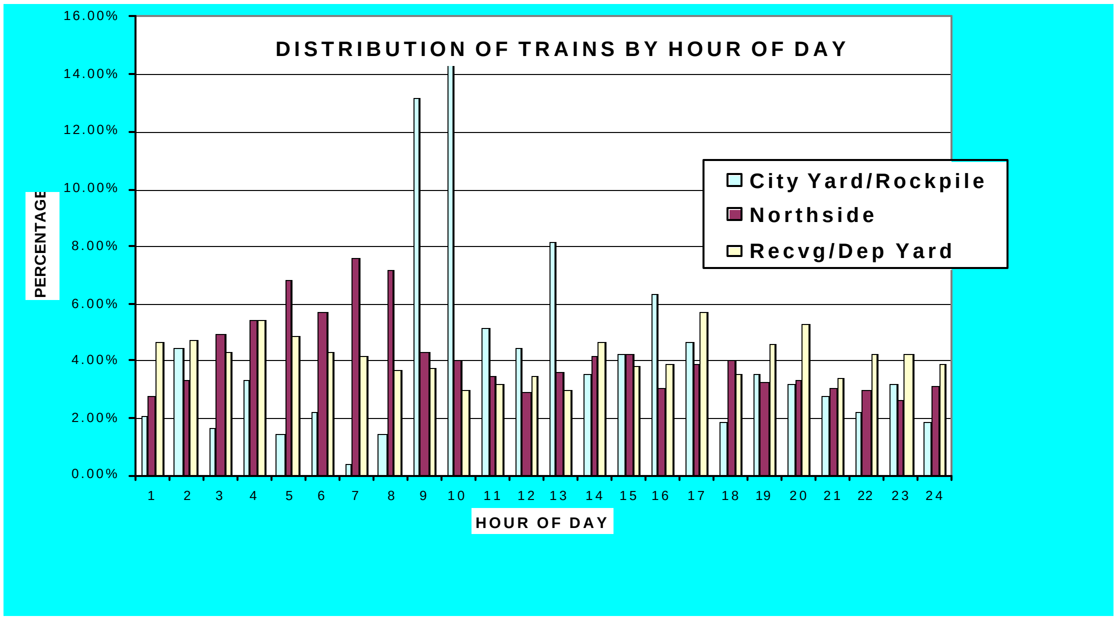


Table C - 5: Distribution of Trains by Hour of Day

Hour	Northside	Main Receiving and Departure Yards	City Yard Rock pile
1	2.73%	4.67%	2.04%
2	3.36%	4.72%	4.45%
3	4.93%	4.29%	1.67%
4	5.45%	5.44%	3.34%
5	6.83%	4.87%	1.48%
6	5.68%	4.34%	2.23%
7	7.62%	4.19%	0.37%
8	7.17%	3.67%	1.48%
9	4.33%	3.77%	13.17%
10	4.00%	3.02%	14.66%
11	3.47%	3.20%	5.19%
12	2.95%	3.52%	4.45%
13	3.58%	3.02%	8.16%
14	4.14%	4.67%	3.53%
15	4.26%	3.82%	4.27%
16	3.10%	3.87%	6.31%
17	3.92%	5.69%	4.64%
18	4.00%	3.55%	1.86%
19	3.29%	4.62%	3.53%
20	3.32%	5.27%	3.15%
21	3.10%	3.42%	2.78%
22	3.02%	4.24%	2.23%
23	2.61%	4.22%	3.15%
24	3.14%	3.90%	1.86%
Total	100.00%	100.00%	100.00%

As mentioned previously, during the survey period, UPRR recorded locomotive model number for locomotives in each of the three major areas of the yard by month and hour to allow determination of the fleet composition for each area, as well as to determine the monthly temporal and hourly distribution. Figure C-3 and Table C-6 present the percent distribution of locomotives by model group and location of arrival and departure trains. The most common locomotive classifications passing through the Yard are the GP-4X, Dash-8, GP-60, and Dash-9.

Figure C - 3: Distribution of Locomotives at the J.R. Davis Yard

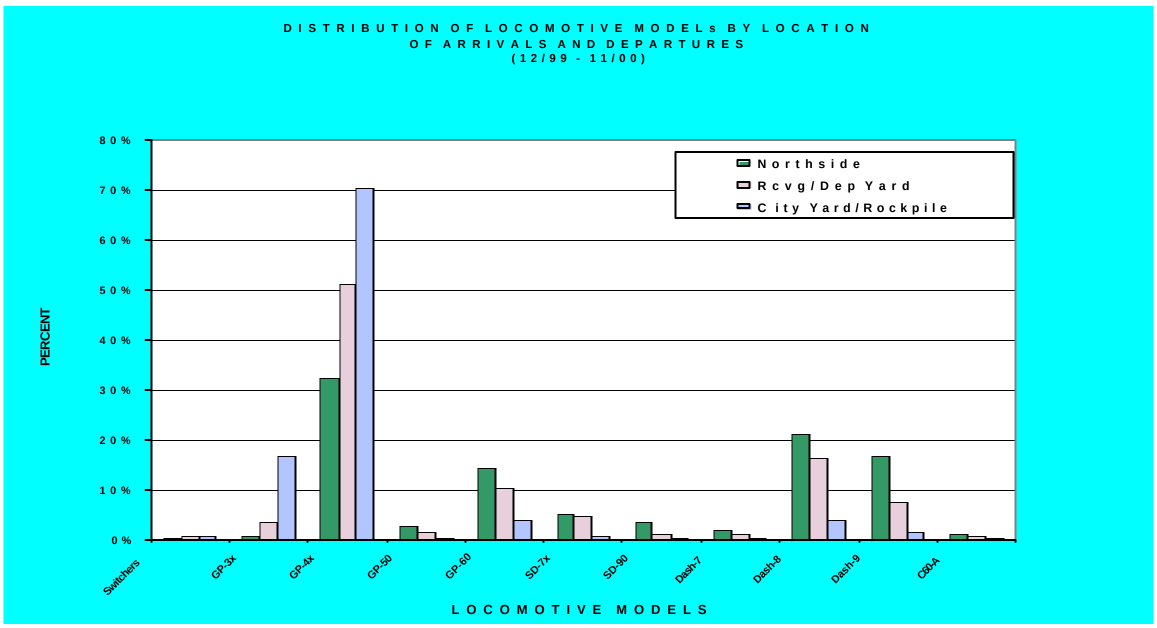
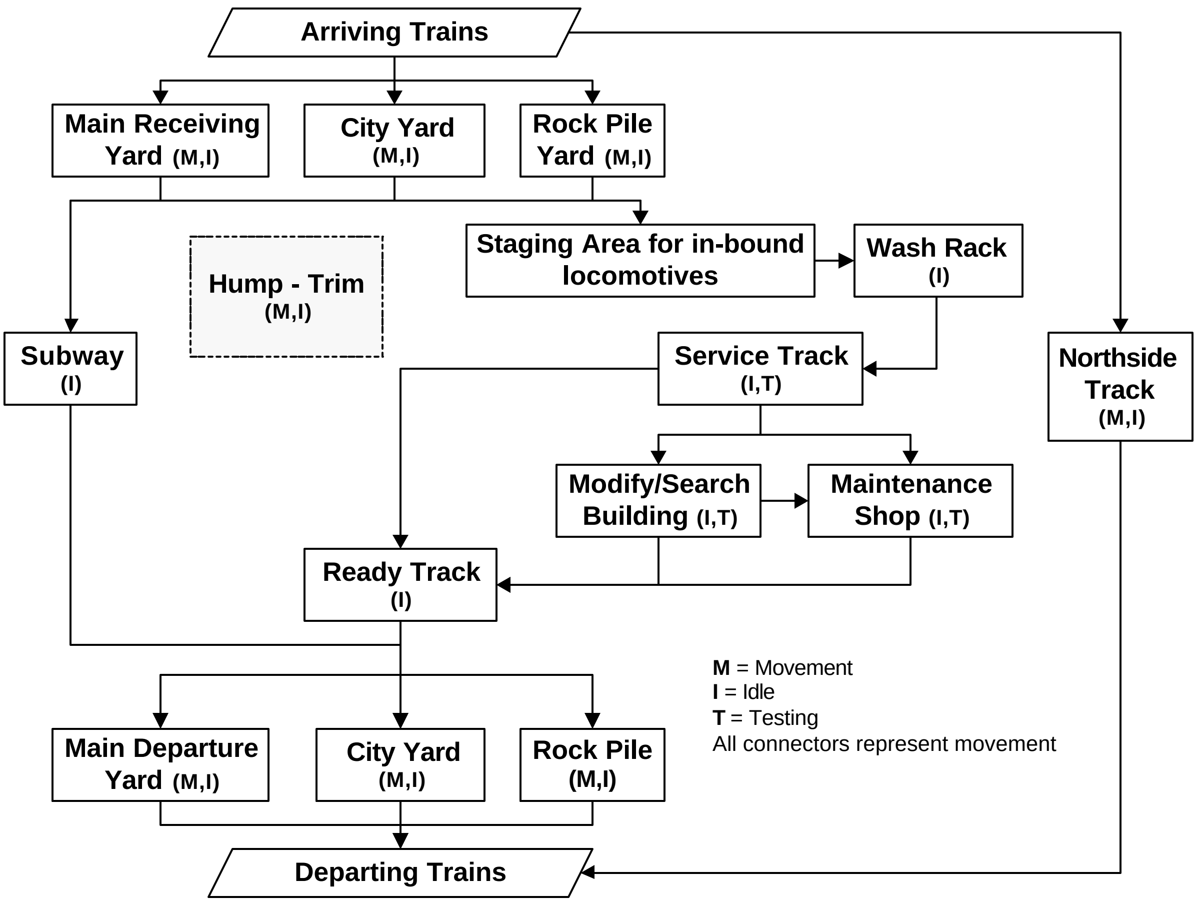


Table C - 6

Distribution of Locomotives by Model Group			
Arrival/Departure(12/99 – 11/00)			
Locomotive Class	Northside	Main Receiving and Departure Yards	City Yard Rock pile
Switchers	0.22%	0.89%	0.99%
GP-3x	0.70%	3.55%	16.81%
GP-4x	32.58%	51.40%	70.35%
GP-50	2.67%	1.59%	0.53%
GP-60	14.27%	10.47%	4.04%
SD-7x	5.00%	4.99%	0.73%
SD-90	3.54%	1.27%	0.20%
Dash-7	1.88%	1.29%	0.53%
Dash-8	20.98%	16.22%	4.10%
Dash-9	16.96%	7.54%	1.59%
C60-A	1.21%	0.78%	0.13%
Total	100.00%	100.00%	100.00%

Figure C-4 presents a generalized schematic of the train and locomotive acitivites in the major areas of the Yard. In the following sets of tables, the key activity assumptions for each area are presented.

Figure C – 4: Schematic of Train and Locomotive Paths Within J.R. Davis Yard



Summary of Locomotive Activities in Each Area

The following are brief summaries of the activities in each area identified in Figure C-4 and the key assumptions used in the development of the emissions inventory.

Main Receiving Yard, Rockpile Yard, City Yard

There are three receiving yards at the J.R. Davis Yard. The *Main Receiving Yard* which handles long haul trains and the *City Yard* and the *Rockpile Yard* which each handle short haul trains. In the receiving yards, the locomotives are disconnected from the railcars. Locomotives can spend between ½ to 1 hour in the receiving yards. While in the receiving yards, locomotives can either be idling or moving. During movement, the pulling locomotive is in either notch 1 or notch 2. In the receiving Yard, locomotives can also reach notch 3. *The Main Receiving Yard* only receives incoming trains whereas the *Rockpile Yard* and *City Yard* are used as both receiving and departure yards. It was assumed approximately 31,000 locomotives enter the Yard.

Subway

The *Subway* is used for rapid turn-around fueling when full routine service is not required. The maximum service time at the *Subway* is two hours. During the time spent in the *Subway* locomotives are idling. It was assumed XXXX locomotives are serviced each month at the *Subway*.

Staging Area

All locomotives needing routine or unplanned service or maintenance arrive at the *Staging Area*. This is the area prior to entering the *Wash Rack* (service tracks). Locomotives may idle in this area for up to 1 hour. It was assumed approximately XXXX locomotives annually enter this area.

The area comprised of the *Service Tracks*, *Mod/Search Building*, and the *Maintenance Shop* are often referred to as the "Service Area." This is the area in the Yard where the majority of the maintenance and servicing of locomotives takes place. Briefly, the activities in these areas include:

Service Tracks

The *Service Tracks* are located approximately 500 feet north of the *Wash Rack*. In this area, routine service and fueling is provided. Some quarterly maintenance, other periodic maintenance and minor repair work may also occur here. Emissions in this area are from locomotives idling and pre or post service testing. Time spent in the *Service Tracks* area depends on the service performed and may range from two to six hours. For locomotive servicing that takes longer than 24 hours the locomotives are sent to the Mod/Search building or Maintenance shop. It was assumed that approximately XXXX locomotives (out of the XXXX locomotives) are serviced in this area prior to moving to the *Ready Tracks* for consisting. The remaining locomotives move to the *Mod/Search Building* or the *Maintenance Shop* for service or repair that takes longer than 24 hours.

Mod/Search Building/Maintenance Shop

Listed below are the primary locations where locomotives are typically serviced, prior to Shop release. Emissions in these areas are from locomotives idling and pre or post service testing. It was assumed that approximately XXXX to XXXX locomotives are serviced in these areas.

- The *Mod/Search Building*: Unscheduled maintenance, testing, and, if possible, repaired. Locomotives requiring major repairs are usually taken to the Shop for these repairs and any subsequent load testing. We assumed approximately 25 percent of the total are serviced in this area.

- The *Maintenance Shop*: The remaining 75 percent are serviced in this area.
    - East End – Planned maintenance or major unscheduled repairs. Pre-testing and load testing occurs here.
    - West End – Testing of locomotives after completing shop maintenance prior to release.

Five types of testing events were identified by UPRR. One or more test events may be associated with a single locomotive servicing.

- Planned Maintenance Pretests. This test is typically performed before semiannual, annual, biennial, and triennial maintenance and inspections.
- Planned Maintenance Load Tests. This is a standard load test following semiannual, annual, biennial, and triennial maintenance.
- Quarterly Maintenance Tests. This is a brief test (average duration – 10 minutes) following quarterly maintenance. Pre-maintenance testing is not required for quarterly maintenance.
- Unscheduled Maintenance Diagnostic Testing. Locomotives brought in for unscheduled maintenance typically undergo a brief diagnostic test prior to servicing.
- Unscheduled Maintenance Load Tests. Unscheduled maintenance commonly does not require any testing following service if the diagnostic testing identifies the nature and cause of a problem whose repair can be verified without additional testing. If not, a standard 30-minute load test is conducted following repair.

According to standard service practices post-maintenance load testing (e.g., quarterly 10-minute or 30-minute testing following planned or unscheduled service) is the final step prior to releasing a locomotive from the shop areas. A review of the available data showed that increased numbers of locomotive were released toward the ends of shifts. Therefore, it was reasonable to assume that post-maintenance testing is not uniform throughout the day and occurs during the hour a locomotive is released.

No data was available to identify the time of day for pre-service testing events. However, service personnel estimated that these events occur uniformly throughout the day. Thus, 1/24 of 4.2 percent of those test activities can be assumed to occur in each hour of the day.

While some variation was seen in monthly locomotive releases and testing totals, no seasonally dependent pattern was expected. Therefore, on the average daily releases and testing estimates were assumed to be 1/365 of annual totals.

Ready Tracks

Once locomotives are released from the *Service Area* they will move to the *Ready Tracks* for consisting. The newly formed consists will then move to the *Main Departure Yard*, *City Yard*, or *Rockpile Yard*. Locomotives may spend 2-3 hours idling in the

Ready Tracks area. It was assumed that approximately XXXX locomotives are annually consisted.

Main Departure Yard, City Yard, and Rockpile Yard

The total horsepower of locomotives are matched to trainload in the *Ready Tracks* area, i.e., consisting. The consist moves to a departure yard to connect to railcars. The newly formed train idles in their respective yard until departure to yard boundary (Antelope Rd on the west, and Linden Street-Marysville "Y" on the east). It was assumed that approximately 31,100 working locomotives annually depart from the Yard.

Hump and Trim

The Hump Operations have three sets of locomotives, two working and one trade-out set. However, only one set is actually working at any given time. The other working set is kept at the west-end of the *Main Receiving Yard*, which is either idling or turned-off. The Trim Operations have five sets of locomotives, three working and two trade-out sets. The tradeout sets for both operations are kept at the *Service tracks*, and they are either idling or turned-off.

Locomotive Movements

There are several areas within the Yard where locomotives are moving at various notch settings. These are briefly described below.

Movement from/to Yard Boundaries to/from Receiving/Departure Yards:

Departing trains accelerate from a stop to a maximum speed of 15 mph from main departure tracks, with maximum speed in notch 3. Departures from the *City Yard* and *Rockpile Yard* travel at a maximum speed of 5 mph until reaching yard boundary, with a maximum speed in notch 2.

Arrival trains entering the Yard are either moving or enter from a stop position. Trains are stopped prior to entering the Yard for traffic control purposes. The maximum speed and notch setting are the same as for departing trains.

Movements within the Yard:

There are several areas in the Yard where one locomotive of each consist is on and pulling in notch setting of 1 or 2 and the other locomotives are either idling or off. These include:

Movements from the arrival yards to *Staging Area* (*Service Tracks)* or *Subway* and from these areas to departure yards.

Movements in *Service Area*: Movement occurs from *Staging Area* to *Wash Rack*, wash to servicing, *Service Tracks* to *Ready Tracks* (for consisting), *Ready Tracks* to departure yards.

Movements in *Maintenance Shop* Areas: Movement from *Service Tracks* to the *Mod/Search Building* or the *Maintenance Shop*. Shop releases, from either of these locations go directly to the *Ready Tracks* for consisting. Consists leave the *Ready Tracks* to departure yards.

Northside Tracks

The train traffic on the Northside is controlled out of UPRR's Omaha office. These trains either stop for crew changes or pass through, e.g., AMTRAK. The maximum speed limit for the Northside is 40 mph, which can be reached in notch 5 or notch 6.

A brief summary of each of the following tables that describe the key activity assumptions is presented below. A general assumption was applied throughout our work regarding distance traveled in a specific notch setting. We divided the distance traveled equally by the number of notch settings engaged to travel that distance.

Table C - 7: This table presents estimated average train speeds, notch settings, and distance traveled for arrival and departure trains by location and direction to/from the Yard boundary. The total distance column represents the distance traveled from Yard boundary (depending on whether it is an eastbound or westbound arrival or departure train) to or from a receiving or departing yard. We assumed locomotives on arrival trains idled for 0.5 hours in their respective arrival locations prior to disconnecting from a train; and, the locomotive consists idled for 2.0 hours prior to leaving their respective departure locations.

Table C - 8: This table presents the track length, train speed and distance traveled in each notch setting for each location listed.

Tables C – 9 and C - 10: These tables present the assumed idling times in the identified areas for all locomotives passing through the Yard. Crew changes only occur on the *Northside Tracks*, and result in an arrival and departure event. The in-bound locomotive area, identified in Figure D-4, is the pre-service staging area for locomotives.

Tables C – 11 and C - 12: These tables present the assumed times for locomotive consists to travel from one location to another within the Yard.

TABLE C-7: TRAIN AND LOCOMOTIVE ACTIVITY								
	***TOTAL DISTANCE (m/mi)**	**RW IDLING TIME (hr)**	**ESTIMATED AVERAGE SPEED (MPH) PER NOTCH SETTING**					
			TN-1	**TN-2**	**TN-3**	**TN-4**	**TN-5**	**TN-6**
CITY YARD								
EB DEPARTURES	636/0.4	2.00	5.00	5.00				
WB ARRIVALS	636/0.4	0.50	5.00	5.00				
DISTANCE IN NOTCH	miles		0.21	0.21				
CITY YARD								
WB DEPARTURES	4018/2.5	2.00	5.00	5.00				
EB ARRIVALS	4018/2.5	0.50	5.00	5.00				
DISTANCE IN NOTCH	miles		1.25	1.25				
RECEIVING YARD								
EB ARRIVALS	1787/1.11	0.50	6.00	12.00	15.00			
DISTANCE IN NOTCH	miles		0.37	0.37	0.37			
WB ARRIVALS	1364/0.85	0.50	6.00	12.00	15.00			
DISTANCE IN NOTCH	miles		0.28	0.28	0.28			
DEPARTURE YARD								
EB DEPARTURES	2645/1.64	2.00	6.00	12.00	15.00			
DISTANCE IN NOTCH	miles		0.55	0.55	0.55			
WB DEPARTURES	751/0.47	2.00	6.00	12.00	15.00			
DISTANCE IN NOTCH	miles		0.16	0.16	0.16			
NORTHSIDE								
EB DEPARTURES	3437/2.14	0.25	6.00	12.00	15.00			
WB ARRIVALS	3437/2.14	0.25	6.00	12.00	15.00			
DISTANCE IN NOTCH	miles		0.71	0.71	0.71			
NORTHSIDE								
EB ARRIVALS	2445/1.52	0.25	6.00	12.00	15.00			
WB DEPARTURES		0.25	6.00	12.00	15.00			
DISTANCE IN NOTCH	miles		0.51	0.51	0.51			
NORTHSIDE								
THROUGHS	5882/3.66					20.00	30.00	40.00
DISTANCE IN NOTCH	miles					1.00	1.33	1.33

*Distance is measured from boundary of each area to the boundary of the yard (by direction), i.e., City yard EB distance is from EB of that area to the eastern most portion (boundary) of the yard. This distance is the same for an EB departure and a WB arrival.

TABLE C-7, CON'T: TRAIN AND LOCOMOTIVE ACTIVITY								
	TOTAL DISTANCE (m/mi)	**IDLING TIME (hr)**	**ESTIMATED AVERAGE SPEED (MPH) PER NOTCH SETTING**					
			TN-1	**TN-2**	**TN-3**	**TN-4**	**TN-5**	**TN-6**
ROCKPILE	3368/2.09							
EB DEPARTURES		2.00	5.00	5.00				
WB ARRIVALS		0.50	5.00	5.00				
DISTANCE IN NOTCH	miles		1.05	1.05				
ROCKPILE	645/0.4							
WB DEPARTURES		2.00	5.00	5.00				
EB ARRIVALS		0.50	5.00	5.00				
DISTANCE IN NOTCH	miles		0.20	0.20				

Formula: Notch Emission Rate (g/s) X DISTANCE (mi) X 3600 (sec/hr)/SPEED OF TRAIN (mph) = grams

TABLE C-8: WORK AREA DIMENSIONS (TRACK DISTANCE)			Distance		Miles/Hour	
		Meters/Miles	TN-1	TN-2	TN-1	TN-2
	DEPARTURE TRACK	3081/1.91	0.96	0.96	6	12
	RECEIVING TRACK	2185 / 1.36	0.68	0.68	6	12
	CITY YARD	1035/0.64	0.32	0.32	5	5
	ROCKPILE	2518/1.56	0.78	0.78	5	5

TABLE C-9 LOCOMOTIVE ACTIVITY				
	DURATION OF IDLING (s)			
LOCATION	**EB Arrivals**	**WB Arrivals**	**EB Departures**	**WB Departures**
(1) DEPARTURE TRACKS			7200.00	7200.00
RECEIVING TRACKS	1800.00	1800.00		
CITY YARD	1800.00	1800.00	7200.00	7200.00
ROCKPILE	1800.00	1800.00	7200.00	7200.00
(2) NORTHSIDE	900.00	900.00	900.00	900.00

Assumption 1: Idling times greater than 1 hour (3600 secs) are combined emissions from two sequential, 1-hr. times.
Assumption 2: A crew change take 30 minutes. Therefore, 15 mins. Idling for arrivals and 15 mins. Idlig for departures (900 s)

Conversion table	
secs	minutes
600	10
900	15
1800	30
2700	45
3600	60
7200	120

TABLE C-10 LOCOMOTIVE ACTIVITY	
LOCATION	**IDLING (s)**
(3) SUBWAY	7200.00
IN-BOUND LOCOMOTIVES	
(4) WASH RACKS	3600.00
(3) SERVICE TRACKS	7200.00
READY TRACKS	7200.00
MOD/SEARCH BUILDING	7200.00
WESTSIDE DIESEL SHOP	3600.00
EASTSIDE DIESEL SHOP	7200.00

Assumption 3: Idling times greater than 1 hour (3600 secs) are combined emissions from two sequential, 1-hr. times.
Assumption 4: Idling emissions of the in-bound area include the idling emissions that occur at the Wash Racks.

TABLE C-11: LOCOMOTIVE MOVEMENT			TIME (secs)	
LOCATION	to/from	LOCATION	EB	WB
RECEIVING TRACKS	to	IN-BOUND LOCO AREA	1800.00	2700
	to	SUBWAY	1800.00	2700
CITY YARD	to	IN-BOUND LOCO AREA	1800.00	2700
ROCKPILE	to	IN-BOUND LOCO AREA	2700.00	3600
SUBWAY	to/from	CITY YARD	1800	2700
	to/from	ROCKPILE	2700	3600
	to	DEPARTURE YARD	1800	3600
READY TRACKS	to	DEPARTURE YARD	1800	2700
	to	CITY YARD	1800	2700
	to	ROCKPILE	2700	3600

Formula: Notch Emission Rate (g/s) X Time in Notch (sec) = grams

TABLE C-12: LOCOMOTIVE MOVEMENT			
LOCATION	to/from	LOCATION	TIME (secs)
IN-BOUND LOCO AREA	to	WASH RACK	300.00
WASH RACK	to	SERVICE TRACKS	300.00
SERVICE TRACKS	to	MODSEARCH BUILDINGS	900.00
	to	READY TRACKS	300.00
MODSEARCH BUILDINGS	to	EAST-SIDE, MAINT SHOP	1800.00
	to	READY TRACKS	600
WEST-SIDE, MAINT SHOP	to	READY TRACKS	600

ASSUMPTIONS FOR TRAIN AND LOCOMOTIVE MOVEMENTS THROUGH THE YARD

The UPRR provided the initial estimates of the number of train events per year for arrival, departure, and through trains at J.R. Davis Yard. As previously stated, a representative data set was developed from obtaining seven consecutive days of operation for each month for the period between December 1999 and November 2000. The number of total arrival train events per year by location and direction are listed in table C-1, and the number of locomotives per train event were calculated based on the information provided in table C-2.

Subway: It was assumed, based on discussions with UPRR management at the Yard that on the average XXXX locomotives per month are processed through the Subway.

Service Tracks: The initial locomotive service and shop release data provided by UPRR was taken from data analyzed from November 1, 1999 through October 31, 2000. For this period of the database it was estimated that XXXX locomotives were released from the Shop. However, after further discussion with UPRR management at the Yard it was determined that on the average XXXX locomotives are released per month from the Service Tracks and Shop areas. Based on this additional information, we increased the number of releases from these areas to XXXX locomotives for a given year. We assumed the additional XXXX locomotives were non-working locomotives being transported to the Yard for maintenance and repair. UPRR classifies these locomotives as dead in consists or DICs.

Mod/Search Building and Maintenance Shop: The XXXX locomotives were assumed to be serviced in the following manner: 25 percent of this total, i.e., XXXX locomotives, are serviced at the Mod/Search Building; and, the remaining XXXX locomotives are serviced at the Maintenance Shop.

Ready Tracks: We assumed all locomotives that depart from departure tracks in the Yard were consisted at the Ready Tracks or passed through the Subway. Therefore, the train and locomotive totals listed on page C-22 were derived from the departure train totals listed in Table C-1 and the number of locomotives per consist were calculated based on the numbers presented in table C-2.

ASSUMPTIONS FOR TRAIN AND LOCOMOTIVE MOVEMENTS THROUGH THE YARD

ANNUAL TOTALS OF TRAINS, CONSISTS, OR LOCOMOTIVES DEPARTING FROM SPECIFIED AREAS WITHIN J.R. DAVIS YARD
ROSEVILLE, CA

ASSUMPTION

1: All locomotives departing from each area are consisted at the Ready Tracks, except for the XXXX locomotives/year serviced at the Subway.

	CONSISTS DEPARTING FROM READY TRACKS MINUS SUBWAY ACTIVITY			
	DEPARTURE YARD	**CITY YARD**	**ROCKPILE**	
EB	XXXX	XXXX	XXXX	
WB	XXXX	XXXX	XXXX	
TOTAL	XXXX	XXXX	XXXX	XXXX
	LOCOMOTIVES DEPARTING FROM READY TRACKS MINUS SUBWAY			
	DEPARTURE YARD	**CITY YARD**	**ROCKPILE**	
EB	XXXX	XXXX	XXXX	
WB	XXXX	XXXX	XXXX	
TOTAL	XXXX	XXXX	XXXX	XXXX

ASSUMPTION

1: Locomotives departing from Subway are distributed in the same percentages as locomotIves arriving at the Subway.

	CONSISTS DEPARTING FROM THE SUBWAY AFTER REFUELING & SERVICING FROM SPECIFIED AREAS		
DPTS	**DEPARTURE YARD**	**CITY YARD**	**ROCKPILE**
EB	XXXX	XXXX	XXXX
WB	XXXX	XXXX	XXXX

ASSUMPTIONS FOR TRAIN AND LOCOMOTIVE MOVEMENTS THROUGH THE YARD

LOCOMOTIVES PROCESSED THROUGH SERVICE TRACKS, MOD/SEARCH BUILDING, AND MAINTENNACE SHOP AREAS

SERVICE TRACK MINUS SUBWAY ACTIVITY

1: We assumed XXXX locomotives/month or XXXX locomotives/year were serviced at the Subway-not the Service Track area
2: XXXX locomotives are subtracted from in-bound totals and the remaining are distributed according to the following percentages.
3: 87.23% of arriving trains terminate in Receiving yard and 12.77% of these trains terminate in the City yard/Rockpile
4: Arriving trains in Receiving yard are split 49% EB, 51% WB. 90% of 12.77% from City yard, while 10% are from Rockpile
5: Arriving trains in City yard are spilt 42% EB, 58% WB: Rockpile split 46% EB, 54% WB
6: XXXX locomotives/3.05 locos/train = XXXX total trains at Subway. Receiving yard = XXXX x .8723 = XXXX
7: XXXX locomotives/3.01 locos/train = XXXX total trains at Subway. Cityyard/Rockpile number = XXXX x .1277 = XXXX

GENERAL ASSUMPTION

All arriving locomotives, except those serviced at the Subway, are processed through the Service Area (Staging Tracks, Wash Racks,Service Tracks, Mod/Search Bldg., Maintenance Shop, and Ready Tracks).

SERVICE TRACK ASSUMPTIONS

1: We assumed XXXX locomotives from the total entering the Service Tracks were released from the shop during 11/99 - 10/00.
2: These XXXX locomotives are distributed in the specified areas according to the following percentages.
3: 87.23% of the XXXX locomotives came from the Receiving yard and 12.77% came from City yard/rockpile
4: Total trains from Receiving yard are split 49% EB, 51% WB. 90% of 12.77% are from City yard, while 10% of the 12.77% are from
5: Trains from the City yard are spilt 42% EB, 58% WB: Trains from the Rockpile are split 46% EB and 54% WB
6: 87.23% of XXXX locos/3.05 locos/train = total of XXXX trains from Receiving yard, EB (49% of total) = XXXX & WB (51% of total)=XXXX
7: 12.77% of XXXX locos/3.01 locos/train = total of XXXX trains. 90% of XXXX are from City yard = XXXX and 10% of XXXX are from Rockpile = XXX
8: City yard split of XXXX trains: EB trains = XXXX & WB trains = XXXX
9: Rockpile split of XXXX trains: EB trains = XXXX & WB trains = 1XXXX
10: We assumed XXXX of the XXXX locomotives going from Service tracks to Shop are DICs (non-working)

ANNUAL TOTAL OF LOCOMOTIVES ARRIVING AT THE SERVICE TRACKS MINUS SUBWAY ACTIVITY

ARRIVALS	RECEIVING YARD	CITY YARD	ROCKPILE
EB	XXXX	XXXX	XXXX

ASSUMPTIONS FOR TRAIN AND LOCOMOTIVE MOVEMENTS THROUGH THE YARD

10: We assumed XXXX of the XXXX locomotives going from Service tracks to Shop are DICs (non-working)

ANNUAL TOTAL OF LOCOMOTIVES ARRIVING AT THE SERVICE TRACKS MINUS SUBWAY ACTIVITY

ARRIVALS	**RECEIVING YARD**	**CITY YARD**	**ROCKPILE**	
EB	XXXX	XXXX	XXXX	
WB	XXXX	XXXX	XXXX	
TOTAL	XXXX	XXXX	XXXX	XXXX

ANNUAL TOTALS OF LOCOMOTIVES DEPARTING FROM SERVICE TRACKS TO READY TRACKS

ARRIVALS	**RECEIVING YARD**	**CITY YARD**	**ROCKPILE**	
EB	XXXX	XXXX	XXXX	
WB	XXXX	XXXX	XXXX	
TOTAL	XXXX	XXXX	XXXX	XXXX

SERVICE TRACKS TO MOD/SEARCH BLDG AND MAINTENANCE SHOP ASSUMPTIONS

1: We assume XXXX of the XXXX locomotives going from Service tracks to Shop are DICs (non-working)

ANNUAL TOTALS OF LOCOMOTIVES LEAVING SERVICE TRACKS TO MOD/SEARCH BLDG AND MAINTENANCE SHOP
ADJUSTED ANNUAL LOCOMOTIVES ARRIVING AT THE MOD/SEARCH BUILDING

ARRIVALS	**RECEIVING YARD**	**CITY YARD**	**ROCKPILE**	
EB	XXXX	XXXX	XXXX	
WB	XXXX	XXXX	XXXX	
TOTAL	XXXX	XXXX	XXXX	XXXX

ASSUMPTIONS FOR TRAIN AND LOCOMOTIVE MOVEMENTS THROUGH THE YARD

7: 12.77% of XXXX locos/3.01 locos/train = total of XXXX trains. 90% of XXXX are from City yard = XXXX and 10% of XXXX are from Rockpile

8: City yard split of XXXX trains: EB trains = XXXX & WB trains = XXXX

9: Rockpile split of XXXX trains: EB trains = XXXX & WB trains = XXXX

ANNUAL LOCOMOTIVE TOTALS ARRIVING AT THE EAST-SIDE MAINTENANCE SHOP

ARRIVALS	RECEIVING YARD	CITY YARD	ROCKPILE	
EB	XXXX	XXXX	XXXX	
WB	XXXX	XXXX	XXXX	
TOTAL	XXXX	XXXX	XXXX	XXXX

EAST-SIDE / WEST-SIDE SHOP AREAS
ASSUMPTIONS

1: The East-side Shop numbers listed above will also be used for idling that occurs at the West-side of Maint. Shop.

2: The East-side Shop numbers listed above will also be used for movement from the West-side Maint. Shop to the Ready Tracks.

ASSUMPTIONS FOR TRAIN AND LOCOMOTIVE MOVEMENTS THROUGH THE YARD

	DEPARTURE YARD	CITY YARD	ROCKPILE	
EB	XXXX	XXXX	XXXX	
WB	XXXX	XXXX	XXXX	
TOTAL	XXXX	XXXX	XXXX	XXXX
	LOCOMOTIVES DEPARTING FROM READY TRACKS MINUS SUBWAY			
	DEPARTURE YARD	**CITY YARD**	**ROCKPILE**	
EB	XXXX	XXXX	XXXX	
WB	XXXX	XXXX	XXXX	
TOTAL	XXXX	XXXX	XXXX	XXXX

TOTAL ANNUAL TRAINS OR LOCOMOTIVES DEPARTING FROM DEPARTURE YARD, CITY YARD, AND ROCKPILE

	DEPARTURE YARD	CITY YARD	ROCKPILE	GRAND TOTAL
EB	XXXX	XXXX	XXXX	
WB	XXXX	XXXX	XXXX	
TOTAL	XXXX	XXXX	XXXX	XXXX
	LOCOMOTIVES IN EACH AREA			
EB	XXXX	XXXX	XXXX	
WB	XXXX	XXXX	XXXX	
TOTAL	XXXX	XXXX	XXXX	31,147.00

A brief summary of each of the following tables that describe the key activity assumptions is presented below.

Table C - 13: This table presents the locomotive emissions rates in g/s for modeling purposes.

Table C – 14: This table presents the standard service and testing types and estimates of test durations that occur for servicing and/or maintenance of locomotives.

Table C – 15: This table presents the assumed hourly fraction of locomotive releases following post-maintenance testing. This is based on standard service practices that dictate post-maintenance load testing is the final step prior to releasing a locomotive for use.

Table C – 16: This table presents the fraction of shop releases and load tests by locomotive model group. The locomotive models were grouped according to their manufacturer and engine, using the same 11 locomotive groups as used for the train activity data sets. No load tests are shown for switchers because the Roseville Yard does not possess the equipment to load-testing these models.

Table C – 17: This table presents the estimated number of service events involving locomotive testing, by type of test and location.

Table C – 18: This table presents the GP-3x locomotive emission rates for the EPA switcher duty-cycle, which is a reasonable assumption for notch settings in yard operations.

Table C – 19: This table presents the percentage in notch setting for the EPA Switcher Duty-Cycle, which was used to calculate emissions during "pullback" Hump operations.

Table C – 20: This table presents the number of hours a hump set is operating (pushing and pullback) on a daily and annual basis. For example, in an eight-hour shift a hump set is pushing for 5.5 hours and pullback for 1.5 hours. Hump set operations are 24/7 except for 4 hours per week set aside for Hump maintenance.

Tables C – 21 and C – 22: These tables present a summary of Hump operations during pushing and pulling modes of operations, which details total annual hours of operations (or seconds) and total annual emissions for each mode of operation.

Tables C – 23 and C – 24: These tables present total annual idling emissions for the working and tradeout consists that are used during Hump operations.

Table C – 25: This table summarizes total annual emissions resulting from idling or movement of locomotives associated with Hump Operations.

Table C – 26: This table presents the locomotive emission rates for switcher and GP-3x locomotive model groups. Trim operations use either of these two locomotive model groups for its operations.

Table C – 27: This table presents the EPA Switcher Duty-Cycle (excluding TN-7 and TN-8), which was considered appropriate for working consists during Trim operations.

Table C – 28: This table presents the daily and annual hours of operation for one Trim set.

Tables C – 29 and C – 30: These tables present the percentage of operating time and the emission rate during an eight – hour shift for each notch setting. To illustrate, 60 percent of a shift is spent in idle, notch 2 and notch 4. The remaining 40 percent is spent in the EPA switcher duty-cycle identified in Table D – 27. Table D – 26 explains the reason for two locomotive model groups being used during Trim operations.

Tables C – 31 and C – 32: These tables present the total annual hours of operation and emission rates for the trade-out locomotive sets (Switcher and GP-3x) used during Trim operations.

Tables C – 33 and C – 34: These tables present the total annual hours of operation and total annual emissions for the working trim consists and the trade-out consists, i.e., Switcher and GP-3x locomotive model groups.

LOCOMOTIVE TEST EVENTS

TABLE C - 13			Locomotive Model Emissions Rate (g/s)							
Locomotive Class	Idle	D.Brk.	T/N-1	T/N-2	T/N-3	T/N-4	T/N-5	T/N-6	T/N-7	T/N-8
Switchers	0.0086	0.0156	0.0064	0.0211	0.0383	0.0442	0.0558	0.0856	0.0958	0.1244
GP-3x	0.0106	0.0200	0.0086	0.0306	0.0517	0.0589	0.0742	0.1158	0.1286	0.1689
GP-4x	0.0122	0.0245	0.0096	0.0343	0.0661	0.0715	0.0919	0.1416	0.1661	0.2217
GP-50	0.0072	0.0178	0.0142	0.0396	0.0838	0.0864	0.1094	0.1844	0.2015	0.2577
GP-60	0.0044	0.0261	0.0138	0.0370	0.0813	0.0863	0.1060	0.1831	0.2039	0.2578
SD-7x	0.0067	0.0013	0.0114	0.0183	0.0436	0.0675	0.0892	0.1041	0.1320	0.1637
SD-90	0.0170	0.0301	0.0139	0.0275	0.0711	0.1177	0.1560	0.0915	0.0717	0.2593
Dash-7	0.0092	0.1089	0.0169	0.0194	0.0372	0.0558	0.0858	0.1219	0.1256	0.1436
Dash-8	0.0106	0.1253	0.0194	0.0222	0.0428	0.0642	0.0986	0.1403	0.1442	0.1653
Dash-9	0.0083	0.0114	0.0104	0.0231	0.0643	0.0969	0.1204	0.1586	0.1880	0.2504
C60-A	0.0197	0.0233	0.0190	0.0218	0.0772	0.0650	0.0767	0.0865	0.0633	0.1008

TABLE C - 14	Testing Types and Time Spent in Each Notch (s)			Total (s)
	Idle	TN-1	Tn-8	
Planned Maintenance (PM) 10-min. Pretests	120		480	600
Planned Maintenance (PM) 30-min. Load Tests	600	600	600	1800
Quarterly Maintenance (QM)10-min. Load Tests	120		480	600
Unscheduled (US) Maint. 15-min. DiagnosticTests	300		600	900
Unscheduled (US) Maint. 30-min. Load Tests	600	600	600	1800

LOCOMOTIVE TEST EVENTS

TABLE C - 15	
Post-Maintenance Testing	
Hour	Hourly Fraction
1	0.0488
2	0.0993
3	0.0188
4	0.0163
5	0.0163
6	0.0186
7	0.0315
8	0.0390
9	0.0166
10	0.0086
11	0.0166
12	0.0198
13	0.0180
14	0.0374
15	0.0609
16	0.0731
17	0.0182
18	0.0237
19	0.0266
20	0.0339
21	0.0401
22	0.0417
23	0.0819
24	0.1943
Total	1.0000

TABLE C - 16		
Locomotive Class	Shop Releases	Load Tests
Switchers	6.46%	
GP-3x	7.47%	4.94%
GP-4x	44.70%	47.15%
GP-50	2.37%	2.74%
GP-60	10.22%	11.99%
SD-7x	4.73%	4.80%
SD-90	1.19%	1.32%
Dash-7	1.56%	1.85%
Dash-8	13.69%	16.04%
Dash-9	7.13%	8.59%
C60-A	0.49%	0.57%
Total	100.01%	99.99%

TABLE C - 17	Locomotive Servicing Events					
Test Type	Service Track	Shop-East	Shop-West	Mod/Search	Subway	Totals
PM 10-Minute Pretest	45	764	0	764		1,573
PM 30-minute Load Test	42		764	0		806
QM 10-Minute Load Test	810		311	0		1,121
US 15-Minute Diagnostic	1,309	35	0	3,744		5,088
US 30-Minute Load Test	673		2,506	0		3,179
Totals	2,879	0	3,581	4,508		11,767

Calculations:

Pre-Test : (% shop releases by loco class)(total # of tests/yr converted to [tests/hr])(EF[g/s](Duration of test(s) for idle, TN-1, & TN-2, where applicable)

Post-Test: Step 1: By Model -(load test%)(% shop releases by loco class)(hrly fraction)(total Load tests/yr converted to number of tests/day, i.e., 1/365)

Step: two: Step 1 x [(EF(g/s))(duration of test (s))]

Answers are in total grams emitted every hour

HUMP OPERATIONS

TABLE C-18	Hump sets	Locomotive Model Emission Rates (g/s)						
Locomotive Class	Locomotives/ consist	Idle	T/N-1	T/N-2	T/N-3	T/N-4	T/N-5	T/N-6
GP-3x	2.00	0.0106	0.0086	0.0306	0.0517	0.0589	0.0742	0.1158

Assumptions: Areas of Operation

Three hump sets are always available, two sets always working and one trade-out set
Pushing: For each 8-hour period a hump set is "pushing" for 5.5 hours along the 7500-8000 ft portion to the west of the Hump.
Pullback: For each 8-hr period a hump set is "in "pullback" mode for 1.5 hours along the south side of the map.
Hump operations are 24/7, 365 days a year - except for 4 hours Hump maintenance
Hump Maintenance Adj. Is 4 hrs/wk X 52 weeks = 208 hrs (no activity)
Area of Hump activities are to the west of the middle of the Bowl.
See map for location of activities: roseville1.bmp
Trade-Out Hump Set is kept at the Service Track (idling or shutdown in the Ready Track area)

Assumptions: Throttle positions

Pushing: Always in TN-2. Average speed of 1.5 mph.
Pullback: EPA switcher Duty Cycle, excluding TN-7 and TN-8. Maximum speed of 10 mph.
Trade out set is either idling or shutdown-depending on weather and maintenance schedule of locomotives.

TABLE C-19	EPA SWITCHER DUTY CYCLE			(PULLBACK OPERATIONS)			
	Notch Position						
	Idle	TN-1	TN-2	TN-3	TN-4	TN-5	TN-6
Percent in Notch	59.8%	12.4%	12.3%	5.8%	3.6%	3.6%	1.5%

TABLE C-20		Hours In Each Hump Operation					
	8 hr. Shift	Daily	Annual hrs.	Hump Maintenance		Adj. Annual hrs.	
Pushing	5.50	16.50	6,022.50	208.00		5,814.50	
Pulback	1.50	4.50	1,642.50	N/A		1,642.50	

HUMP OPERATIONS

TABLE C-21		Emissions During Pushing Operations In Hump Area				
Working Consist						
Locomotive Class	Number of Locos/consist	TN-2 (g/s)	Total hours per year	Seconds per Year	Total Emissions (g/yr)	Annual Emissions Rate (g/s)
GP-3x	2	0.0306	5,814.50	20,932,200.00	1,279,190.00	0.04056285

TABLE C-22		Emissions During Pullback Operations in the Hump Area								
Working Consist										
Locomotive Class	Number of Locos/consist	Seconds per Year	Idle (g/yr)	TN-1 (g/yr)	TN-2 (g/yr	TN-3 (g/y)	TN-4 (g/yr)	TN-5 (g/yr)	TN-6 (g/yr)	Emissions Rate (g/s)
GP-3x	2	5,913,000.00	74,648.34	12,627.54	44,446.05	35,438.58	25,071.12	31,575.42	20,547.68	0.0077484
			(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	
GP-3x	2		2.37E-03	4.00E-04	1.41E-03	1.12E-03	7.95E-04	1.00E-03	6.52E-04	

HUMP OPERATIONS

TABLE C-23		*Idle Emissions at West End of Receiving Yard				
Working Consist						
Locomotive Class	Number of Locos/consist	Idle (g/s)	Total hours per year	Seconds per Year	Total Emissions (g/yr)	Emission Rate (g/s)
GP-3x	2	0.0106	4,380.00	15,768,000.00	332,880.00	0.0106

Assumption: Consist will idle 50 percent of the maximum hours in a year.
Calculation: 1 year x 365 days/yr x 24 hrs/yr = 8,760 hrs/yr; 8760/2 = 4380.0

TABLE C-24	*Idle Emissions at Service Track						
Trade-Out Consist							
Locomotive Class	Number of Locos/consist	Idle (g/s)	Total hours per year	Seconds per Year	Total Emissions (g/yr)	Emission Rate (g/s)	Emission Rate (g/hr)
GP-3x	2	0.0106	4,380.00	15,768,000.00	332,880.00	0.0106	38.00

Assumption: Consist will idle 50 percent of the maximum hours in a year.
Calculation: 1 year x 365 days/yr x 24 hrs/yr = 8,760 hrs/yr; 8760/2 = 4380.0

TABLE C-25				
Total Locomotive Emissions During Hump Operations				
Working	g/yr	lb/yr	tons/yr	Hump Area
Pushing	1,279,190.00	2,817.60	1.41	1.41
Pulling	244,354.73	538.23	0.27	0.27
Idling				
*Service Trks	332,880.00	733.22	0.37	0.37
W. Rec. Yd	332,880.00	733.22	0.37	
Totals	2,189,304.73	4,822.26	2.41	2.05

* This is Trade-out consist

TRIM OPERATIONS

TABLE C-26	Trim sets		Locomotive Model Emissions Rates (g/s)					
Locomotive Class	Locomotives/consist	Idle	T/N-1	T/N-2	T/N-3	T/N-4	T/N-5	T/N-6
Switchers	2.00	0.0086	0.0064	0.0211	0.0383	0.0442	0.0558	0.0856
GP-3x	2.00	0.0106	0.0086	0.0306	0.0517	0.0589	0.0742	0.1158

Assumptions: Areas of Operation

Five Trim sets are always available, three sets always working and two trade-out sets are available.
Each Trim set is 2 locomotives (either switchers or GP 38s)
Trim operations are 24/7, 365 days a year.
Trim sets operations occur east of a line bisecting the Bowl, and sets move trains into and out of Receiving and Departure yards.
See map for location of activities: roseville1.bmp
Trade-Out Trim Sets are kept at the Service Track (idling or shutdown)
Approximately 50% of the trim set operating time is in the Bowl tracks.
The remainder of the Trim set operating time is spent in other portions of the Trim operating areas.

Assumptions: Throttle positions

During 60% of 8-hr. shift 1/3 of time is spent in idle, TN-1, and TN-4 notch settings
Remaining 40% of 8-hr. shift is spent in EPA switcher duty cycle, excluding TN-7 and TN-8.
Trade out sets are either idling or shutdown-depending on weather and maintenance schedules of locomotives.
Speed limit of 15 mph. Typical speed of 5 mph, but it may increase to 7 mph or 10 mph.

TABLE C-27		EPA SWITCHER DUTY CYCLE			(Trim Operations)		
		Notch Position					
	Idle	TN-1	TN-2	TN-3	TN-4	TN-5	TN-6
Percent in Notch	59.8%	12.4%	12.3%	5.8%	3.6%	3.6%	1.5%

TABLE C-28		Hours of Operation For One Trim Set		
	8 hr. Shift	Daily	Annual hrs.	Annual Seconds
Hours	8.00	24.00	8,760.00	31,536,000.00

TRIM OPERATIONS

TABLE C-29		One Working Consist	60 Percent of 8-hour shift Spent In This Mode During Trim Set Operations							
Locomotive Class	Number of Locos/consist	Seconds per Year	Idle (g/yr)	TN-2 (g/yr	TN-4 (g/yr)					Annual Emission Rate (g/s)
Switchers	2	31,536,000.00	107,537.76	263,640.96	551,564.64					0.02926
			g/s	g/s	g/s					
Switchers	2		3.41E-03	8.36E-03	1.75E-02					
		40 Percent of 8-hour Shift Spent In This Mode During Trim Set Operations								
Locomotive Class	Number of Locos/consist	Seconds per Year	Idle (g/yr)	TN-1 (g/yr)	TN-2 (g/yr	TN-3 (g/y)	TN-4 (g/yr)	TN-5 (g/yr)	TN-6 (g/yr)	Annual Emission Rate (g/s)
Switchers	2	31,536,000.00	129,914.30	19,986.82	65,510.78	56,092.03	40,113.79	50,709.89	32,376.96	0.012516
			g/s	g/s	g/s	g/s	g/s	g/s	g/s	
Switchers	2		4.12E-03	6.34E-04	2.08E-03	1.78E-03	1.27E-03	1.61E-03	1.03E-03	
							Grand Total for One consist			0.041776
							Grand Total for Three Consists			0.125328

Assumption: There are always three working consists in the Trim Area.
Assumption: The above calculation represent 2 Locomotives or 1 consist set. A total of 3 consists or 6 locomotives in Grand Total

TABLE C-30		One Working Consist	60 Percent of 8-hour shift Spent In This Mode During Trim Set Operations							
Locomotive Class	Number of Locos/consist	Seconds per Year	Idle (g/yr)	TN-2 (g/yr	TN-4 (g/yr)					Annual Emission Rate (g/s)
GP-3x	2	31,536,000.00	131,820.48	381,585.60	735,419.52					0.0396
			g/s	g/s	g/s					
GP-3x			4.18E-03	1.21E-02	2.33E-02					
		40 Percent of 8-hour Shift Spent In This Mode During Trim Set Operations								
Locomotive Class	Number of Locos/consist	Seconds per Year	Idle (g/yr)	TN-1 (g/yr)	TN-2 (g/yr	TN-3 (g/y)	TN-4 (g/yr)	TN-5 (g/yr)	TN-6 (g/yr)	Annual Emission Rate (g/s)
GP-3x	2	31,536,000.00	159,249.79	26,938.75	94,818.24	75,602.30	53,485.06	67,360.90	43,835.04	0.01653
			g/s	g/s	g/s	g/s	g/s	g/s	g/s	
GP-3x			5.05E-03	8.54E-04	3.01E-03	2.40E-03	1.70E-03	2.14E-03	1.39E-03	
							Grand Total for One consist			0.05613
							Grand Total for Three Consists			0.16839

Assumption: There are always three working consists in the Trim Area.
Assumption: The above calculation represent 2 Locomotives or 1 consist set. A total of 3 consists or 6 locomotives in Grand Total

TRIM OPERATIONS

Table C-31		Trade-Out Consist		*Idle Emissions at Service Track		
Locomotive Class	Number of Locos/consist	Idle (g/s)	Total hours per year	Seconds per Year	Total Emissions (g/yr)	Emission Rate (g/s)
Switchers	2	0.0086	4,380.00	15,768,000.00	271,560.00	0.0086
			Grand Total for Two Consists			0.0172

Assumption 1: There are always two trade-out consists.
Assumption 2: Consist will idle 50 percent of the maximum hours in a year.
Calculation: 1 year x 365 days/yr x 24 hrs/yr = 8,760 hrs/yr; 8760/2 = 4380.0

Table C-32		Trade-Out Consist		*Idle Emissions at Service Track		
Locomotive Class	Number of Locos/consist	Idle (g/s)	Total hours per year	Seconds per Year	Total Emissions (g/yr)	Emission Rate (g/s)
GP-3x	2	0.0106	4,380.00	15,768,000.00	332,880.00	0.0106
			Grand Total for Two Consists			0.0211

Assumption: Consist will idle 50 percent of the maximum hours in a year.
Calculation: 1 year x 365 days/yr x 24 hrs/yr = 8,760 hrs/yr; 8760/2 = 4380.0

Table C-33							
Total Switcher Locomotive Emissions During Trim Operations					50% Split of Working Emissions		
Switchers	# of Locos	g/yr	lbs/yr	tons/yr	Bowl Tracks	Trim Area	
Working	6.00	3,952,343.81	8,705.60	4.35	2.18	2.18	
*Trade-outs							
Idling	4.00	543,120.00	1,196.30	0.60			
Totals	10.00	4,495,463.81	9,901.90	4.95			

*Locomotives idling at Service tracks

Table C-34							
Total GP-3x Locomotive Emissions During Trim Operations					50% Split of Working Emissions		
GP-3x	# of Locos	g/yr	lbs/yr	tons/yr	Bowl Tracks	Trim Area	
Working	6.00	5,310,347.04	11,696.80	5.85	2.92	2.92	
*Trade-outs							
Idling	4.00	665,760.00	1,466.43	0.73			
Totals	10.00	5,976,107.04	13,163.23	6.58			

APPENDIX D

Locomotive Emissions by Area or Activity

(Note: Union Pacific Rail Road representatives reviewed a draft version of Appendix C and indicated that several data points are considered confidential. Throughout this appendix, the confidential data has been redacted and is replaced with XXXX.)

Appendix D provides a detailed summary of the diesel PM emissions inventory resulting from all train and locomotive activities that result in emissions of diesel PM that occur within J.R. Davis Yard in Roseville, California. ARB staff calculated the diesel PM emissions inventory based on the assumptions and activity data presented in Appendix C for idling, movement, and servicing of locomotives that occur within the Yard. The activity data for working trains terminating, originating, and passing through the Yard was compiled from the period between December 1999 and November 2000. The activity data for locomotive releases from the *Subway*, *Service Tracks*, *Mod/Search Bldg*., and the *Maintenance Shop* is based on information provided for the period between November 1999 and October 2000.

A. Emissions Calculations by Activity and Location

Appendix A, schematic of J.R. Davis Yard identifies the five areas of activity considered in our emissions calculations for air dispersion modeling purposes. The locomotive activities that occur in these areas are considered unique and continuous on an hourly basis for 24 hours a day, 7 days a week, 365 days a year. A complete description of the activities in these five areas may also be found in Appendix A.

A two-step calculation methodology was used to quantify emissions of diesel PM for each type of locomotive event. First, emissions were calculated on a per - train basis, accounting for spatial distribution. Second, these emissions were scaled linearly based on monthly and hourly variation for train activity in the *Northside, Main Receiving Yard*, *Main Departure Yard*, *City Yard*, and *Rockpile Yard*. Each train can be thought of as a single set of sources with a specific set of emission rates and stack characteristics. The resulting calculations generated emissions rates for air dispersion modeling purposes. The following sections outline the formulas and assumptions used to generate hourly, daily, and annual average emissions rates for each type of event that occurs in each area of activity.

1. Trains that Originate, Terminate, or Pass Through J.R. Davis Yard

To calculate diesel PM emissions associated with originating, terminating, or through trains we assumed an average train speed over a specified distance traveled. Depending on the location that a train begins and the direction it travels, limits on notch settings and train speeds were set due to Yard speed limits. Table D-1 summarizes train speed limits on all tracks in the Yard.

For originating and terminating trains we assumed a train’s speed in any notch setting was equal to 75 percent of the maximum speed in that notch setting, taking into account track speed limits in the Yard. Due to the length of track from boundary to receiving or departure yard areas and the speed limits on these yard tracks, it was determined that originating and terminating trains would, at a maximum, only use notch settings one through three.

TABLE D-1 Train or Locomotive Maximum Speed Limits (mph)			
	Departures	**Arrivals**	**Through Trains**
Tracks	**EB or WB**	**EB or WB**	
Northside	40	40	40
Departure	15	n/a	
Receiving	n/a	15	
City Yard	5	5	
Rockpile	5	5	
Speed limits are from Yard boundary to/from identified Area			
Maximum speed limit in the Yard is 15 mph			

The available data did not permit us to accurately determine an average speed of through trains. Thus, taking into account that the maximum speed limit on the Northside is 40 mph, and Amtrak trains stop at the Roseville station, we assumed all the through trains on the average traveled at speeds of 20, 30, or 40 mph for a specified distance.

The length of track traveled between Yard boundaries and major areas of activity (e.g., *Main Receiving* or *Departure Yards* or *City Yard* or *Rockpile Yard*) and the *Northside tracks* (Yard boundary to Yard boundary) were divided equally into three segments. Each segment was assigned a notch setting and speed based on the aforementioned assumptions and limitations.

Appendix C, Locomotive and Train Activities by Location, details the train speeds, track lengths, notch settings, and time in notch settings used to calculate diesel PM emissions by location and direction for originating, terminating, or through trains; and for locomotive idling and movement activities within the Yard.

Tables D-2 through D-8 (and a summary of the data in these tables by area is presented in Table D-9) present a detailed estimate of annual locomotive activities by direction and location. Included in these tables are the duration of each emissions event and the resulting annual hourly emissions rate (g/hr) and annual total diesel PM emissions in tpy. Appendix C provides a detailed explanation of the assumptions referred to in the “duration of each event” column where numbers are not listed. Figure D-1 is a graphic presentation of the data in Table D-9.

Table D-10 is a summary of diesel PM emissions by locomotive model and Area (same areas previously listed) and Figure D-2 is a graphic presentation of this data.

Tables D-11 through D-13 present summaries of the daily, hourly, and annual diesel PM emissions by locomotive model, activity, and area, respectively. Figures D-3 and D-4 present graphic presentations of the annual average diesel PM emissions by locomotive model resulting from the three activities (i.e., testing, movement, and idling) identified as the contributors of all locomotive diesel PM at the Yard.

TABLE D - 2

AREA 1 — MOVEMENT OF TRAINS INTO AND OUT OF YARD

YARD BOUNDARY TO YARD LOCATION	ANNUAL NUMBER OF LOCOMOTIVES	DURATION OF EACH EVENT (mins)	ANNUAL AVERAGE HOURLY EMISSIONS RATE (g/hr)	ANNUAL DIESEL PM EMISSIONS (tpy)
Receiving Yard				
Eastbound Arrvls	XXXX	30.00	XXXX	0.159
Westbound Arrvls	XXXX	30.00	XXXX	0.127
SUB-TOTAL	XXXX		XXXX	0.286
City Yard				
EB Arrvls/WB Dpts	XXXX	assumptions*	XXXX	0.126
WB Arrvls/EB Dpts	XXXX	assumptions	XXXX	0.022
SUB-TOTAL	XXXX		XXXX	0.148
Rockpile				
EB Arrvls/WB Dpts	XXXX	assumptions	XXXX	0.002
WB Arrvls/EB Dpts	XXXX	assumptions	XXXX	0.011
SUB-TOTAL	XXXX		XXXX	0.014
Departure Yard				
Eastbound Dpts	XXXX	assumptions	XXXX	0.143
Westbound Dpts	XXXX	assumptions	XXXX	0.109
SUB-TOTAL	XXXX		XXXX	0.252
Northside (1)				
EB Arrvls/WB Dpts	XXXX	assumptions	XXXX	0.177
WB Arrvls/EB Dpts	XXXX	assumptions	XXXX	0.247
Throughs	XXXX	assumptions	XXXX	0.412
SUB-TOTAL	XXXX		XXXX	0.836
GRAND-TOTAL	XXXX		XXXX	1.536

*Assumptions are detailed in Appendix C

TABLE D - 3				
AREA 2	IDLING AND MOVEMENT OF LOCOMOTIVES WITHIN CERTAIN LOCATIONS IN THE YARD			
YARD LOCATION	ANNUAL NUMBER OF LOCOMOTIVES	DURATION OF EACH EVENT (mins)	ANNUAL AVERAGE HOURLY EMISSIONS RATE (g/hr)	ANNUAL DIESEL PM EMISSIONS (tpy)
Receiving Yard				
Eastbound Arrvls	XXXX	assumptions*	XXXX	0.153
Westbound Arrvls	XXXX	assumptions	XXXX	0.161
Idling EB Arrvls	XXXX	30.00	XXXX	0.260
Idling WB Arrvls	XXXX	30.00	XXXX	0.267
SUB-TOTAL	XXXX		XXXX	0.844
City Yard				
EB Arrvls	XXXX	assumptions	XXXX	0.014
WB Arrvls	XXXX	assumptions	XXXX	0.019
EB Dpts	XXXX	assumptions	XXXX	0.019
WB Dpts	XXXX	assumptions	XXXX	0.019
Idling EB Arrvls	XXXX	30.00	XXXX	0.028
Idling WB Arrvls	XXXX	30.00	XXXX	0.039
Idling EB Dpts	XXXX	120.00	XXXX	0.154
Idling WB Dpts	XXXX	120.00	XXXX	0.155
SUB-TOTAL	XXXX		XXXX	0.446
Northside (idling)				
EBArrvls/WB Dpts	XXXX	15.00	XXXX	0.096
WB Arrvls/EB Dpts	XXXX	15.00	XXXX	0.096
SUB-TOTAL	XXXX		XXXX	0.193
Rockpile				
EB Arrvls	XXXX		XXXX	0.004
WB Arrvls	XXXX		XXXX	0.005
EB Dpts	XXXX		XXXX	0.004
WB Dpts	XXXX		XXXX	0.006
Idling EB Arrvls	XXXX	30.00	XXXX	0.003
Idling WB Arrvls	XXXX	30.00	XXXX	0.004
Idling EB Dpts	XXXX	120.00	XXXX	0.014
Idling WB Dpts	XXXX	120.00	XXXX	0.019
SUB-TOTAL	XXXX		XXXX	0.058
Departure Yard*				
Idling EB Dpts	XXXX	120.00	XXXX	0.630
Idling WB Dpts	XXXX	120.00	XXXX	1.644
SUB-TOTAL	XXXX		XXXX	2.274
Subway				
Idling	XXXX	120.00	XXXX	0.806
SUB-TOTAL	XXXX		XXXX	0.806
GRAND-TOTAL	XXXX		XXXX	4.620

* Assumptions are provided in Appendix C

TABLE D - 4				
AREA 3 IDLING LOCOMOTIVES AT SERVICE TRACKS, MODSEARCH BUILDING, MAINTENANCE SHOP, AND READY TRACKS				
YARD LOCATION	ANNUAL NUMBER OF LOCOMOTIVES	DURATION OF EACH EVENT (mins)	ANNUAL AVERAGE HOURLY EMISSIONS RATE (g/hr)	ANNUAL DIESEL PM EMISSIONS (tpy)
Service Tracks				
In-bound Locos	XXXX	60.00	XXXX	0.812
Inspection pits	XXXX	120.00	XXXX	1.625
Hump set idling	XXXX	assumptions*	XXXX	0.367
Trim set idling	XXXX	assumptions	XXXX	0.598 - 0.733
SUB-TOTAL	XXXX		XXXX	3.402 - 3.537
Modsearch Building				
Idling	XXXX	120.00	XXXX	0.151
SUB-TOTAL	XXXX		XXXX	0.151
Maintenance Shop				
East side Idling	XXXX	120.00	XXXX	0.454
West-side Idling	XXXX	60.00	XXXX	0.227
SUB-TOTAL	XXXX		XXXX	0.681
Ready Tracks				
Idling	XXXX	120.00	XXXX	1.430
SUB-TOTAL	XXXX		XXXX	1.430
GRAND-TOTAL				5.663- 5.798

*Assumptions are provided in Appendix C

TABLE D-5				
AREA 3 MOVEMENT OF LOCOMOTIVES BETWEEN SERVICE TRACKS, MOD/SEARCH BLDG. AND MAINTENANCE SHOP				
YARD LOCATION TO YARD LOCATION	ANNUAL NUMBER OF LOCOMOTIVES	DURATION OF EACH EVENT (mins)	ANNUAL AVERAGE HOURLY EMISSIONS RATE (g/hr)	ANNUAL DIESEL PM EMISSIONS (tpy)
SERVICE TRACKS Area				
In-bound to Wash Racks	XXXX	5.00	XXXX	0.099 - 0.139
Wash Racks to Service Trks	XXXX	5.00	XXXX	0.099 - 0.139
Service Trks to Ready Trks	XXXX	5.00	XXXX	0.073 - 0.102
Service Trks to Modsearch	XXXX	15.00	XXXX	0.078 - 0.124
SUB-TOTAL	XXXX		XXXX	0.35 - 0.50
Maintenance Shop Area				
Modsearch Buildings				
To East-side Maint. Shop	XXXX	30.00	XXXX	0.118 - 0.185
To Ready Tracks	XXXX	10.00	XXXX	0.013 - 0.021
Maintenance Shop				
West-side to Ready Tracks	XXXX	10.00	XXXX	0.039 - 0.062
SUB-TOTAL	XXXX		XXXX	0.039 - 0.062
GRAND-TOTAL	XXXX		XXXX	0.519 - 0.772

TABLE D - 6				
AREA 3 LOCOMOTIVE TESTING AT SERVICE TRACKS, MODSEARCH BUILDING, AND MAINTENANCE SHOP				
YARD LOCATION	**ANNUAL NUMBER OF TESTS**	**DURATION OF EACH EVENT (mins)**	**ANNUAL AVERAGE HOURLY EMISSIONS RATE (g/hr)**	**ANNUAL DIESEL PM EMISSIONS (tpy)**
Service Tracks				
Pre-test emissions	XXXX	assumptions*	XXXX	0.188
Post test emissions	XXXX	assumptions	XXXX	0.204
SUB-TOTAL	XXXX	assumptions	XXXX	0.392
Modsearch Building				
Pre-test emissions	XXXX	assumptions	XXXX	0.607
Post test emissions	XXXX	assumptions	XXXX	none
SUB-TOTAL	XXXX		XXXX	0.607
Maintenance Shop				
East-side				
Pre-test emissions	XXXX	assumptions	XXXX	0.089
Post test emissions	XXXX	assumptions	XXXX	none
SUB-TOTAL	XXXX		XXXX	0.089
West-side				
Pre-test emissions	XXXX	assumptions	XXXX	
Post test emissions	XXXX	assumptions	XXXX	0.534
SUB-TOTAL	XXXX		XXXX	0.534
GRAND-TOTAL	XXXX		XXXX	1.622

* Assumptions are detailed in Appendix C

TABLE D - 7 (AREA 4) HUMP AND TRIM OPERATIONS				
YARD LOCATION	**ANNUAL NUMBER OF LOCOMOTIVES**	**DURATION OF ACTIVITY (mins)**	**ANNUAL AVERAGE HOURLY EMISSIONS RATE (g/hr)**	**ANNUAL DIESEL PM EMISSIONS (tpy)**
Hump operations				
Working sets (2)				
Pushing	XXXX	assumptions*	XXXX	1.409
Pulling	XXXX	assumptions	XXXX	0.269
Idling W. Rec yd	XXXX	assumptions	XXXX	0.367
SUB-TOTAL	XXXX		XXXX	2.045
Trim operations*				
Working sets (3)	XXXX			
Bowl tracks		assumptions	XXXX	2.18 - 2.92
Trim area		assumptions	XXXX	2.18 - 2.92
SUB-TOTAL	XXXX		XXXX	4.353 - 5.848
GRAND-TOTAL				6.397 - 7.893

*Assumptions are detailed in Appendix C

TABLE D - 8				
AREA 5 MOVEMENT OF LOCOMOTIVES BETWEEN CERTAIN LOCATIONS IN THE YARD				
YARD LOCATION TO YARD LOCATION	ANNUAL NUMBER OF LOCOMOTIVES	DURATION OF EACH EVENT (mins)	ANNUAL AVERAGE HOURLY EMISSIONS RATE (g/hr)	ANNUAL DIESEL PM EMISSIONS (tpy)
Receiving Yard				
EB To Subway	XXXX	30.00	XXXX	0.089 - 0.139
WB to Subway	XXXX	45.00	XXXX	0.140 - 0.218
EB to Service Tracks	XXXX	30.00	XXXX	0.185 - 0.288
WB to Service Tracks	XXXX	45.00	XXXX	0.289 - 0.450
SUB-TOTAL	XXXX		XXXX	0.703 - 1.095
City Yard				
EB to Subway	XXXX	30.00	XXXX	0.01 - 0.017
EB to Service Tracks	XXXX	30.00	XXXX	0.017 - 0.029
WB to Subway	XXXX	45.00	XXXX	0.021 - 0.035
WB to Service Tracks	XXXX	45.00	XXXX	0.035 - 0.060
SUB-TOTAL	XXXX		XXXX	0.083 - 0.141
Rockpile				
EB to Subway	XXXX	45.00	XXXX	0.002 - 0.003
EB to Service Tracks	XXXX	45.00	XXXX	0.003 - 0.005
WB to Subway	XXXX	60.00	XXXX	0.003 - 0.005
WB to Service Tracks	XXXX	60.00	XXXX	0.004 - 0.008
SUB-TOTAL	XXXX		XXXX	0.012 - 0.020
SUBWAY				
To EB. Depart Yd	XXXX	30.00	XXXX	0.045 - 0.070
To WB. Depart Yd	XXXX	60.00	XXXX	0.260 - 0.396
To City Yd Staging Area	XXXX	30 - 45	XXXX	0.031 - 0.052
To EB. Rockpile	XXXX	45.00	XXXX	0.002 - 0.004
To WB. Rockpile	XXXX	60.00	XXXX	0.003 - 0.004
SUB-TOTAL	XXXX		XXXX	0.340 - 0.527
READY TRACKS				
To EB. Depart Yd	XXXX	30.00	XXXX	0.10 - 0.155
To WB. Depart Yd	XXXX	45.00	XXXX	0.460 - 0.718
To City Yard Staging Area	XXXX	30 - 45	XXXX	0.061 - 0.109
To EB. Rockpile	XXXX	45.00	XXXX	0.003 - 0.006
To WB. Rockpile	XXXX	60.00	XXXX	0.007 - 0.012
SUB-TOTAL	XXXX		XXXX	0.63 - 1.116
GRAND-TOTAL			XXXX	1.768 - 2.784

TABLE D - 9	SUMMARY OF DIESEL PM EMISSIONS AT J.R. DAVIS YARD BY AREA			
Location	**Total Emissions (tpy)**		**Percent Contribution of Total**	
	Low-end	**High-end**	**Low-end**	**High-end**
AREA 1	1.536		6.94%	6.14%
AREA 2	4.620		20.88%	18.46%
AREA 3	7.804	8.192	35.27%	32.73%
AREA 4	6.397	7.893	28.91%	31.54%
AREA 5	1.768	2.784	7.99%	11.12%
GRAND TOTAL	22.125	25.025	100.00%	100.00%

Table D-9 presents two emissions totals that result from idling and movement of locomotives in the Yard. A range of emissions totals were created due to the uncertainties in locomotive operations in Areas 3, 4, and 5. We knew the pulling locomotive during movement of locomotives in area 3 and area 5 was performed in either notch 1 or notch 2. Therefore, we created a range in emissions for this activity based on the pulling locomotive's throttle setting in notch 1(low-end); and, the high-end based on a throttle setting in notch 2.

Regarding the uncertainties associated with Area 4, i.e., *Hump and Trim Operations*. We knew only GP-3x locomotives were used in *Hump Operations,* however in *Trim Operations* switchers and GP-3x locomotives were used to perform these activities. Therefore, we assumed the low-end emissions presented for Area 4 resulted from 100 percent switcher locomotives; while, the high-end emissions total represented 100 percent GP-3x locomotives. The activities (and emissions) identified by Table D-9 represent the low-end (22 tpy) and the high-end of our emissions range (25 tpy). Figure D-1 is a graphic representation of the data presented in Table D-9.

FIGURE D – 1: SUMMARY OF DIESEL PM EMISSIONS AT J.R. DAVIS YARD BY AREA

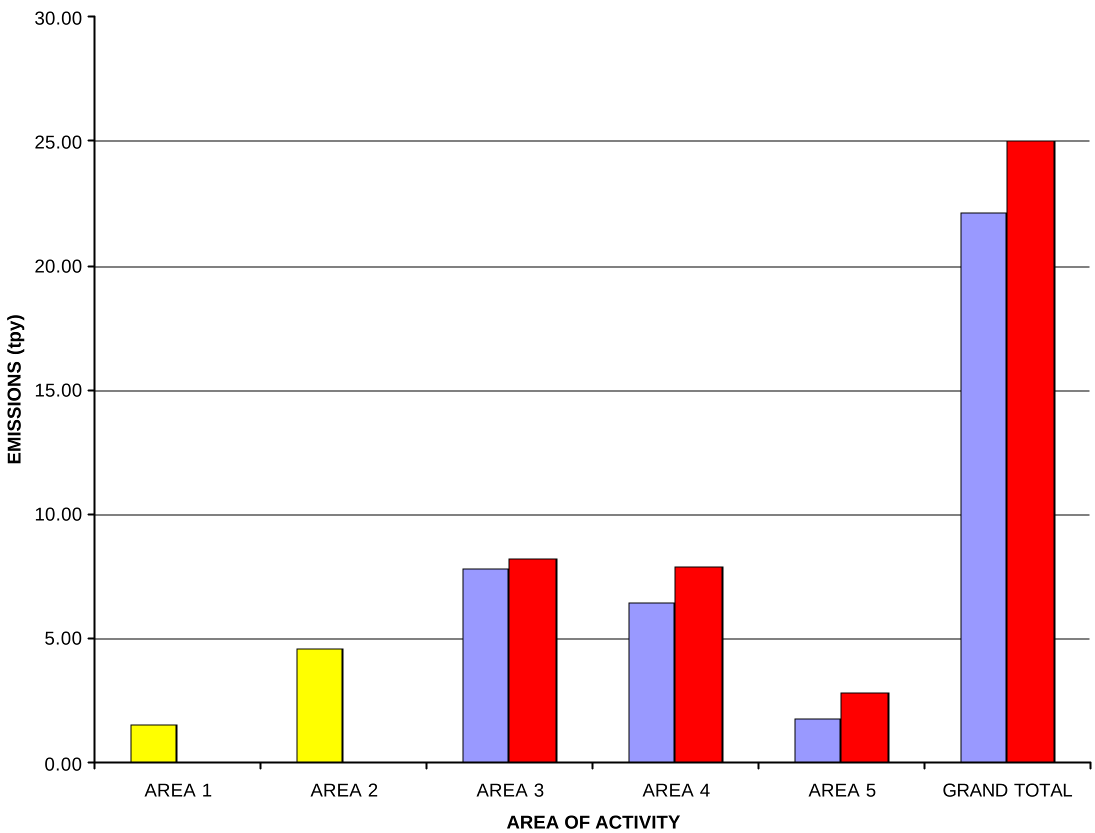
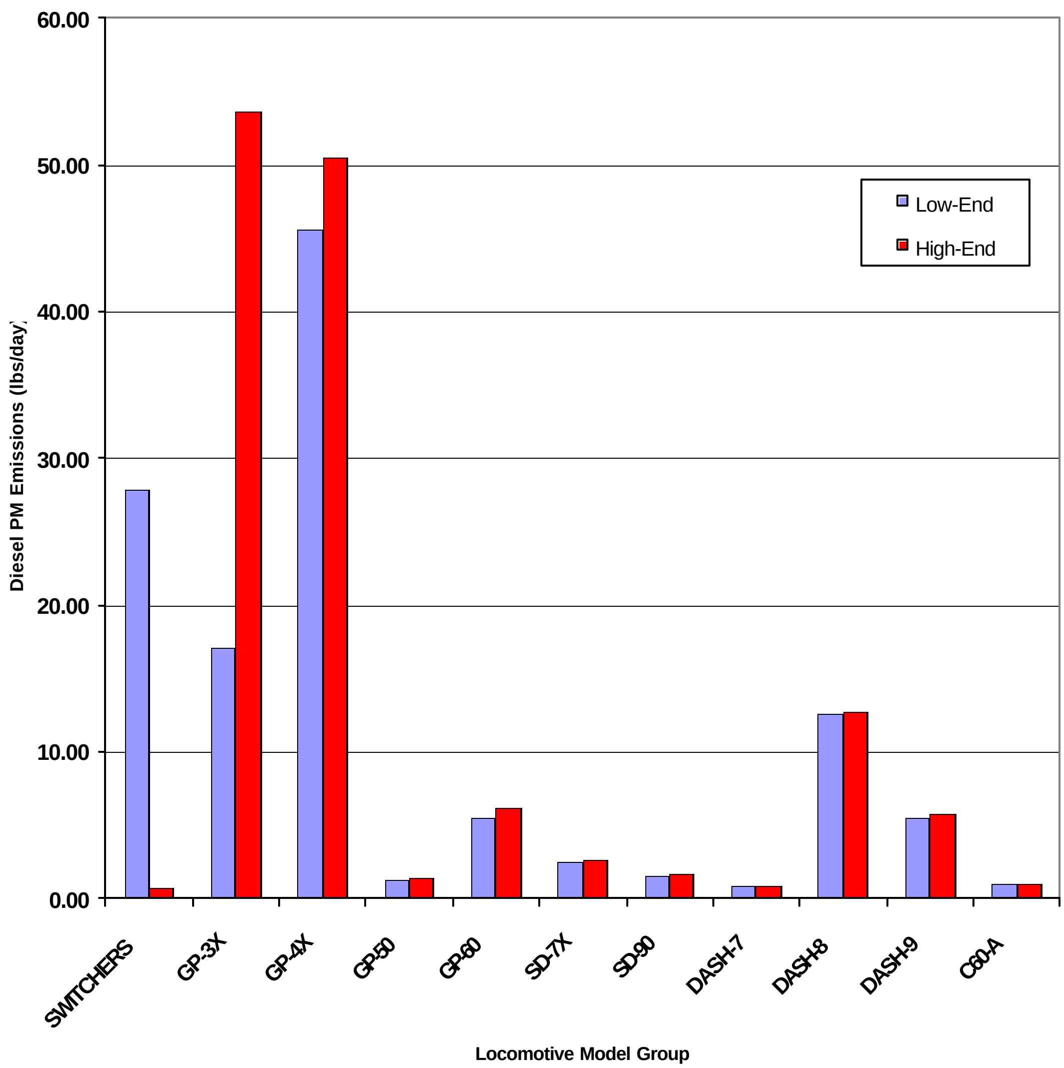


Figure D – 2 SUMMARY OF DAILY EMISSIONS BY LOCOMOTIVE MODEL



The differences in emissions due to the assumptions used to estimate switching operations at the Yard are seen in the bar chart for the switcher and GP-3x locomotive models. As previously discussed the higher emissions in the switcher locomotive model (high-end) occurs because we assume 100 percent of the locomotives used (see Table D-10) in Trim operations are switcher engines. The upper bound of emissions for the GP-3x (high-end) is due to the assumption that Trim operations are performed 100 percent by GP-3x locomotives..

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TABLE D - 10		SUMMARY TABLE DIESEL PM EMISSIONS BY LOCOMOTIVE MODEL AND AREA AT J.R. DAVIS YARD												
LOCATION	**SWITCHERS**	**GP-3X**	**GP-4X**	**GP-50**	**GP-60**	**SD-7X**	**SD-90**	**DASH-7**	**DASH-8**	**DASH-9**	**C60-A**	**Daily Annual Average (g/day)**	**Hourly Annual Average (g/hr)**	**Annual Average (tpy)**
AREA 1		**Movement into & out of Yard**												
	12.80	110.99	1611.71	100.79	557.30	133.68	105.25	47.99	629.30	473.78	37.49	3821.09	159.21	1.54
AREA 2		**Idling & movement within certain locations in Yard**												
	80.29	577.19	6939.91	127.21	545.44	331.01	225.52	108.76	1744.31	657.88	149.44	11486.95	478.62	4.62
AREA 3		**Idling at Service Tracks, Modsearch building, Maintenance Shop, & Ready Tracks**												
***Switchers**	1580.70	1549.98	6946.41	126.23	505.38	352.85	228.43	129.64	1839.71	664.82	163.26	14087.40	586.98	5.66
100% GP-3x	92.70	3373.98	6946.41	126.23	505.38	352.85	228.43	129.64	1839.71	664.82	163.26	14423.40	600.98	5.80
Assumption: Idling emissions from Trim operations are 100% from Switcher locomotives.														
AREA 3		**Movement of locomotives between Service Tracks, Mod/Search bldg., & Maintenance Shop**												
(Idle + Notch 1)	7.09	78.91	770.02	13.99	73.01	36.95	22.88	14.10	199.69	61.15	13.69	1291.47	53.81	0.52
AREA 3		**Movement of locomotives between Service Tracks, Mod/Search bldg., & Maintenance Shop**												
(Idle + Notch 2)	11.50	116.20	1210.05	26.35	148.26	47.22	28.06	15.10	213.37	90.05	14.34	1920.51	80.02	0.77
AREA 3			**Locomotive testing at Service Tracks, Mod/Search bldg., & Maintenance Shop**											
	86.48	182.25	1968.21	125.12	539.50	151.09	63.37	48.59	487.73	372.31	11.70	4036.36	168.18	1.62
AREA 4			**Hump & Trim Operations**											
Hump GP-3x Trim Switchers	10828.32	5086.08										15914.40	663.10	6.40
100% GP-3x		19634.88										19634.88	818.12	7.89
AREA 5			**Movement of locomotives between locations in the Yard**											
Idle + Notch 1	28.92	205.11	2482.29	56.99	253.91	148.60	73.26	56.69	803.09	245.93	55.01	4409.80	183.74	1.77
Idle + Notch 2	46.95	356.40	4277.33	107.35	514.22	189.91	94.09	60.70	857.91	362.14	57.63	6924.62	288.53	2.78
GRAND TOTAL														
Low-end	12624.60	7790.50	20718.55	550.34	2474.54	1154.18	718.70	405.76	5703.83	2475.87	430.59	55047.47	2293.64	22.13
High-end	330.73	24351.89	22953.62	613.05	2810.10	1205.76	744.71	410.78	5772.33	2620.98	433.86	62247.82	2593.66	25.02

TABLE D - 11 SUMMARY OF DIESEL PM EMISSIONS FROM IDLING BY LOCOMOTIVE MODEL AT J.R. DAVIS YARD

LOCATION	SWITCHERS	GP-3X	GP-4X	GP-50	GP-60	SD-7X	SD-90	DASH-7	DASH-8	DASH-9	C60-A	Daily Annual Avg (g/day)	Hourly Annual Avg (g/hr)	Annual Avg (tpy)
AREA 2		**Idling & movement within certain locations in Yard**												
	74.58	519.50	6388.26	110.23	437.99	300.60	215.00	97.90	1593.25	607.77	142.46	10487.54	436.98	4.22
AREA 3		**Idling at Service Tracks, Modsearch building, Maintenance Shop, & Ready Tracks**												
***Switchers**	1580.70	1549.98	6946.41	126.23	505.38	352.85	228.43	129.64	1839.71	664.82	163.26	14087.40	586.98	5.66
											GP-3x	100%		5.798
	Assumption: Idling emissions from Trim operations are 100% from Switcher locomotives.												30.03	0.29
AREA 4														
Hump Operations														
***GP-3x**	0	912	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	912.00	38.00	0.37
SUMMARY OF DIESEL PM EMISSIONS FROM IDLING LOCOMOTIVES (EXCLUDING EMISSIONS FROM TESTING)														
GRAND TOTAL	1655.28	2981.47	13334.67	236.47	943.37	653.45	443.43	227.54	3432.96	1272.59	305.71	25486.94	1061.96	10.25
(SUMMARY OF DIESEL PM EMISSIONS FROM TESTING EVENTS (AREA 3)														
GRAND-TOTAL	86.48	182.25	1968.21	125.12	539.50	151.09	63.37	48.59	487.73	372.31	11.70	4036.36	168.18	1.62

TABLE D - 12 SUMMARY OF DIESEL PM EMISSIONS FROM MOVEMENT BY LOCOMOTIVE MODEL AT J.R. DAVIS YARD

LOCATION	SWITCHERS	GP-3X	GP-4X	GP-50	GP-60	SD-7X	SD-90	DASH-7	DASH-8	DASH-9	C60-A	Daily Annual Average (g/day)	Hourly Annual Average (g/hr)	Annual Average (tpy)
Area 1	**Movement of trains into & out of Yard**													
Movement into & out of Yard	12.80	110.99	1611.71	100.79	557.30	133.68	105.25	47.99	629.30	473.78	37.49	3821.09	159.21	1.54
Area 2		**Movementof locomotives within certain locations in Yard**												
	5.71	57.69	551.65	16.98	107.45	30.41	10.52	10.86	151.06	50.11	6.98	999.42	41.64	0.40
Area 3	**Movement of locomotives at Service Tracks & Maintenance Shop**													
(Idle + Notch 1)	7.09	78.91	770.02	13.99	73.01	36.95	22.88	14.10	199.69	61.15	13.69	1291.47	53.81	0.52
(Idle + Notch 2)	11.50	116.20	1210.05	26.35	148.26	47.22	28.06	15.10	213.37	90.05	14.34	1920.51	80.02	0.77
Area 4		**Hump & Trim Operations**												
Hump - GP-3x Trim Switchers	10828.32	4174.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15002.40	625.10	6.03
100% GP-3x		18722.88										18722.88	780.12	7.53
Assumptions: Emissions from Hump & Trim operations are 100% from GP-3x locomotives (high-end)														
Area 5		**Movement of locomotives between locations in the Yard**												
(Idle + Notch 1)	28.92	205.11	2482.29	56.99	253.91	148.60	73.26	56.69	803.09	245.93	55.01	4409.80	183.73	1.77
(Idle + Notch 2)	46.95	356.40	4277.33	107.35	514.22	189.91	94.09	60.70	857.91	362.14	57.63	6924.62	288.53	2.78
SUMMARY OF DIESEL PM EMISSIONS FROM MOVEMENT OF LOCOMOTIVES (EXCLUDING EMISSIONS FROM TESTING)														
GRAND TOTAL														
Low-end	10882.84	4626.78	5415.67	188.75	991.67	349.64	211.91	129.63	1783.14	830.97	113.18	25524.17	1063.50	10.26
High-end	76.97	19364.17	7650.74	251.46	1327.23	401.22	237.91	134.65	1851.64	976.09	116.44	32388.52	1349.52	13.02
SUMMARY OF DIESEL PM EMISSIONS FROM TESTING EVENTS (AREA 3)														
GRAND-TOTAL	86.48	182.25	1968.21	125.12	539.50	151.09	63.37	48.59	487.73	372.31	11.70	4036.36	168.18	1.62

TABLE D - 13 (Area 3) LOCOMOTIVE TESTING AT SERVICE TRACKS, MOD/SEARCH BLDG., AND MAINTENANCE SHOP														
YARD LOCATION	SWITCHERS	GP-3X	GP-4X	GP-50	GP-60	SD-7X	SD-90	DASH-7	DASH-8	DASH-9	C60-A	Daily Annual Average (g/day)	Hourly Annual Average (g/hr)	Annual Average (tpy)
Service Tracks														
Pre-test emissions	18.38	28.75	225.09	13.69	58.74	17.46	7.04	5.11	51.60	40.11	1.20	467.18	19.47	0.19
Post test emissions		19.94	247.88	16.57	71.96	18.71	8.21	6.57	65.50	50.25	1.58	507.16	21.13	0.20
SUB-TOTAL	18.38	48.70	472.97	30.26	130.70	36.17	15.25	11.67	117.11	90.36	2.77	974.35	40.60	0.39
Mod/Search Bldg.														
Pre-test emissions	59.41	92.95	727.75	44.30	190.13	56.48	22.77	16.52	166.80	129.76	3.86	1510.69	62.95	0.61
Post test emissions														
SUB-TOTAL	59.41	92.95	727.75	44.30	190.13	56.48	22.77	16.52	166.80	129.76	3.86	1510.69	62.95	0.61
Maintenance Shop														
East-side														
Pre-test emissions	8.70	13.62	106.81	6.54	28.11	8.31	3.33	2.42	24.44	19.13	0.55	221.96	9.25	0.089
Post test emissions														
SUB-TOTAL	8.70	13.62	106.81	6.54	28.11	8.31	3.33	2.42	24.44	19.13	0.55	221.96	9.25	0.09
West-side														
Pre-test emissions														
Post test emissions		26.98	660.69	44.03	190.56	50.14	22.01	17.98	179.39	133.06	4.52	1329.36	55.39	0.53
SUB-TOTAL		26.98	660.69	44.03	190.56	50.14	22.01	17.98	179.39	133.06	4.52	1329.36	55.39	0.53
GRAND-TOTAL	86.48	182.25	1968.21	125.12	539.50	151.09	63.37	48.59	487.73	372.31	11.70	4036.36	168.18	1.62

*Pre-test emissions testing: Planned maintenance (PM) for 10 mins. Unscheduled maintenance (US) for 15 mins.

**Post-test emissions testing: Quarterly maint. (QM) 10-min load test. PM 30-min. Load test. US 30-min. load test
Load tests are not performed on Switchers

Figure D – 3 Total Annual Average Diesel PM Emissions (Low - End)

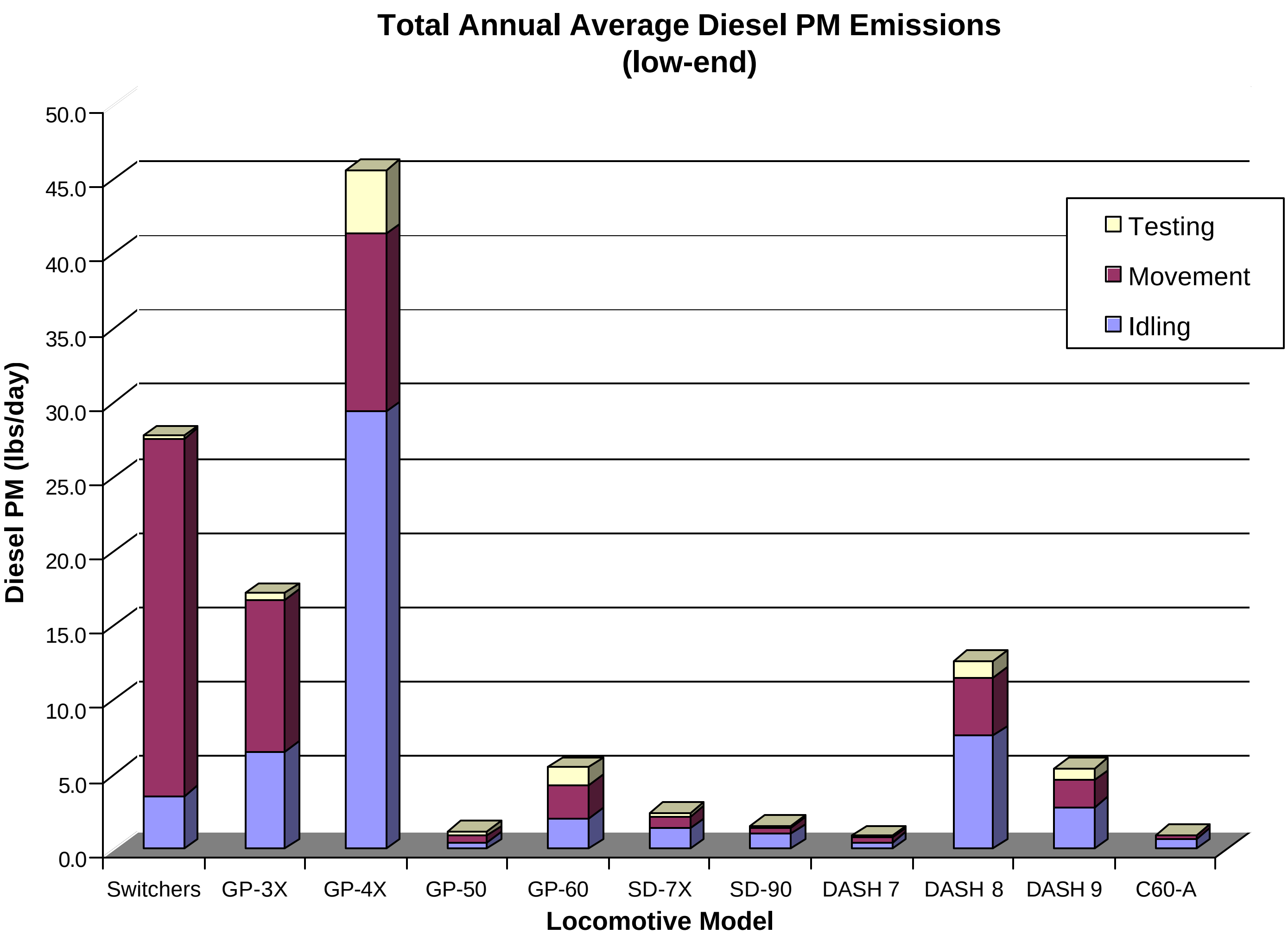
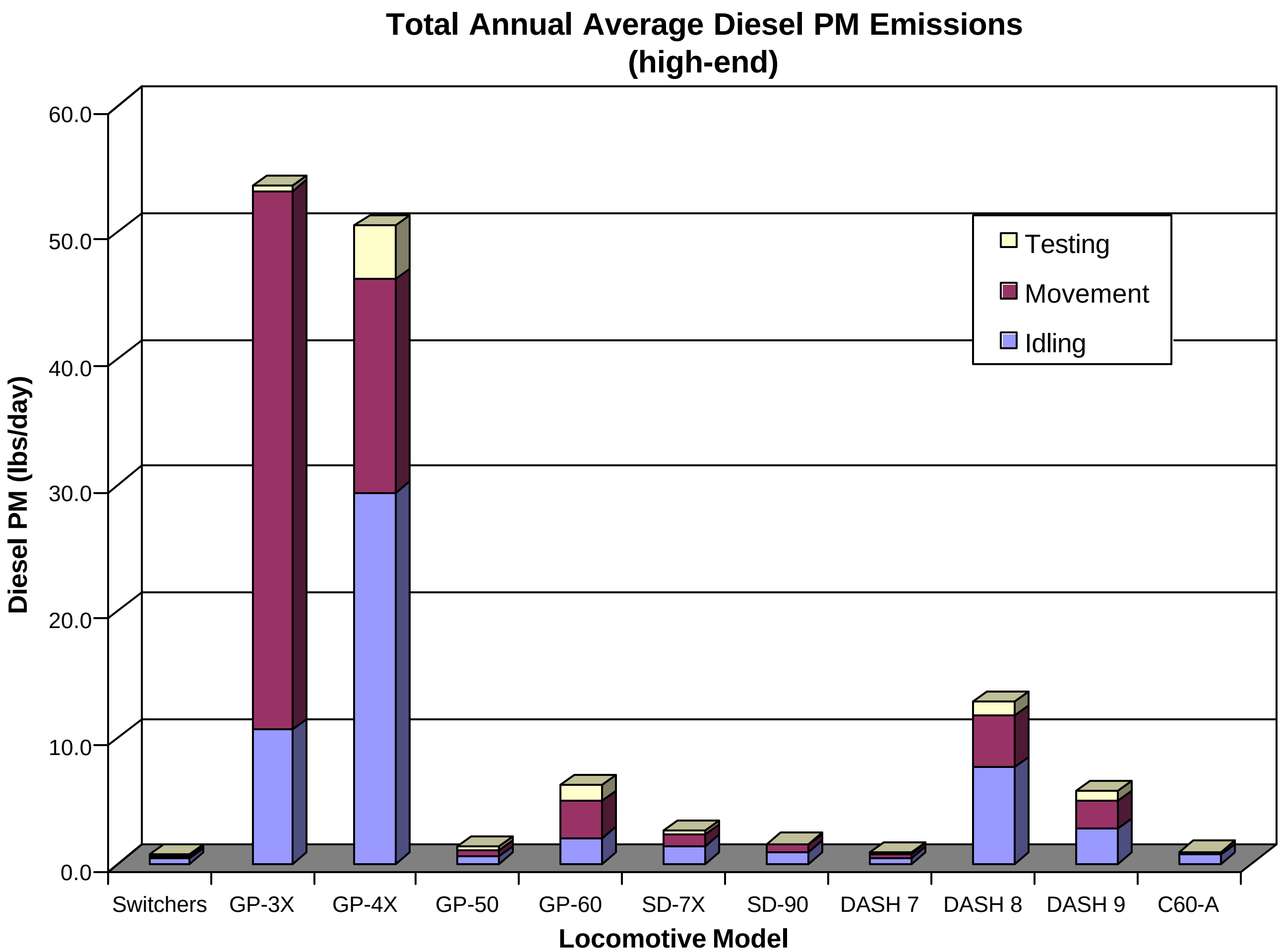


Figure D – 4 Total Annual Average Diesel PM Emissions (High - End)



Alternate Emissions Calculation

Based on the methodology outlined in Chapter III, we estimated the emissions of diesel PM for the period under review ranged from 22.0 to 25.0 tons per year. An alternative calculation was performed as a sensitivity study to determine if the assumptions and approach used were reasonable. This alternative approach, which is described below, resulted in an estimate of 24.3 tons per year of diesel PM. Table D-15 contains the annual emission totals by locomotive model for each location and activity, including low-temperature idling, for J.R. Davis Yard resulting from the alternate calculation method.

The approach for the alternative emissions calculation entailed estimating the train emissions using an acceleration based train speed approach and accounting for additional idling emissions during cold weather. The primary emissions calculation methodology assumed a constant speed over a given distance of track (did not take into account acceleration or deceleration).

Acceleration Based Train Speeds : To determine the speeds of trains entering and departing the yard, and to determine which notch speed settings and total time/distance required to move through that notch setting the following assumptions were provided by senior staff at the Yard and were used to develop the nominal throttle, speed, and distance profile:

- Train acceleration and speed are limited by both locomotive traction and yard speed.
- Trains accelerate from a stop in notch 1, and the throttle is moved up one notch at a time when threshold speeds are reached.
- For notches 1 through 4, the maximum speed in each notch is approximately 8 mph per notch setting.
- The threshold speed for advancing the throttle to the next notch setting is approximately 75 percent of the maximum speed in the current notch.
- For normal matching of horsepower to load, approximately 3 minutes is spent in each notch prior to reaching the threshold speed for advancing to the next notch.
- The average acceleration rate for notch 1 through 4 is 2 mph per minute.
- Grade within the Yard is relatively flat; therefore, it will not significantly affect the time, notch, and acceleration values.

Based on the above assumptions and the following formulas we derived a nominal speed, time and distance in notch setting profile. (See Table D-2)

Formulas:
Train acceleration (a): 2mph/min = 120 miles/hr^2 or 0.05 ft/s^2
Velocity (v): acceleration (a) x time (t)
$v = at$
Standard equation for motion from a stop
Distance (d) = $1/2at^2$

TABLE D – 14 DEPARTURE NOTCH SETTING, SPEED, AND DISTANCE PROFILE						
Notch Setting	Velocity (v) (ft/s)	Time (t) (s)	Distance (d) feet	miles	Threshold Speed mph	ft/s
TN –1	0.0 -8.8	176.0	774.4	0.15	6.0	8.8
TN – 2	8.8 - 17.6	176.0	2,323.2	0.44	12.0	17.6
TN – 3	17.6 - 26.4	176.0	3,872.0	0.733	18.0	26.4
TN – 4	26.4 - 35.2	176.0	5,420.8	1.027	24.0	35.2
TN – 5	35.2 - 58.7	175.2	6,934.4	1.313	max 40.0	58.7

Low Temperature Idling Methodology: To account for additional idling emissions occurring due to the Smart-Start system installed on trains which automatically start trains and keep them idling when the temperature drops to 40 F or less, meteorological data was gathered to determine which hours of the year were at 40 F or below. For all 8760 hours in the year, the temperature was then determined. Taking this data, the total number of hours in the year at or below 40 F was found. Using meteorological data that is provided by the California Energy Commission (CEC) for a typical year, we found that on average 359 hours of the year (out of a total of 8760 hours) had temperatures at or below 40 F for the climate zone the Railyard was located in. Next, using the temporal data provided by the Railyard, the fraction of the total annual Railyard activity for these hours of the year was determined, by multiplying the fraction of activity in the given month by the fraction of activity for the given hour of day, since both these temporal factor sets were provided by the Railyard. This gave the number of trains that would, on average, be subject to these low temperatures, and thus, the emissions associated with their idling. For Roseville Railyard, using the CEC data, the emissions from low temperature idling amounted to 0.251 tons/year of PM10 emissions (about 1% of the total 24.31 tons/year of PM10 emissions in the yard).

This alternate emissions calculation methodology resulted in an estimate of 24.3 tons per year for the time period under review. This falls within the range that was estimated using the methodology described in Chapter III. Table D-15 provides the emissions estimate calculated with the alternate methodology as well as the previous estimate (the last two columns on the right).

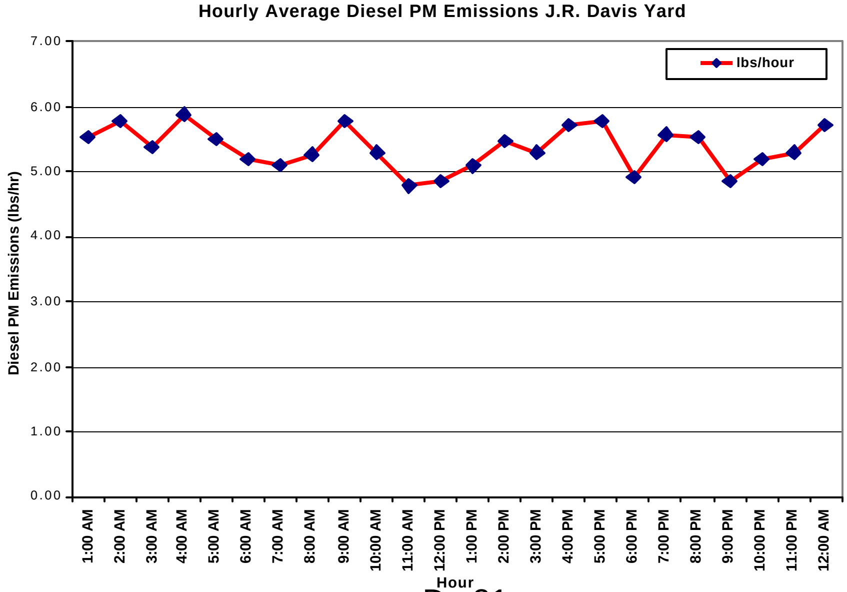
Locomotive Emissions			TABLE D - 15			Locomotive Model Type Distribution						(alt)	1st Calculation	
PM10 (Tons/Year)	*Switchers*	*GP-3x*	*GP-4x*	*GP-50*	*GP-60*	*SD-7x*	*SD-90*	*Dash-7*	*Dash-8*	*Dash-9*	*C60-A*	Total	*Low Total*	*High Total*
Northside														
Arriving into	0.0004	0.0016	0.0892	0.0092	0.0471	0.0091	0.0100	0.0034	0.0430	0.0419	0.0036	0.2583	0.1770	0.1770
Moving/Idling within	0.0004	0.0016	0.0850	0.0041	0.0134	0.0071	0.0128	0.0037	0.0472	0.0298	0.0051	0.2102	0.1930	0.1930
Low Temperature Idle	0.0001	0.0003	0.0173	0.0008	0.0027	0.0014	0.0026	0.0007	0.0096	0.0061	0.0010	0.0427	0.0427	0.0427
Departing out of	0.0005	0.0022	0.1271	0.0131	0.0675	0.0129	0.0144	0.0046	0.0588	0.0611	0.0053	0.3676	0.2470	0.2470
Passing through	0.0006	0.0026	0.1453	0.0140	0.0718	0.0183	0.0223	0.0066	0.0843	0.0846	0.0054	0.4557	0.4120	0.4120
Receiving Yard														
Arriving into	0.0022	0.0122	0.2110	0.0081	0.0511	0.0137	0.0052	0.0037	0.0538	0.0266	0.0033	0.3910	0.2860	0.2860
Moving/Idling within	0.0064	0.0331	0.5486	0.0142	0.0755	0.0303	0.0159	0.0100	0.1446	0.0557	0.0105	0.9449	0.8440	0.8440
Low Temperature Idle	0.0003	0.0016	0.0265	0.0005	0.0019	0.0014	0.0009	0.0006	0.0072	0.0026	0.0006	0.0441	0.0441	0.0441
Moving to other areas	0.0059	0.0308	0.5090	0.0140	0.0764	0.0300	0.0148	0.0101	0.1451	0.0534	0.0100	0.8994	0.7030	1.0950
Departure Yard														
Moving/Idling within	0.0167	0.0814	1.3664	0.0250	0.1005	0.0723	0.0466	0.0257	0.3721	0.1352	0.0334	2.2754	2.2740	2.2740
Low Temperature Idle	0.0003	0.0017	0.0282	0.0005	0.0021	0.0016	0.0010	0.0006	0.0077	0.0028	0.0007	0.0470	0.0470	0.0470
Departing out of	0.0027	0.0149	0.2598	0.0101	0.0635	0.0169	0.0066	0.0046	0.0645	0.0337	0.0042	0.4814	0.2520	0.2520
City Yard														
Arriving into	0.0012	0.0297	0.1395	0.0012	0.0087	0.0008	0.0003	0.0006	0.0055	0.0022	0.0002	0.1900	0.1260	0.1260
Moving/Idling within	0.0035	0.0741	0.3569	0.0019	0.0106	0.0021	0.0013	0.0020	0.0176	0.0055	0.0009	0.4763	0.4460	0.4460
Low Temperature Idle	0.0001	0.0013	0.0063	0.0000	0.0001	0.0000	0.0000	0.0000	0.0003	0.0001	0.0000	0.0083	0.0083	0.0083
Moving to other areas	0.0008	0.0173	0.0827	0.0006	0.0035	0.0006	0.0003	0.0006	0.0044	0.0013	0.0002	0.1120	0.0830	0.1410
Departing out of	0.0002	0.0049	0.0232	0.0002	0.0015	0.0002	0.0001	0.0001	0.0012	0.0004	0.0000	0.0320	0.0220	0.0220
Rockpile														
Arriving into	0.0001	0.0026	0.0123	0.0001	0.0008	0.0001	0.0000	0.0001	0.0005	0.0002	0.0000	0.0167	0.0020	0.0020
Moving/Idling within	0.0005	0.0102	0.0489	0.0003	0.0018	0.0003	0.0002	0.0003	0.0023	0.0008	0.0001	0.0655	0.0580	0.0580
Low Temperature Idle	0.0000	0.0001	0.0007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0009	0.0009	0.0009
Moving to other areas	0.0001	0.0025	0.0120	0.0001	0.0005	0.0001	0.0000	0.0001	0.0006	0.0002	0.0000	0.0163	0.0120	0.0200
Departing out of	0.0000	0.0005	0.0024	0.0000	0.0002	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0033	0.0110	0.0110
Subway														
Moving/Idling within	0.0059	0.0422	0.5016	0.0080	0.0325	0.0226	0.0146	0.0063	0.1180	0.0426	0.0105	0.8066	0.8060	0.8060
Low Temperature Idle	0.0001	0.0009	0.0102	0.0002	0.0007	0.0005	0.0003	0.0002	0.0024	0.0009	0.0002	0.0164	0.0164	0.0164
Moving to other areas	0.0031	0.0233	0.2731	0.0066	0.0361	0.0137	0.0068	0.0048	0.0673	0.0246	0.0046	0.4638	0.3400	0.5270
Service Tracks														
Moving/Idling within	0.0179	0.1277	1.5190	0.0242	0.0983	0.0684	0.0443	0.0252	0.3573	0.1291	0.0317	2.4433	3.4020	3.5370
Low Temperature Idle	0.0002	0.0017	0.0206	0.0003	0.0013	0.0009	0.0006	0.0003	0.0049	0.0018	0.0004	0.0332	0.0332	0.0332
Moving to other areas	0.0023	0.0175	0.2055	0.0049	0.0272	0.0103	0.0051	0.0036	0.0506	0.0185	0.0034	0.3490	0.3490	0.5040
Test (PM 10)	0.0002	0.0003	0.0024	0.0001	0.0006	0.0002	0.0001	0.0001	0.0005	0.0004	0.0000	0.0050	0.1880	0.1880
Test (PM 30)		0.0003	0.0032	0.0002	0.0009	0.0002	0.0001	0.0001	0.0009	0.0006	0.0000	0.0066	0.2040	0.2040
Test (QM 10)		0.0036	0.0454	0.0030	0.0133	0.0034	0.0015	0.0012	0.0115	0.0093	0.0003	0.0926		
Test (US 15)	0.0072	0.0113	0.0882	0.0054	0.0230	0.0068	0.0028	0.0020	0.0202	0.0157	0.0005	0.1630		
Test (US 30)		0.0041	0.0511	0.0034	0.0147	0.0039	0.0017	0.0014	0.0139	0.0103	0.0004	0.1050		
Modsearch Building														
Moving/Idling within	0.0011	0.0079	0.0941	0.0016	0.0061	0.0042	0.0027	0.0016	0.0221	0.0080	0.0020	0.1513	0.1510	0.1510
Low Temperature Idle	0.0000	0.0002	0.0019	0.0000	0.0001	0.0001	0.0001	0.0000	0.0005	0.0002	0.0000	0.0031	0.0123	0.0123
Moving to other areas	0.0011	0.0085	0.0991	0.0024	0.0131	0.0050	0.0025	0.0017	0.0244	0.0089	0.0017	0.1684	0.1310	0.2060
Test (PM 10)	0.0033	0.0052	0.0406	0.0025	0.0107	0.0032	0.0013	0.0009	0.0093	0.0073	0.0002	0.0844	0.6070	0.6070
Test (PM 30)														
Test (QM 10)														
Test (US 15)	0.0206	0.0322	0.2521	0.0153	0.0658	0.0196	0.0079	0.0067	0.0579	0.0449	0.0013	0.5233		
Test (US 30)														
Maintenance Shop														
Moving/Idling within	0.0050	0.0356	0.4232	0.0068	0.0274	0.0191	0.0124	0.0070	0.0996	0.0360	0.0088	0.6806	0.6810	0.6810
Low Temperature Idle	0.0001	0.0006	0.0058	0.0001	0.0004	0.0003	0.0002	0.0001	0.0014	0.0005	0.0001	0.0093	0.0093	0.0093
Moving to other areas	0.0003	0.0025	0.0297	0.0007	0.0039	0.0015	0.0007	0.0006	0.0073	0.0027	0.0005	0.0505	0.0390	0.0620
Test (PM 10)	0.0033	0.0052	0.0406	0.0025	0.0107	0.0032	0.0013	0.0009	0.0093	0.0073	0.0002	0.0844	0.0890	0.0890
Test (PM 30)		0.0047	0.0580	0.0039	0.0167	0.0044	0.0019	0.0016	0.0158	0.0117	0.0004	0.1192	0.5340	0.5340
Test (QM 10)		0.0014	0.0174	0.0012	0.0051	0.0013	0.0006	0.0004	0.0044	0.0036	0.0001	0.0355		
Test (US 15)	0.0002	0.0003	0.0024	0.0001	0.0006	0.0002	0.0001	0.0001	0.0005	0.0004	0.0000	0.0049		
Test (US 30)		0.0154	0.1904	0.0127	0.0548	0.0145	0.0063	0.0052	0.0519	0.0383	0.0013	0.3908		
Ready Tracks														
Moving/Idling within	0.0133	0.0946	1.1259	0.0180	0.0729	0.0507	0.0329	0.0187	0.2649	0.0957	0.0235	1.8110	1.4290	1.4290
Low Temperature Idle	0.0003	0.0019	0.0230	0.0004	0.0015	0.0010	0.0007	0.0004	0.0054	0.0019	0.0005	0.0369	0.0369	0.0369
Moving to other areas	0.0055	0.0423	0.4959	0.0119	0.0655	0.0249	0.0123	0.0086	0.1221	0.0447	0.0083	0.8421	0.6300	1.0010
Hump/Trim														
Hump Operations		2.4146										2.4146	2.0450	2.0450
Trim Operations	2.1896	2.8613										5.0509	4.3530	5.8480
ow Temperature Idle (Hump)		0.0037										0.0037	0.0037	0.0037
Low Temperature Idle (Trim)	0.0025	0.0031										0.0057	0.0057	0.0057
	2.33	**6.10**	**9.72**	**0.25**	**1.21**	**0.50**	**0.32**	**0.18**	**2.41**	**1.11**	**0.19**	**24.31**	**22.38**	**25.28**
Note: Hump & Trim idling (tradeout consists) that occurs at Service Tracks are included in Hump and Trim emissions totals										without low-temp			**22.13**	**25.02**

Temporal Distribution of Emissions

Table D-16 presents the annual average diesel PM emissions estimated at the Yard in g/hr and lbs./hr. Figure D-5 is a graphic representation of this data. The relatively consistent emissions level further substantiates that Yard activities are continuous 24 hours a day, 7-days a week, 365 days a year. The activities probably associated with the peak emissions levels represent crew changes, shop releases, or maintenance trains.

TABLE D - 16				
J.R. DAVIS YARD				
ANNUAL AVERAGE DIESEL PM EMISSIONS				
Hours	(g/hr)		lbs/hr	
1:00 AM	2508.67		5.53	
2:00 AM	2619.41		5.77	
3:00 AM	2445.97		5.39	
4:00 AM	2667.99		5.88	
5:00 AM	2499.74		5.51	
6:00 AM	2362.48		5.20	
7:00 AM	2319.13		5.11	
8:00 AM	2392.20		5.27	
9:00 AM	2624.50		5.78	
10:00 AM	2408.99		5.31	
11:00 AM	2166.50		4.77	
12:00 PM	2202.28		4.85	
1:00 PM	2307.15		5.08	
2:00 PM	2479.41		5.46	
3:00 PM	2408.15		5.30	
4:00 PM	2596.39		5.72	
5:00 PM	2626.27		5.78	
6:00 PM	2231.61		4.92	
7:00 PM	2527.47		5.57	
8:00 PM	2511.44		5.53	
9:00 PM	2198.97		4.84	
10:00 PM	2352.65		5.18	
11:00 PM	2402.19		5.29	
12:00 AM	2599.19		5.73	
Daily	58458.73		128.76	
hourly avg	2435.78		5.37	
tpy	23.50		23.50	

FIGURE D – 5 Hourly Average Diesel PM Emissions at J.R. Davis Yard



APPENDIX E

Example Input To ISCST3 Model

This appendix provides an example input to the ISCST3 model. The input contains the information for a basic model run, i.e., low bound emission rate (22 TPY), Roseville meteorological data with rural dispersion coefficients, modeling domain of 6km x 8km, and modeling resolution of 50m x 50m. Please note that this is not the complete modeling input.

An Example Input to ISCST3 Model

```
** This input runstream file is for computing concentrations
** of diesel PM from Roseville Railyard.
** To run this case, type:
**
**     ISCST3 totavg.inp totavg.out
**
**    CONSIDERING BUILDING DOWNWASH
**    USING THE AVERAGE STACK INFORMATION (Read from the UP's Document)
**    GRID RECEPTORS
**    ROSEVILLE MET DATA
**
**    Relocation for Emission sources (Location file is from ROB)
**
CO STARTING
   TITLEONE  Locomotive Engines in Roseville Rail Yard
   TITLETWO  RURAL with downwash, Revised src locations
** Relocated inbound loco idling, svc track idling and load testing, trim bowl, and
** ready track sources
   MODELOPT  DFAULT RURAL CONC
   AVERTIME  PERIOD
   POLLUTID  DIESELPM
** TERRHGTS  ELEV
   FLAGPOLE  1.5
   RUNORNOT  RUN
   ERRORFIL  ERRORS.OUT
CO FINISHED

SO STARTING
** LOCATION  Srcid   Srctyp   Xs   Ys    (Zs)
** 11 locomotive models are considered and in the order of
** SWITCHER, GP-3X, GP-4X, GP-5X, GP-6X, SD-7X, SD-9X,
** and DASH-7, DASH-8, DASH-9, and CA60-A.
**
**
*********************************
** AREA SOURCES
*********************************
**
**
** Consider idling, notch 1 and notch 8 emissions from locomotives
** located in TRACK SERVICE, INBOUND AREA, SHOP-WEST, and MOD/SEARCH
** and Subway (note: Shop east has been included in Shop-West)
**
** LOCATION at INBOUND LOCOMOTIVE AREA (6 TRACKS)
**
** LOCATION FOR 1ST TRACK--MOVED
   LOCATION  IB1T01  POINT   18654.    9864.   0.
   LOCATION  IB1T02  POINT   18654.    9864.   0.
   LOCATION  IB1T03  POINT   18654.    9864.   0.
   LOCATION  IB1T04  POINT   18654.    9864.   0.
   LOCATION  IB1T05  POINT   18654.    9864.   0.
   LOCATION  IB1T06  POINT   18654.    9864.   0.
   LOCATION  IB1T07  POINT   18654.    9864.   0.
   LOCATION  IB1T08  POINT   18654.    9864.   0.
   LOCATION  IB1T09  POINT   18654.    9864.   0.
   LOCATION  IB1T10  POINT   18654.    9864.   0.
   LOCATION  IB1T11  POINT   18654.    9864.   0.
** LOCATION FOR 2ND TRACK
   LOCATION  IB2T01  POINT   18756.    9948.   0.
   LOCATION  IB2T02  POINT   18756.    9948.   0.
   LOCATION  IB2T03  POINT   18756.    9948.   0.
   LOCATION  IB2T04  POINT   18756.    9948.   0.
   LOCATION  IB2T05  POINT   18756.    9948.   0.
   LOCATION  IB2T06  POINT   18756.    9948.   0.
   LOCATION  IB2T07  POINT   18756.    9948.   0.
   LOCATION  IB2T08  POINT   18756.    9948.   0.
   LOCATION  IB2T09  POINT   18756.    9948.   0.
   LOCATION  IB2T10  POINT  18756.    9948.   0.
   LOCATION  IB2T11  POINT  18756.    9948.   0.
** LOCATION FOR 3RD TRACK--MOVED
   LOCATION  IB3T01  POINT   18693.    9896.   0.
   LOCATION  IB3T02  POINT   18693.    9896.   0.
   LOCATION  IB3T03  POINT   18693.    9896.   0.
   LOCATION  IB3T04  POINT   18693.    9896.   0.
   LOCATION  IB3T05  POINT   18693.    9896.   0.
   LOCATION  IB3T06  POINT   18693.    9896.   0.
   LOCATION  IB3T07  POINT   18693.    9896.   0.
   LOCATION  IB3T08  POINT   18693.    9896.   0.
   LOCATION  IB3T09  POINT   18693.    9896.   0.
   LOCATION  IB3T10  POINT  18693.    9896.   0.
   LOCATION  IB3T11  POINT  18693.    9896.   0.
** LOCATION FOR 4ST TRACK
   LOCATION  IB4T01  POINT   18799.    9978.   0.
   LOCATION  IB4T02  POINT   18799.    9978.   0.
   LOCATION  IB4T03  POINT   18799.    9978.   0.
   LOCATION  IB4T04  POINT   18799.    9978.   0.
   LOCATION  IB4T05  POINT   18799.    9978.   0.
   LOCATION  IB4T06  POINT   18799.    9978.   0.
   LOCATION  IB4T07  POINT   18799.    9978.   0.
   LOCATION  IB4T08  POINT   18799.    9978.   0.
   LOCATION  IB4T09  POINT   18799.    9978.   0.
   LOCATION  IB4T10  POINT  18799.    9978.   0.
   LOCATION  IB4T11  POINT  18799.    9978.   0.
** LOCATION FOR 5ST TRACK--MOVED
```

```
   LOCATION  IB5T01  POINT   18720.    9993.   0.
   LOCATION  IB5T02  POINT   18720.    9993.   0.
   LOCATION  IB5T03  POINT   18720.    9993.   0.
   LOCATION  IB5T04  POINT   18720.    9993.   0.
   LOCATION  IB5T05  POINT   18720.    9993.   0.
   LOCATION  IB5T06  POINT   18720.    9993.   0.
   LOCATION  IB5T07  POINT   18720.    9993.   0.
   LOCATION  IB5T08  POINT   18720.    9993.   0.
   LOCATION  IB5T09  POINT   18720.    9993.   0.
   LOCATION  IB5T10  POINT  18720.    9993.   0.
   LOCATION  IB5T11  POINT  18720.    9993.   0.
** LOCATION FOR 6ST TRACK
   LOCATION  IB6T01  POINT   18825.    9992.   0.
   LOCATION  IB6T02  POINT   18825.    9992.   0.
   LOCATION  IB6T03  POINT   18825.    9992.   0.
   LOCATION  IB6T04  POINT   18825.    9992.   0.
   LOCATION  IB6T05  POINT   18825.    9992.   0.
   LOCATION  IB6T06  POINT   18825.    9992.   0.
   LOCATION  IB6T07  POINT   18825.    9992.   0.
   LOCATION  IB6T08  POINT   18825.    9992.   0.
   LOCATION  IB6T09  POINT   18825.    9992.   0.
   LOCATION  IB6T10  POINT  18825.    9992.   0.
   LOCATION  IB6T11  POINT  18825.    9992.   0.
**
** LOCATION FOR SUBWAY
** LOCATION FOR 1ST TRACK
   LOCATION  SB1T01  POINT   18576.    9445.   0.
   LOCATION  SB1T02  POINT   18576.    9445.   0.
   LOCATION  SB1T03  POINT   18576.    9445.   0.
   LOCATION  SB1T04  POINT   18576.    9445.   0.
   LOCATION  SB1T05  POINT   18576.    9445.   0.
   LOCATION  SB1T06  POINT   18576.    9445.   0.
   LOCATION  SB1T07  POINT   18576.    9445.   0.
   LOCATION  SB1T08  POINT   18576.    9445.   0.
   LOCATION  SB1T09  POINT   18576.    9445.   0.
   LOCATION  SB1T10  POINT  18576.    9445.   0.
   LOCATION  SB1T11  POINT  18576.    9445.   0.
** LOCATION FOR 2ND TRACK
   LOCATION  SB2T01  POINT   18588.    9439.   0.
   LOCATION  SB2T02  POINT   18588.    9439.   0.
   LOCATION  SB2T03  POINT   18588.    9439.   0.
   LOCATION  SB2T04  POINT   18588.    9439.   0.
   LOCATION  SB2T05  POINT   18588.    9439.   0.
   LOCATION  SB2T06  POINT   18588.    9439.   0.
   LOCATION  SB2T07  POINT   18588.    9439.   0.
   LOCATION  SB2T08  POINT   18588.    9439.   0.
   LOCATION  SB2T09  POINT   18588.    9439.   0.
   LOCATION  SB2T10  POINT  18588.    9439.   0.
   LOCATION  SB2T11  POINT  18588.    9439.   0.
**
** LOCATION FOR MOD-SEARCH BUILDING
**
** LOCATION FOR 1ST TRACK AND IDLING CONDITION
   LOCATION  MIS1T01  POINT   19503.    10512.   0.
   LOCATION  MIS1T02  POINT   19503.    10512.   0.
   LOCATION  MIS1T03  POINT   19503.    10512.   0.
   LOCATION  MIS1T04  POINT   19503.    10512.   0.
   LOCATION  MIS1T05  POINT   19503.    10512.   0.
   LOCATION  MIS1T06  POINT   19503.    10512.   0.
   LOCATION  MIS1T07  POINT   19503.    10512.   0.
   LOCATION  MIS1T08  POINT   19503.    10512.   0.
   LOCATION  MIS1T09  POINT   19503.    10512.   0.
   LOCATION  MIS1T10  POINT  19503.    10512.   0.
   LOCATION  MIS1T11  POINT  19503.    10512.   0.
** LOCATION FOR 2ND TRACK
   LOCATION  MIS2T01  POINT   19510.    10504.   0.
   LOCATION  MIS2T02  POINT   19510.    10504.   0.
   LOCATION  MIS2T03  POINT   19510.    10504.   0.
   LOCATION  MIS2T04  POINT   19510.    10504.   0.
   LOCATION  MIS2T05  POINT   19510.    10504.   0.
   LOCATION  MIS2T06  POINT   19510.    10504.   0.
   LOCATION  MIS2T07  POINT   19510.    10504.   0.
   LOCATION  MIS2T08  POINT   19510.    10504.   0.
   LOCATION  MIS2T09  POINT   19510.    10504.   0.
   LOCATION  MIS2T10  POINT  19510.    10504.   0.
   LOCATION  MIS2T11  POINT  19510.    10504.   0.
**
** LOCATION FOR 1ST TRACK AND NOTCH 8 CONDITION
   LOCATION  M8S1T01  POINT   19503.    10512.   0.
   LOCATION  M8S1T02  POINT   19503.    10512.   0.
   LOCATION  M8S1T03  POINT   19503.    10512.   0.
   LOCATION  M8S1T04  POINT   19503.    10512.   0.
   LOCATION  M8S1T05  POINT   19503.    10512.   0.
   LOCATION  M8S1T06  POINT   19503.    10512.   0.
   LOCATION  M8S1T07  POINT   19503.    10512.   0.
   LOCATION  M8S1T08  POINT   19503.    10512.   0.
   LOCATION  M8S1T09  POINT   19503.    10512.   0.
   LOCATION  M8S1T10  POINT  19503.    10512.   0.
   LOCATION  M8S1T11  POINT  19503.    10512.   0.
** LOCATION FOR 2ND TRACK
   LOCATION  M8S2T01  POINT   19510.    10504.   0.
   LOCATION  M8S2T02  POINT   19510.    10504.   0.
   LOCATION  M8S2T03  POINT   19510.    10504.   0.
   LOCATION  M8S2T04  POINT   19510.    10504.   0.
   LOCATION  M8S2T05  POINT   19510.    10504.   0.
   LOCATION  M8S2T06  POINT   19510.    10504.   0.
   LOCATION  M8S2T07  POINT   19510.    10504.   0.
   LOCATION  M8S2T08  POINT   19510.    10504.   0.
   LOCATION  M8S2T09  POINT   19510.    10504.   0.
   LOCATION  M8S2T10  POINT  19510.    10504.   0.
   LOCATION  M8S2T11  POINT  19510.    10504.   0.
**
**
** LOCATION FOR SHOP WEST (POST MAINTANCE)
```

```
** IDLING CONDITION
** LOCATION FOR 1ST TRACK
   LOCATION  SIW1T01  POINT   19523.    10586.   0.
   LOCATION  SIW1T02  POINT   19523.    10586.   0.
   LOCATION  SIW1T03  POINT   19523.    10586.   0.
   LOCATION  SIW1T04  POINT   19523.    10586.   0.
   LOCATION  SIW1T05  POINT   19523.    10586.   0.
   LOCATION  SIW1T06  POINT   19523.    10586.   0.
   LOCATION  SIW1T07  POINT   19523.    10586.   0.
   LOCATION  SIW1T08  POINT   19523.    10586.   0.
   LOCATION  SIW1T09  POINT   19523.    10586.   0.
   LOCATION  SIW1T10  POINT  19523.    10586.   0.
   LOCATION  SIW1T11  POINT  19523.    10586.   0.
** LOCATION FOR 2ND TRACK
   LOCATION  SIW2T01  POINT   19518.    10592.   0.
   LOCATION  SIW2T02  POINT   19518.    10592.   0.
   LOCATION  SIW2T03  POINT   19518.    10592.   0.
   LOCATION  SIW2T04  POINT   19518.    10592.   0.
   LOCATION  SIW2T05  POINT   19518.    10592.   0.
   LOCATION  SIW2T06  POINT   19518.    10592.   0.
   LOCATION  SIW2T07  POINT   19518.    10592.   0.
   LOCATION  SIW2T08  POINT   19518.    10592.   0.
   LOCATION  SIW2T09  POINT   19518.    10592.   0.
   LOCATION  SIW2T10  POINT  19518.    10592.   0.
   LOCATION  SIW2T11  POINT  19518.    10592.   0.
** LOCATION FOR 3RD TRACK
   LOCATION  SIW3T01  POINT   19511.    10599.   0.
   LOCATION  SIW3T02  POINT   19511.    10599.   0.
   LOCATION  SIW3T03  POINT   19511.    10599.   0.
   LOCATION  SIW3T04  POINT   19511.    10599.   0.
   LOCATION  SIW3T05  POINT   19511.    10599.   0.
   LOCATION  SIW3T06  POINT   19511.    10599.   0.
   LOCATION  SIW3T07  POINT   19511.    10599.   0.
   LOCATION  SIW3T08  POINT   19511.    10599.   0.
   LOCATION  SIW3T09  POINT   19511.    10599.   0.
   LOCATION  SIW3T10  POINT  19511.    10599.   0.
   LOCATION  SIW3T11  POINT  19511.    10599.   0.
** LOCATION FOR 4ST TRACK
   LOCATION  SIW4T01  POINT   19508.    10604.   0.
   LOCATION  SIW4T02  POINT   19508.    10604.   0.
   LOCATION  SIW4T03  POINT   19508.    10604.   0.
   LOCATION  SIW4T04  POINT   19508.    10604.   0.
   LOCATION  SIW4T05  POINT   19508.    10604.   0.
   LOCATION  SIW4T06  POINT   19508.    10604.   0.
   LOCATION  SIW4T07  POINT   19508.    10604.   0.
   LOCATION  SIW4T08  POINT   19508.    10604.   0.
   LOCATION  SIW4T09  POINT   19508.    10604.   0.
   LOCATION  SIW4T10  POINT  19508.    10604.   0.
   LOCATION  SIW4T11  POINT  19508.    10604.   0.
** LOCATION FOR 5ST TRACK
   LOCATION  SIW5T01  POINT   19503.    10609.   0.
   LOCATION  SIW5T02  POINT   19503.    10609.   0.
   LOCATION  SIW5T03  POINT   19503.    10609.   0.
   LOCATION  SIW5T04  POINT   19503.    10609.   0.
   LOCATION  SIW5T05  POINT   19503.    10609.   0.
   LOCATION  SIW5T06  POINT   19503.    10609.   0.
   LOCATION  SIW5T07  POINT   19503.    10609.   0.
   LOCATION  SIW5T08  POINT   19503.    10609.   0.
   LOCATION  SIW5T09  POINT   19503.    10609.   0.
   LOCATION  SIW5T10  POINT  19503.    10609.   0.
   LOCATION  SIW5T11  POINT  19503.    10609.   0.
**
** NOTCH 1 CONDITION
** LOCATION FOR 1ST TRACK
   LOCATION  S1W1T01  POINT   19523.    10586.   0.
   LOCATION  S1W1T02  POINT   19523.    10586.   0.
   LOCATION  S1W1T03  POINT   19523.    10586.   0.
   LOCATION  S1W1T04  POINT   19523.    10586.   0.
   LOCATION  S1W1T05  POINT   19523.    10586.   0.
   LOCATION  S1W1T06  POINT   19523.    10586.   0.
   LOCATION  S1W1T07  POINT   19523.    10586.   0.
   LOCATION  S1W1T08  POINT   19523.    10586.   0.
   LOCATION  S1W1T09  POINT   19523.    10586.   0.
   LOCATION  S1W1T10  POINT  19523.    10586.   0.
   LOCATION  S1W1T11  POINT  19523.    10586.   0.
** LOCATION FOR 2ND TRACK
   LOCATION  S1W2T01  POINT   19518.    10592.   0.
   LOCATION  S1W2T02  POINT   19518.    10592.   0.
   LOCATION  S1W2T03  POINT   19518.    10592.   0.
   LOCATION  S1W2T04  POINT   19518.    10592.   0.
   LOCATION  S1W2T05  POINT   19518.    10592.   0.
   LOCATION  S1W2T06  POINT   19518.    10592.   0.
   LOCATION  S1W2T07  POINT   19518.    10592.   0.
   LOCATION  S1W2T08  POINT   19518.    10592.   0.
   LOCATION  S1W2T09  POINT   19518.    10592.   0.
   LOCATION  S1W2T10  POINT  19518.    10592.   0.
   LOCATION  S1W2T11  POINT  19518.    10592.   0.
** LOCATION FOR 3RD TRACK
   LOCATION  S1W3T01  POINT   19511.    10599.   0.
   LOCATION  S1W3T02  POINT   19511.    10599.   0.
   LOCATION  S1W3T03  POINT   19511.    10599.   0.
   LOCATION  S1W3T04  POINT   19511.    10599.   0.
   LOCATION  S1W3T05  POINT   19511.    10599.   0.
   LOCATION  S1W3T06  POINT   19511.    10599.   0.
   LOCATION  S1W3T07  POINT   19511.    10599.   0.
   LOCATION  S1W3T08  POINT   19511.    10599.   0.
   LOCATION  S1W3T09  POINT   19511.    10599.   0.
   LOCATION  S1W3T10  POINT  19511.    10599.   0.
   LOCATION  S1W3T11  POINT  19511.    10599.   0.
** LOCATION FOR 4ST TRACK
   LOCATION  S1W4T01  POINT   19508.    10604.   0.
   LOCATION  S1W4T02  POINT   19508.    10604.   0.
   LOCATION  S1W4T03  POINT   19508.    10604.   0.
   LOCATION  S1W4T04  POINT   19508.    10604.   0.
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   LOCATION  S1W4T05  POINT   19508.    10604.   0.
   LOCATION  S1W4T06  POINT   19508.    10604.   0.
   LOCATION  S1W4T07  POINT   19508.    10604.   0.
   LOCATION  S1W4T08  POINT   19508.    10604.   0.
   LOCATION  S1W4T09  POINT   19508.    10604.   0.
   LOCATION  S1W4T10  POINT  19508.    10604.   0.
   LOCATION  S1W4T11  POINT  19508.    10604.   0.
** LOCATION FOR 5ST TRACK
   LOCATION  S1W5T01  POINT   19503.    10609.   0.
   LOCATION  S1W5T02  POINT   19503.    10609.   0.
   LOCATION  S1W5T03  POINT   19503.    10609.   0.
   LOCATION  S1W5T04  POINT   19503.    10609.   0.
   LOCATION  S1W5T05  POINT   19503.    10609.   0.
   LOCATION  S1W5T06  POINT   19503.    10609.   0.
   LOCATION  S1W5T07  POINT   19503.    10609.   0.
   LOCATION  S1W5T08  POINT   19503.    10609.   0.
   LOCATION  S1W5T09  POINT   19503.    10609.   0.
   LOCATION  S1W5T10  POINT  19503.    10609.   0.
   LOCATION  S1W5T11  POINT  19503.    10609.   0.
**
** NOTCH 8 CONDITION
** LOCATION FOR 1ST TRACK
   LOCATION  S8W1T01  POINT   19523.    10586.   0.
   LOCATION  S8W1T02  POINT   19523.    10586.   0.
   LOCATION  S8W1T03  POINT   19523.    10586.   0.
   LOCATION  S8W1T04  POINT   19523.    10586.   0.
   LOCATION  S8W1T05  POINT   19523.    10586.   0.
   LOCATION  S8W1T06  POINT   19523.    10586.   0.
   LOCATION  S8W1T07  POINT   19523.    10586.   0.
   LOCATION  S8W1T08  POINT   19523.    10586.   0.
   LOCATION  S8W1T09  POINT   19523.    10586.   0.
   LOCATION  S8W1T10  POINT  19523.    10586.   0.
   LOCATION  S8W1T11  POINT  19523.    10586.   0.
** LOCATION FOR 2ND TRACK
   LOCATION  S8W2T01  POINT   19518.    10592.   0.
   LOCATION  S8W2T02  POINT   19518.    10592.   0.
   LOCATION  S8W2T03  POINT   19518.    10592.   0.
   LOCATION  S8W2T04  POINT   19518.    10592.   0.
   LOCATION  S8W2T05  POINT   19518.    10592.   0.
   LOCATION  S8W2T06  POINT   19518.    10592.   0.
   LOCATION  S8W2T07  POINT   19518.    10592.   0.
   LOCATION  S8W2T08  POINT   19518.    10592.   0.
   LOCATION  S8W2T09  POINT   19518.    10592.   0.
   LOCATION  S8W2T10  POINT  19518.    10592.   0.
   LOCATION  S8W2T11  POINT  19518.    10592.   0.
** LOCATION FOR 3RD TRACK
   LOCATION  S8W3T01  POINT   19511.    10599.   0.
   LOCATION  S8W3T02  POINT   19511.    10599.   0.
   LOCATION  S8W3T03  POINT   19511.    10599.   0.
   LOCATION  S8W3T04  POINT   19511.    10599.   0.
   LOCATION  S8W3T05  POINT   19511.    10599.   0.
   LOCATION  S8W3T06  POINT   19511.    10599.   0.
   LOCATION  S8W3T07  POINT   19511.    10599.   0.
   LOCATION  S8W3T08  POINT   19511.    10599.   0.
   LOCATION  S8W3T09  POINT   19511.    10599.   0.
   LOCATION  S8W3T10  POINT  19511.    10599.   0.
   LOCATION  S8W3T11  POINT  19511.    10599.   0.
** LOCATION FOR 4ST TRACK
   LOCATION  S8W4T01  POINT   19508.    10604.   0.
   LOCATION  S8W4T02  POINT   19508.    10604.   0.
   LOCATION  S8W4T03  POINT   19508.    10604.   0.
   LOCATION  S8W4T04  POINT   19508.    10604.   0.
   LOCATION  S8W4T05  POINT   19508.    10604.   0.
   LOCATION  S8W4T06  POINT   19508.    10604.   0.
   LOCATION  S8W4T07  POINT   19508.    10604.   0.
   LOCATION  S8W4T08  POINT   19508.    10604.   0.
   LOCATION  S8W4T09  POINT   19508.    10604.   0.
   LOCATION  S8W4T10  POINT  19508.    10604.   0.
   LOCATION  S8W4T11  POINT  19508.    10604.   0.
** LOCATION FOR 5ST TRACK
   LOCATION  S8W5T01  POINT   19503.    10609.   0.
   LOCATION  S8W5T02  POINT   19503.    10609.   0.
   LOCATION  S8W5T03  POINT   19503.    10609.   0.
   LOCATION  S8W5T04  POINT   19503.    10609.   0.
   LOCATION  S8W5T05  POINT   19503.    10609.   0.
   LOCATION  S8W5T06  POINT   19503.    10609.   0.
   LOCATION  S8W5T07  POINT   19503.    10609.   0.
   LOCATION  S8W5T08  POINT   19503.    10609.   0.
   LOCATION  S8W5T09  POINT   19503.    10609.   0.
   LOCATION  S8W5T10  POINT  19503.    10609.   0.
   LOCATION  S8W5T11  POINT  19503.    10609.   0.
**
** LOCATION FOR SERVICE TRACK AREA (5 TRACKS)
** IN-BOUND (1-hr) IDLING
** LOCATION FOR 1ST TRACK
   LOCATION  SIT1T01  POINT   19187.   10334.   0.
   LOCATION  SIT1T02  POINT   19187.   10334.   0.
   LOCATION  SIT1T03  POINT   19187.   10334.   0.
   LOCATION  SIT1T04  POINT   19187.   10334.   0.
   LOCATION  SIT1T05  POINT   19187.   10334.   0.
   LOCATION  SIT1T06  POINT   19187.   10334.   0.
   LOCATION  SIT1T07  POINT   19187.   10334.   0.
   LOCATION  SIT1T08  POINT   19187.   10334.   0.
   LOCATION  SIT1T09  POINT   19187.   10334.   0.
   LOCATION  SIT1T10  POINT  19187.   10334.   0.
   LOCATION  SIT1T11  POINT  19187.   10334.   0.
** LOCATION FOR 2ND TRACK
   LOCATION  SIT2T01  POINT   19168.   10314.   0.
   LOCATION  SIT2T02  POINT   19168.   10314.   0.
   LOCATION  SIT2T03  POINT   19168.   10314.   0.
   LOCATION  SIT2T04  POINT   19168.   10314.   0.
   LOCATION  SIT2T05  POINT   19168.   10314.   0.
   LOCATION  SIT2T06  POINT   19168.   10314.   0.
   LOCATION  SIT2T07  POINT   19168.   10314.   0.
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   LOCATION  SIT2T08  POINT   19168.   10314.   0.
   LOCATION  SIT2T09  POINT   19168.   10314.   0.
   LOCATION  SIT2T010  POINT  19168.   10314.   0.
   LOCATION  SIT2T011  POINT  19168.   10314.   0.
** LOCATION FOR 3RD TRACK
   LOCATION  SIT3T01  POINT   19207.   10354.   0.
   LOCATION  SIT3T02  POINT   19207.   10354.   0.
   LOCATION  SIT3T03  POINT   19207.   10354.   0.
   LOCATION  SIT3T04  POINT   19207.   10354.   0.
   LOCATION  SIT3T05  POINT   19207.   10354.   0.
   LOCATION  SIT3T06  POINT   19207.   10354.   0.
   LOCATION  SIT3T07  POINT   19207.   10354.   0.
   LOCATION  SIT3T08  POINT   19207.   10354.   0.
   LOCATION  SIT3T09  POINT   19207.   10354.   0.
   LOCATION  SIT3T10  POINT  19207.   10354.   0.
   LOCATION  SIT3T11  POINT  19207.   10354.   0.
** LOCATION FOR 4ST TRACK
   LOCATION  SIT4T01  POINT   19141.   10284.   0.
   LOCATION  SIT4T02  POINT   19141.   10284.   0.
   LOCATION  SIT4T03  POINT   19141.   10284.   0.
   LOCATION  SIT4T04  POINT   19141.   10284.   0.
   LOCATION  SIT4T05  POINT   19141.   10284.   0.
   LOCATION  SIT4T06  POINT   19141.   10284.   0.
   LOCATION  SIT4T07  POINT   19141.   10284.   0.
   LOCATION  SIT4T08  POINT   19141.   10284.   0.
   LOCATION  SIT4T09  POINT   19141.   10284.   0.
   LOCATION  SIT4T10  POINT  19141.   10284.   0.
   LOCATION  SIT4T11  POINT  19141.   10284.   0.
** LOCATION FOR 5ST TRACK
   LOCATION  SIT5T01  POINT   19065.   10210.   0.
   LOCATION  SIT5T02  POINT   19065.   10210.   0.
   LOCATION  SIT5T03  POINT   19065.   10210.   0.
   LOCATION  SIT5T04  POINT   19065.   10210.   0.
   LOCATION  SIT5T05  POINT   19065.   10210.   0.
   LOCATION  SIT5T06  POINT   19065.   10210.   0.
   LOCATION  SIT5T07  POINT   19065.   10210.   0.
   LOCATION  SIT5T08  POINT   19065.   10210.   0.
   LOCATION  SIT5T09  POINT   19065.   10210.   0.
   LOCATION  SIT5T10  POINT  19065.   10210.   0.
   LOCATION  SIT5T11  POINT  19065.   10210.   0.
**
** PRE-SERVICE (IDLING + NOTCH 8)
** IDLING CONDITION
** LOCATION FOR 1ST TRACK
   LOCATION  PIS1T01  POINT   19187.   10334.   0.
   LOCATION  PIS1T02  POINT   19187.   10334.   0.
   LOCATION  PIS1T03  POINT   19187.   10334.   0.
   LOCATION  PIS1T04  POINT   19187.   10334.   0.
   LOCATION  PIS1T05  POINT   19187.   10334.   0.
   LOCATION  PIS1T06  POINT   19187.   10334.   0.
   LOCATION  PIS1T07  POINT   19187.   10334.   0.
   LOCATION  PIS1T08  POINT   19187.   10334.   0.
   LOCATION  PIS1T09  POINT   19187.   10334.   0.
   LOCATION  PIS1T10  POINT  19187.   10334.   0.
   LOCATION  PIS1T11  POINT  19187.   10334.   0.
** LOCATION FOR 2ND TRACK
   LOCATION  PIS2T01  POINT   19168.   10314.   0.
   LOCATION  PIS2T02  POINT   19168.   10314.   0.
   LOCATION  PIS2T03  POINT   19168.   10314.   0.
   LOCATION  PIS2T04  POINT   19168.   10314.   0.
   LOCATION  PIS2T05  POINT   19168.   10314.   0.
   LOCATION  PIS2T06  POINT   19168.   10314.   0.
   LOCATION  PIS2T07  POINT   19168.   10314.   0.
   LOCATION  PIS2T08  POINT   19168.   10314.   0.
   LOCATION  PIS2T09  POINT   19168.   10314.   0.
   LOCATION  PIS2T10  POINT  19168.   10314.   0.
   LOCATION  PIS2T11  POINT  19168.   10314.   0.
** LOCATION FOR 3RD TRACK
   LOCATION  PIS3T01  POINT   19207.   10354.   0.
   LOCATION  PIS3T02  POINT   19207.   10354.   0.
   LOCATION  PIS3T03  POINT   19207.   10354.   0.
   LOCATION  PIS3T04  POINT   19207.   10354.   0.
   LOCATION  PIS3T05  POINT   19207.   10354.   0.
   LOCATION  PIS3T06  POINT   19207.   10354.   0.
   LOCATION  PIS3T07  POINT   19207.   10354.   0.
   LOCATION  PIS3T08  POINT   19207.   10354.   0.
   LOCATION  PIS3T09  POINT   19207.   10354.   0.
   LOCATION  PIS3T10  POINT  19207.   10354.   0.
   LOCATION  PIS3T11  POINT  19207.   10354.   0.
** LOCATION FOR 4ST TRACK
   LOCATION  PIS4T01  POINT   19141.   10284.   0.
   LOCATION  PIS4T02  POINT   19141.   10284.   0.
   LOCATION  PIS4T03  POINT   19141.   10284.   0.
   LOCATION  PIS4T04  POINT   19141.   10284.   0.
   LOCATION  PIS4T05  POINT   19141.   10284.   0.
   LOCATION  PIS4T06  POINT   19141.   10284.   0.
   LOCATION  PIS4T07  POINT   19141.   10284.   0.
   LOCATION  PIS4T08  POINT   19141.   10284.   0.
   LOCATION  PIS4T09  POINT   19141.   10284.   0.
   LOCATION  PIS4T10  POINT  19141.   10284.   0.
   LOCATION  PIS4T11  POINT  19141.   10284.   0.
** LOCATION FOR 5ST TRACK
   LOCATION  PIS5T01  POINT   19195.   10367.   0.
   LOCATION  PIS5T02  POINT   19195.   10367.   0.
   LOCATION  PIS5T03  POINT   19195.   10367.   0.
   LOCATION  PIS5T04  POINT   19195.   10367.   0.
   LOCATION  PIS5T05  POINT   19195.   10367.   0.
   LOCATION  PIS5T06  POINT   19195.   10367.   0.
   LOCATION  PIS5T07  POINT   19195.   10367.   0.
   LOCATION  PIS5T08  POINT   19195.   10367.   0.
   LOCATION  PIS5T09  POINT   19195.   10367.   0.
   LOCATION  PIS5T10  POINT  19195.   10367.   0.
   LOCATION  PIS5T11  POINT  19195.   10367.   0.
**
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** NOTCH 8 CONDITION
** LOCATION FOR 1ST TRACK
   LOCATION  P8S1T01  POINT   19187.   10334.   0.
   LOCATION  P8S1T02  POINT   19187.   10334.   0.
   LOCATION  P8S1T03  POINT   19187.   10334.   0.
   LOCATION  P8S1T04  POINT   19187.   10334.   0.
   LOCATION  P8S1T05  POINT   19187.   10334.   0.
   LOCATION  P8S1T06  POINT   19187.   10334.   0.
   LOCATION  P8S1T07  POINT   19187.   10334.   0.
   LOCATION  P8S1T08  POINT   19187.   10334.   0.
   LOCATION  P8S1T09  POINT   19187.   10334.   0.
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** LOCATION FOR 2ND TRACK
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   LOCATION  P8S2T07  POINT   19168.   10314.   0.
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   LOCATION  P8S2T09  POINT   19168.   10314.   0.
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   LOCATION  P8S2T11  POINT  19168.   10314.   0.
** LOCATION FOR 3RD TRACK
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** POST-MAINTENANCE SERVICE AREA (IDLING + NOTCH 1 & 8)
** IDLING CONDITION
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   LOCATION  PIM1T06  POINT   19187.   10334.   0.
   LOCATION  PIM1T07  POINT   19187.   10334.   0.
   LOCATION  PIM1T08  POINT   19187.   10334.   0.
   LOCATION  PIM1T09  POINT   19187.   10334.   0.
   LOCATION  PIM1T10  POINT  19187.   10334.   0.
   LOCATION  PIM1T11  POINT  19187.   10334.   0.
** LOCATION FOR 2ND TRACK
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   LOCATION  PIM2T06  POINT   19168.   10314.   0.
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   LOCATION  PIM2T08  POINT   19168.   10314.   0.
   LOCATION  PIM2T09  POINT   19168.   10314.   0.
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   LOCATION  PIM2T11  POINT  19168.   10314.   0.
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** LOCATION FOR 5ST TRACK
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**
** NOTCH 8 CONDITION
** LOCATION FOR 1ST TRACK
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APPENDIX F

Meteorological Data for Evaluating
Diesel PM Exposure from the
J.R. Davis Yard

Appendix F describes meteorological data available for use in dispersion modeling of the Union Pacific Railroad's J.R. Davis Yard in Roseville. On-site data are the preferred option. No on-site meteorological data are available, however there are a number of monitoring stations within 20 miles of the Yard. Data from each of these stations have some limitations. These limitations and an overall assessment of the representativeness of the data selected for modeling are also described. In addition, this appendix provides a summary of the steps taken to prepare the meteorological data collected from three air monitoring stations for input into air quality dispersion models.

1. Description

Meteorological data files were prepared and evaluated to support air quality dispersion modeling that was conducted to estimate the impacts of emissions from diesel-fueled locomotive engines associated with the activities of the Union Pacific Davis Railyard (Yard) in Roseville, California. Ideally, such modeling would be conducted using on-site data. In the absence of such data, modeling may be conducted using data from nearby stations. A number of factors, including distance, terrain, and data quality affect the representativeness of such data, and these require careful consideration.

Meteorological data necessary to support dispersion modeling include wind speed, wind direction, ambient temperature, and solar radiation. These data should be available for a five-year period and measured 24 hours a day, 365 days each year. We processed the meteorological data collected at the monitoring site closest to the Yard, the ARB's Roseville North Sunrise Station, which is approximately 1.5 miles east of the Yard's service area. In addition, we obtained pre-processed meteorological data from McClellan Air Force Base, which is located approximately 10 miles southwest of the Yard's service area.

The dispersion model used in this study, ISCST3, is a steady-state Gaussian plume model. The U.S. EPA guidance recommends that scalar average wind input be used in this model. In many areas, wind data from airports have been used for dispersion model inputs even though wind measurements reported at airports have historically been based on observed wind speed and direction during the last few minutes of each hour.

The ARB Roseville air monitoring station, although closest to the Yard, reports wind speed data processed using "vector averaging," and does not report scalar average wind speed. In effect, vector averaging estimates the direction and distance an air parcel is expected to have traveled over the course of each hour[1]. Since wind direction may vary on a minute to minute basis over the course of an hour, the nominal trajectory followed by an air parcel may meander over a wide area. In such cases, the vector average wind speed could be less than the corresponding scalar average speed. Modeled concentrations are inversely proportional to wind speed inputs, so the use of vector average winds may result in overprediction of concentrations.

To assess the representativeness of wind data from these two stations, data were also obtained and analyzed for two other locations. They are two ARB stations - Folsom-Natoma and Sacramento-Del Paso Manor that are located 10 to 15 miles from the Yard.

2. Wind Speed Comparison

Frequency distributions of wind speeds at each of the three ARB stations were calculated and are shown in Figures F-1. As seen in Figure F-1, the annual average wind speeds for the three stations are about 2.0 m/s. In general, Del Paso and Folsom show slightly lower wind speeds than Roseville. Figure F-2 compares the Roseville and McClellan wind speed distributions. We can see from Figure F-2 that McClellan meteorological data tend to have higher wind speeds. This can be attributed to several factors:

- Residential areas surround the Roseville air monitoring station, while the McClellan Air Force base is located in a very open area. Open areas tend to have higher average wind speeds compared to areas with buildings.
- The Roseville air monitoring station is closer to the Sierra foothills than McClellan Air Force base which is about 10 miles west of Roseville. Generally speaking, as you get closer to the foothills, you would expect lower wind speeds since you are further from the Sacramento River delta. In addition, as winds approach the foothills they diverge and reduce in intensity.
- Wind speeds for Roseville are vector averages and wind data for McClellan are scalar averages. Generally speaking, scalar averages could have higher wind speeds than vector averages.

[1] Different types of models require different types of meteorological inputs. Vector average winds are preferred inputs for the mass-conservative 3-dimensional grid models used to evaluate regional control strategies for photochemical smog.

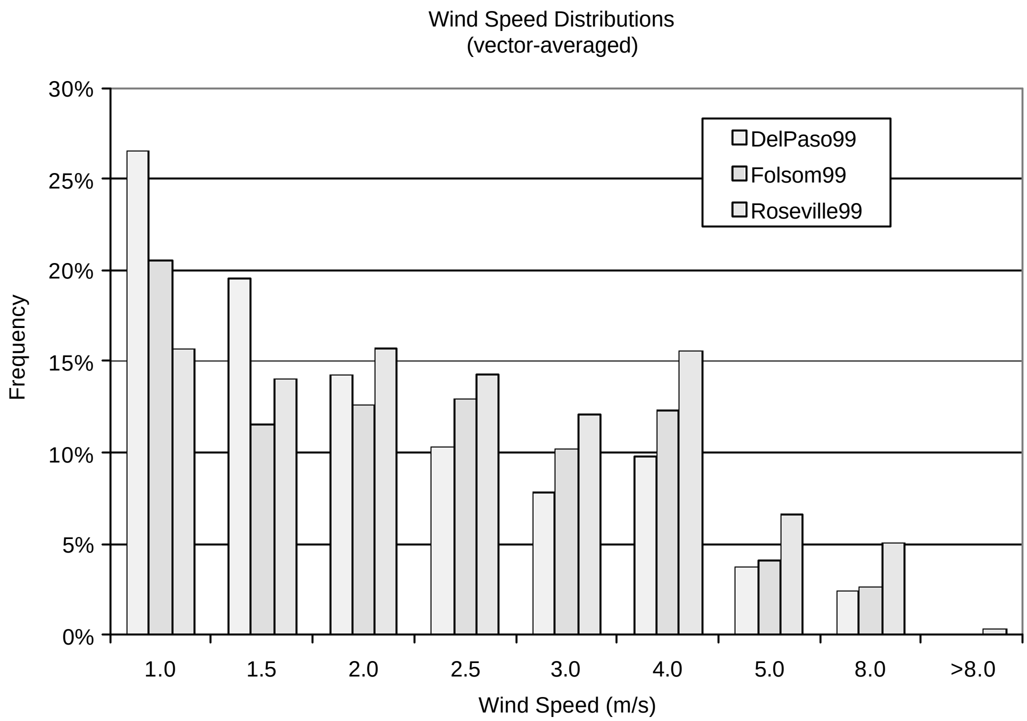


Figure F-1. Wind Speed Distributions of Three Met Data Sets

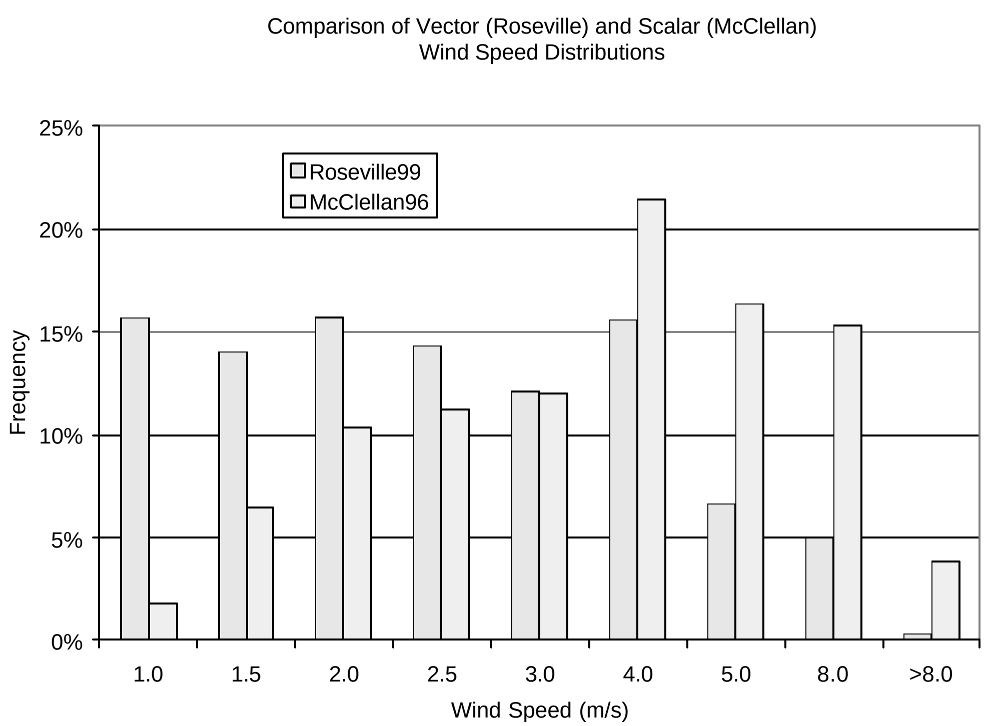


Figure F-2. Roseville and McClellan Wind Speed Distribution Comparison

Table F-1 provides wind speed statistics for the four sites. As discussed above, steady-state Gaussian dispersion models predict concentrations that are inversely proportional to wind speed. The harmonic mean[2] wind speed provides a rough basis for estimating the relative difference of the wind data sets, assuming wind directions and atmospheric stability are similar. The harmonic mean of the McClellan data, 2.58 m/s, is approximately 40 percent higher than that of the Roseville data, 1.82 m/s. Thus, with similar wind directions and atmospheric stability, modeling using the Roseville data would predict concentrations approximately 40 percent higher than the McClellan data.

Table F-1. Wind Speed Statistics

Station	Del Paso	Folsom	Roseville	McClellan
Averaging	Vector	Vector	Vector	Scalar
N	8760	8760	8760	8784
Calm	5.7%	13.1%	0.6%	0.9%
Average (m/s)	1.87	1.93	2.37	3.49
Median (m/s)	1.50	1.75	2.03	3.09
Harmonic Mean (m/s)	1.54	1.71	1.82	2.58
Max (m/s)	8.20	9.10	9.57	14.40

[2] The harmonic mean of non-zero hourly wind speeds u is calculated as $n / \sum_{i=1,n} 1/u$, the inverse of the mean inverse.

Wind patterns in the Sacramento Valley are influenced by a number of factors, including the prevailing southwesterly winds through the Carquinez Strait and the terrain effects of the Sierras and the Sierra foothills. Figure F-3 shows wind direction frequency data for Roseville, and McClellan AFB. Roseville and McClellan direction data are similar. The Roseville station, being somewhat closer to elevated terrain to the east, show prevailing flow toward 310° (Northwest), while the direction of prevailing flow at McClellan is rotated slightly to 330° (NNW).

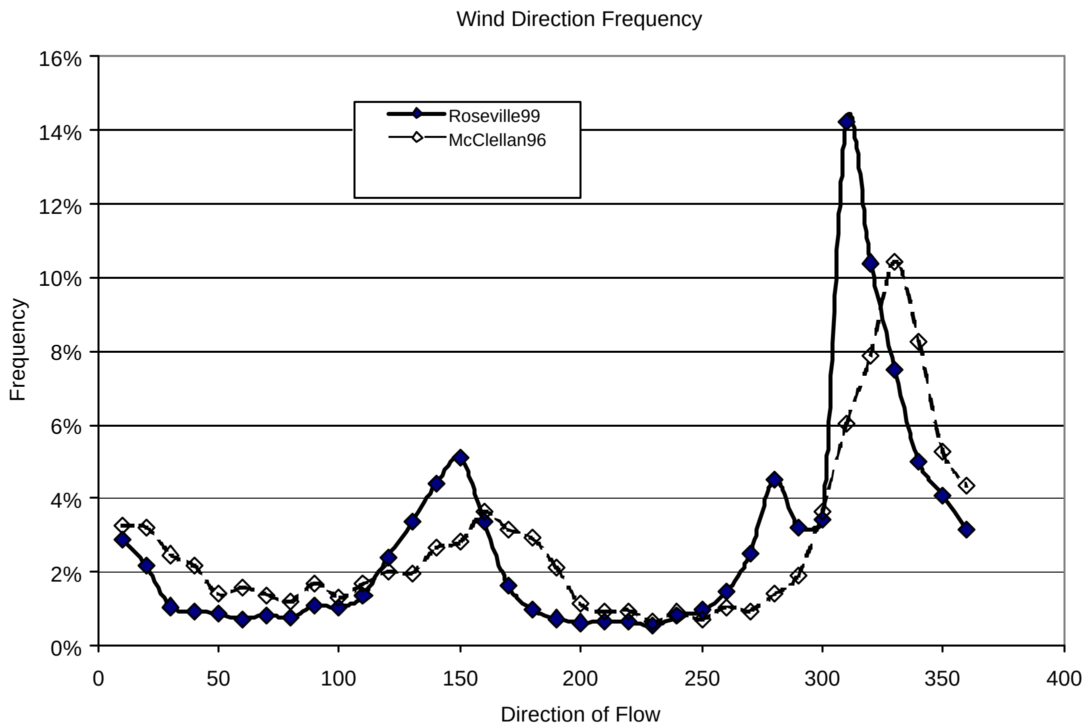


Figure F-3. Wind Direction Frequency Distribution

Traditional wind roses (showing the direction from which winds are blowing) are shown in Figures F-4 through F-7 for Roseville, Del Paso, Folsom, and McClellan AFB. These figures show the wind speed and wind direction distributions for the four sites.

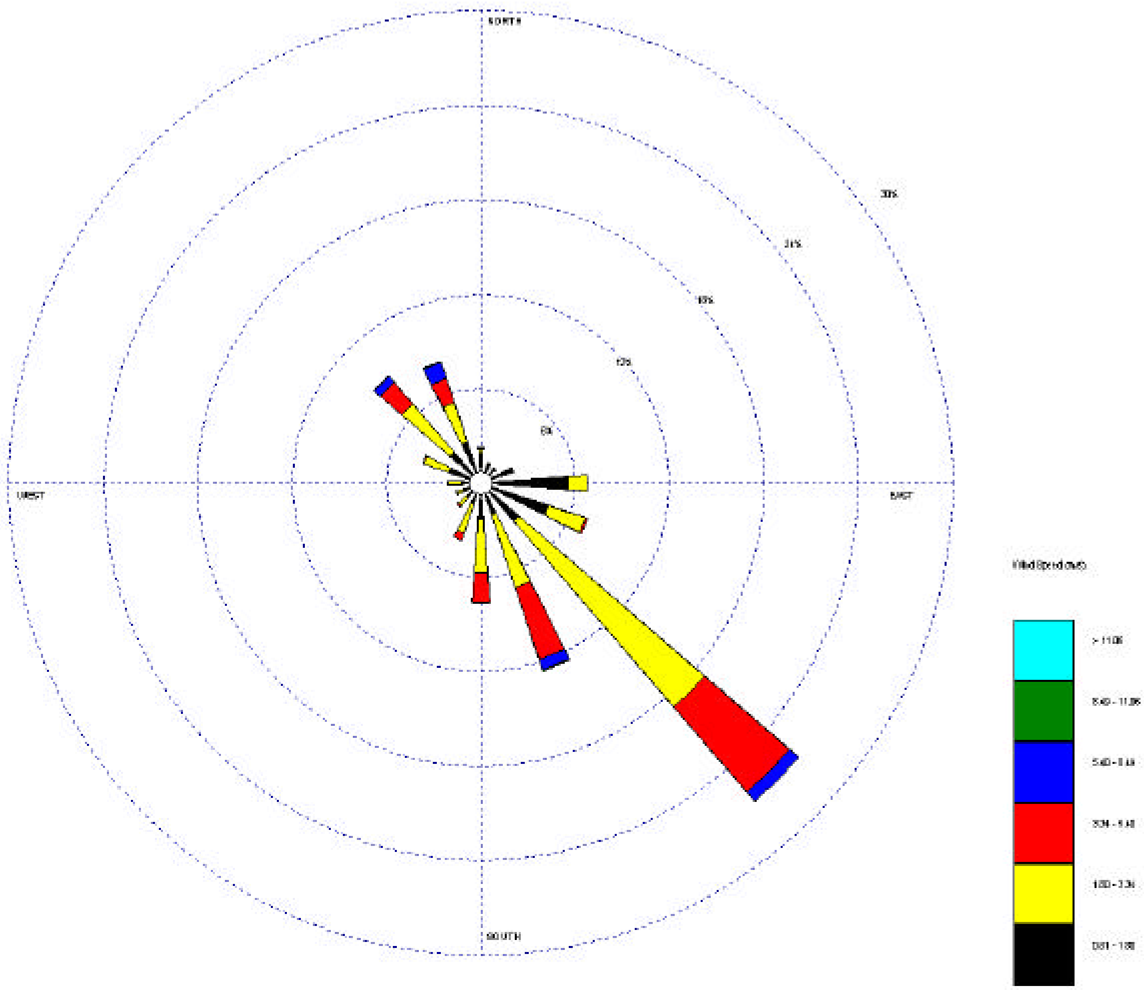


Figure F-4. Wind Speed and Direction for Roseville Station (1999)

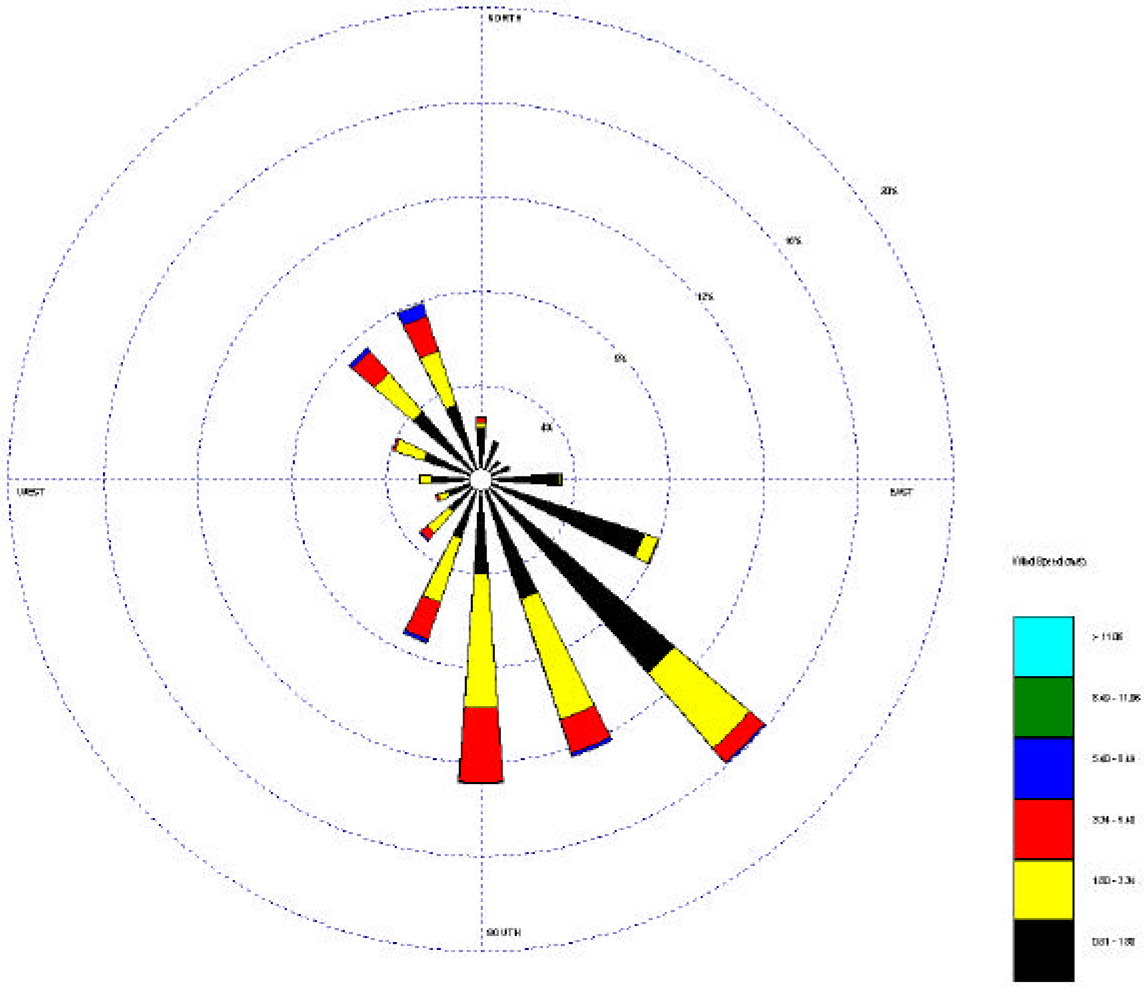


Figure F-5. Wind Speed and Direction for Del Paso Manor Station (1999)

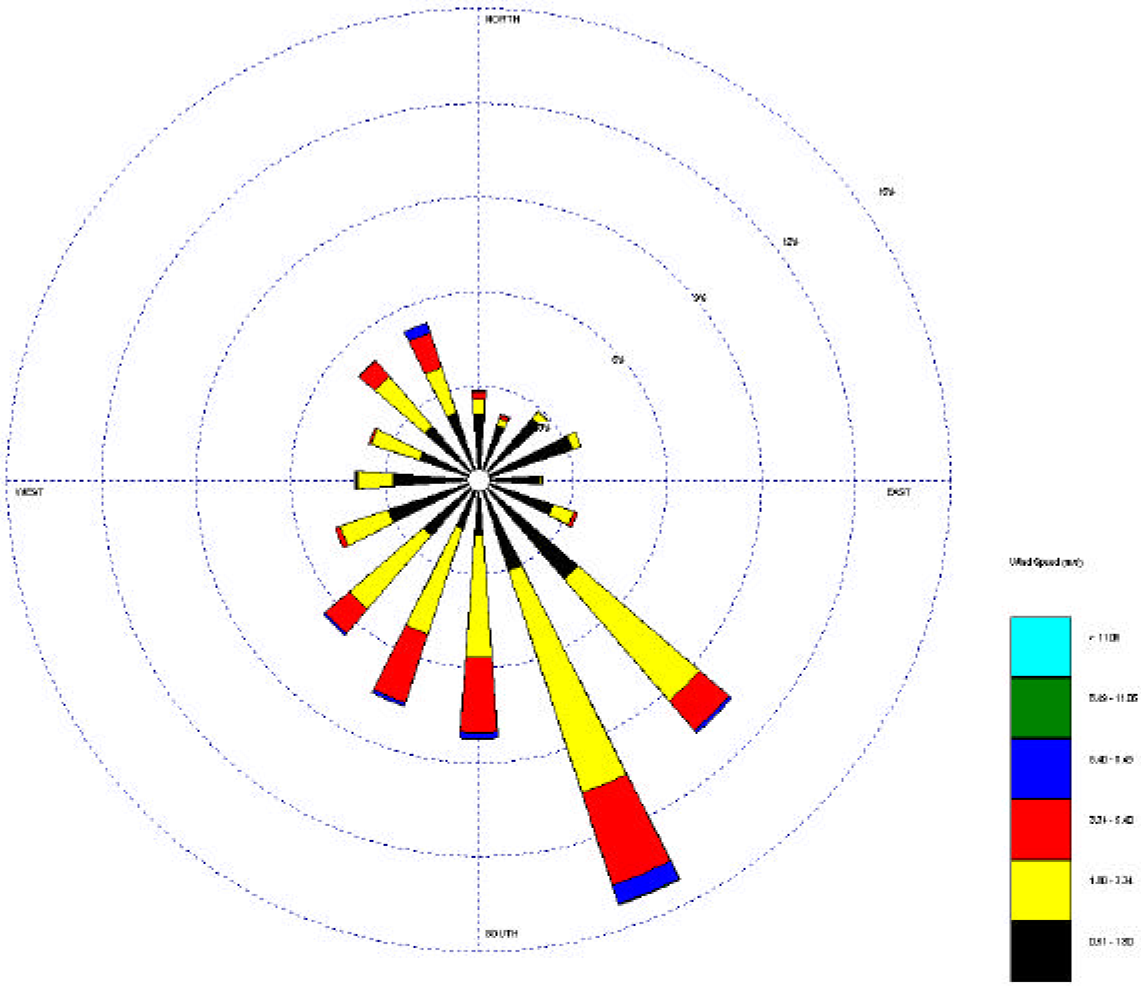


Figure F-6. Wind Speed and Direction for Folsom Station (1999)

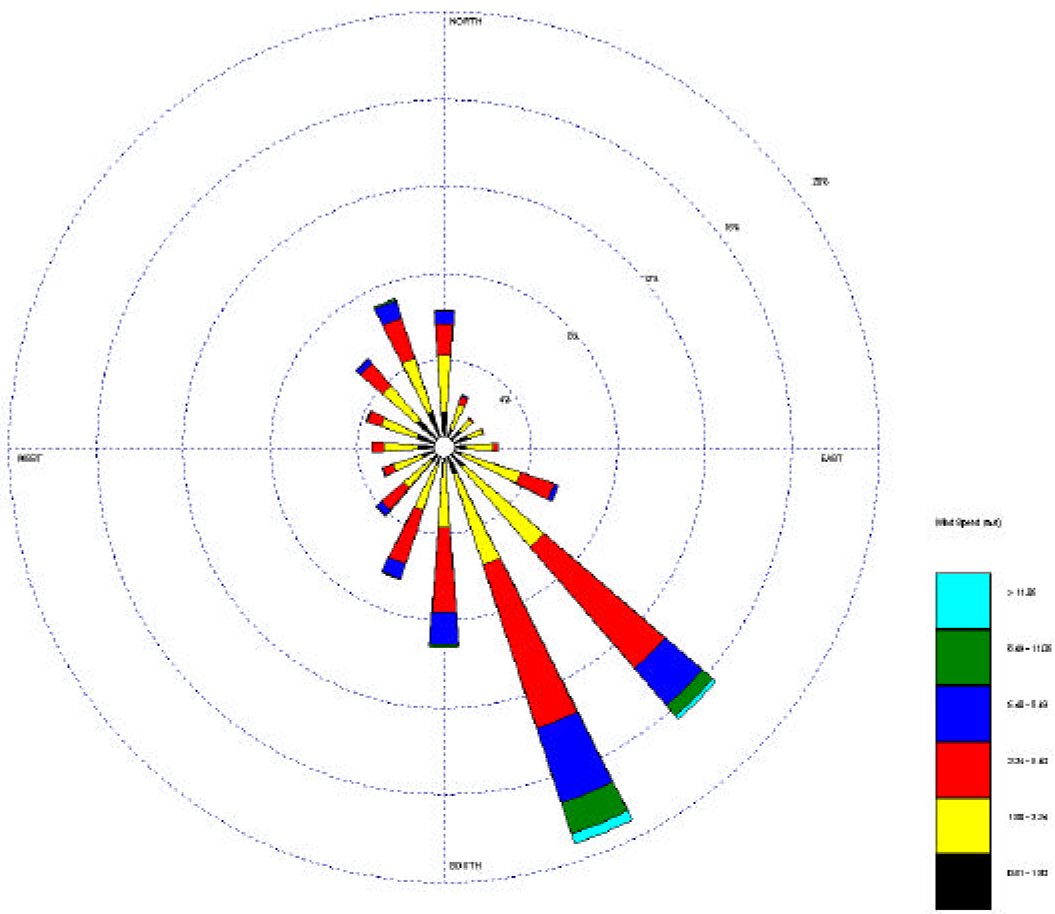


Figure F-7. Wind Speed and Direction for McClellan AFB (1996)

3. Representativeness of Wind Data

As previously noted, the absence of on-site data of the proper type for the J.R. Davis Yard requires the selection of representative data from a nearby site for input to the air dispersion model. Wind direction data for the four closest stations show consistent patterns, with winds predominately from the southeast to south, and with a secondary peak from the northwest to north. The closest station, Roseville, shows the more persistent southeasterly winds.

Because of the similarity of wind direction data, modeled concentration patterns would be expected to show generally the same shape (i.e., highest concentrations generally to the northwest of the Yard). The Roseville and McClellan sites are the closest to the Yard, and are the two most representative data sets available. Therefore, both have been used for modeling.

As the closest site, the Roseville data are expected to provide more representative wind directions than McClellan. However, the potential negative bias in wind speeds could result in higher predicted concentrations than would likely be found if on-site scalar-averaged could have been used. Modeling results based on Roseville data are likely to provide a health-protective upper bound for predicted concentrations.

The data from McClellan AFB were collected approximately 8 miles southwest of the areas of greatest activity in the Yard, and 4 miles from the southwest end of the Yard. Because of the effect of Sacramento Valley terrain on wind directions at different locations, and the rotation and somewhat higher variability in wind directions for McClellan as compared to Roseville, modeled concentrations based on these data may be slightly shifted from those that would be found using on-site data. This effect should be small near the Yard boundary. The magnitude of predicted concentrations is estimated according to the U.S. EPA modeling guidance due to the data being of the proper (scalar-averaged) form provided the meteorological data are representative of the Yard. At greater distances from the Yard, the larger variability in wind direction may result in somewhat lower concentrations than would be found with data from the Roseville air monitoring station.

4. Review and Processing of Data from ARB Stations

The remaining sections of this appendix describe the evaluation and processing of meteorological data from the ARB monitoring stations. There are three air quality monitoring stations operated by the Air Resources Board (ARB) and Sacramento Air Quality Management District (SAQMD) within a 10 to 15 miles radius of the Yard. The one closest to the Yard is the Roseville – North Sunrise Station that is located at 151 North Sunrise Blvd., Roseville, California. This station is located approximately 1 mile from the southeast boundary of the Yard. The data collected at the Roseville station were compared to those from the two next closest ARB stations to the Yard to check for inconsistencies. The station located at 50 Natoma Street in Folsom, California is approximately 10 miles southeast of the Yard. The third station is the Del Paso Manor station located at 2701 Avalon Drive in Sacramento, California, located approximately 12 miles southwest of the Yard. Each of these stations is equipped to collect the following meteorological data: wind speed, wind direction, ambient temperature, relatively humidity, and barometric pressure. In addition, solar radiation is measured at both the Folsom and Del Paso monitoring stations. A summary of the air monitoring sites and the meteorological data collected at each is provided in Table F-2.

Table F-2. Summary of Air Monitoring Stations Selected for Evaluation and Meteorological Data Availability.

Station Name	Roseville-North Sunrise	Folsom-Natoma Street	Sacramento-Del Paso Manor
Location	151 N Sunrise Blvd Roseville, CA 95661	50 Natoma St. Folsom, CA 95630	2701 Avalon Dr. Sacramento, CA 95821
Elevation (m)	161	98	8
Latitude	38^o 44' 46"	38^o 41' 2"	38^o 36' 41"
Longitude	121^o 15' 53"	121^o 9' 49"	121^o 22' 6"
Wind Speed	X	X	X
Wind Direction	X	X	X
Ambient Temperature	X	X	X
Relative Humidity	X	X	X
Barometric Pressure	X	X	X
Total Solar Radiation	–	X	X

Meteorological measurements were collected at each monitoring site on a continuous hourly average basis. The measurement methods used in the monitoring stations are listed in Table F-3. The ARB staff routinely conducts performance audits of the meteorological sensors. The data collected is submitted to the United States Environmental Protection Agency's (U.S.EPA) Aerometric Information Retrieval System (AIRS). For the preparation and evaluation of the meteorological data files, meteorological data were downloaded from the U.S.EPA AIRS website for the three monitoring stations for the time period of January 1995 to December 1999.

Table F-3. The Measurement Methods Used in the Monitoring Stations.

Parameter Measured	Methods Used
Wind Speed	Propeller or Cup Anemometer
Wind Direction	Wind Vane Potentiometer
Ambient Temperature	Aspirated Thermocouple or Thermistor
Relatively Humidity	Thin Film Capacitor
Atmospheric Pressure	Not Applicable
Solar Radiation	Thermopile or Pyranometer

5. Siting of Monitoring Stations

The siting of the three monitoring stations was evaluated to determine if the equipment placement met the criteria for meteorological towers in the *U.S. EPA Volume IV Quality Assurance Handbook for Meteorological Measurements, Section 4.0.4*, or the *ARB Air Monitoring Quality Assurance Manual, Volume II: Standard Operating Procedures for Air Quality Monitoring*. The Handbook or the Manual recommends that the 10-meter tower height is standard for supporting the meteorological sensors. The optimum measurement height may vary according to data needs. If on a building roof, the sensors should be positioned above the roof at 1.5 times the height of the building. The siting for each of the stations is summarized in Table F-4.

Table F-4. The Siting of the Monitoring Stations.

Site	Total wind sensor height above ground (m)	Platform/building height (m)	Height of sensor above platform (m)
Roseville	11.5	4.3	7.2
Del Paso Manor	10.0	N/A	N/A
Folsom	10.0	N/A	N/A

As is shown in Table 4, the siting of the wind sensors at the Folsom and Del Paso stations is standard, i.e., the towers are set up on the open ground and the sensor heights are 10 meters. For the Roseville station, although the tower is set up on the building roof, the wind sensor height does meet the “1.5 times rule,” that is, the height above the roof is at least 1.5 times the height of the building. Each of the stations is periodically subjected to meteorological audits to ensure the meteorological sensors meet the criteria set forth in *the Ambient Monitoring Guidelines for Prevention of Significant Deterioration* (U.S. EPA, May 1987) and the *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements* (U.S. EPA, March 1995). The criteria are summarized in Table F-5 and the performance audits are listed in Table F-6.

Based on the above information, we can conclude that the siting of the three monitoring stations meets the U.S EPA or ARB standards.

Table F-5. Summary of Meteorological Equipment Siting Criteria

Parameter	Height Above Ground (meters)	Horizontal Distance to Obstructions	Other Spacing Criteria
Tower	10	10 times the obstruction height, over level ground	1. An open grid tower is suggested. The tower can be free standing, hinged at the base or an elevated level, or retractable/telescoping. Manufacturer's engineering requirements should be followed for installation. 2. The tower height can vary based on the height of the source, points of impact, the use of the data, and any limitations of the site.
Wind Speed Wind Direction	10	10 times the obstruction height	1. The 10-meter tower height is standard. The optimum measurement height may vary according to data needs. 2. If on a building roof, the recommended height is 1.5 times the building height. When this height is not possible, documentation is essential. 3. The sensors should be on a boom two tower widths away from the tower side. One tower width above the tower top. 4. Flow obstructions (man-made or natural) should be well documented.
Temperature Relative Humidity	1.25 to 2	4 times the obstruction height	1. The sensor height can vary depending on the data use. 2. The sensors should be over open level ground covered in grass or dirt 9 meters in diameter. 3. The sensors should be at least 30 meters away from large paved areas, slopes, ridges, and valleys. 4. Aspirated radiation shields will be used. 5. The sensors should be on a boom one-tower width away from the tower side. 6. If delta T is measured, the sensor heights should be assigned by the regulatory agency.
Solar Radiation	Flat roof or rigid stand, which allows access to the sensor.	Obstructions should not cast a shadow on the sensor face.	1. Light colored walls or artificial radiation sources should not be near the sensor face. 2. A site survey of the angular elevation above the plane of the sensor face should be made through 360 degrees.

Note: Information is from *EPA Volume IV Quality Assurance Handbook for Meteorological*

Measurements, Section 4.0.4.

Table F-6. The Performance Audits of the Meteorological Sensors.

Parameters	Criteria
Wind Speed	Starting Threshold: less than 0.5 m/s Accuracy: +/- 0.25 m/s at speeds less than 5.0 m/s +/- 5% above 5.0 m/s
Wind Direction	Starting Threshold: less than 0.5 m/s Accuracy: +/- 5 degrees
Ambient Temperature	Accuracy: +/- 1.5 degrees Celsius
Relative Humidity	Accuracy: +/- 1.5 degrees Celsius
Barometric Pressure	Accuracy +/- 10.0 Millibars
Total Solar Radiation	Accuracy: +/- 5 %

6. Data Processing Procedures

Several data processing steps were executed to prepare the meteorological data for comparison and as model inputs. These are briefly described below.

(1) The wind speed, wind direction, ambient temperature, relative humidity, and solar radiation were reviewed to determine if the data were 90 % complete consistent with the U.S. EPA's requirement. The results for completeness checking are summarized in Table F-7. The data gaps of a few hours were filled with interpolation, and the data gaps of days were substituted by a previous or later day.

Table F-7. Raw Meteorological Data Availability Summary

Station	Parameter	Time Period	% completeness
Roseville	Wind Speed	1/1/95 - 12/31/99	100.0%
Del Paso Manor		1/1/96 - 12/31/99	92.0%
Folsom		7/1/96 - 11/30/99	99.7%
Roseville	Wind Direction	1/1/95 - 12/31/99	100.0%
Del Paso Manor		1/1/96 - 12/31/99	94.0%
Folsom		7/1/96 - 11/30/99	99.7%
Roseville	Temperature	1/1/95 - 12/31/99	100.0%
Del Paso Manor		1/1/96 - 12/31/99	99.7%
Folsom		7/1/96 - 11/30/99	97.0%
Roseville	Relative Humidity	1/1/95 - 12/31/99	98.0%
Del Paso Manor		1/1/96 - 12/31/99	99.7%
Folsom		7/1/96 - 11/30/99	93.0%
Del Paso Manor	Solar Radiation	1/1/96 - 12/31/99	96.0%
Folsom		7/1/96 - 11/30/99	99.8%

(2) All data were reformatted and all non-metric units were converted into metric systems.

(3) The Air Resources Board's CRAMMET program further processed the data. In this program, the wind flow directions were converted toward which the wind is blowing. The temperatures were converted from degree Celsius to Kevin. The day-time stability classes were calculated based on the U.S. EPA's solar radiation delta temperature methods, and the night-time stability classes were calculated solely based on the wind speeds assuming that the overcast cloud was less than 3/8. Note that the stability curves are based on 10 meters winds. If the siting of wind speed measurement sensor was not at 10 meters from ground, the wind speeds were adjusted from the siting height to 10-meter height using the power law. The mixing heights were calculated based on Holzworth seasonal averages. The input for seasonal mixing heights required by the CRAMMET program is listed in Table F-8.

Table F-8. The Inputs Required by CRAMMET for Seasonal Mixing Heights (meter)

Season	AM	PM
Winter	400	1000
Spring	600	2000
Summer	300	2000
Fall	300	1600

(4) The low wind speeds were checked. If the wind speed was less than the threshold (0.25 m/s), the wind speed was set to 0.0 m/s; if the wind speed was between the threshold and 1.0 m/s, the wind speed was set to 1.0 m/s.

The overall meteorological data processing sequence is summarized in Figure F-8.

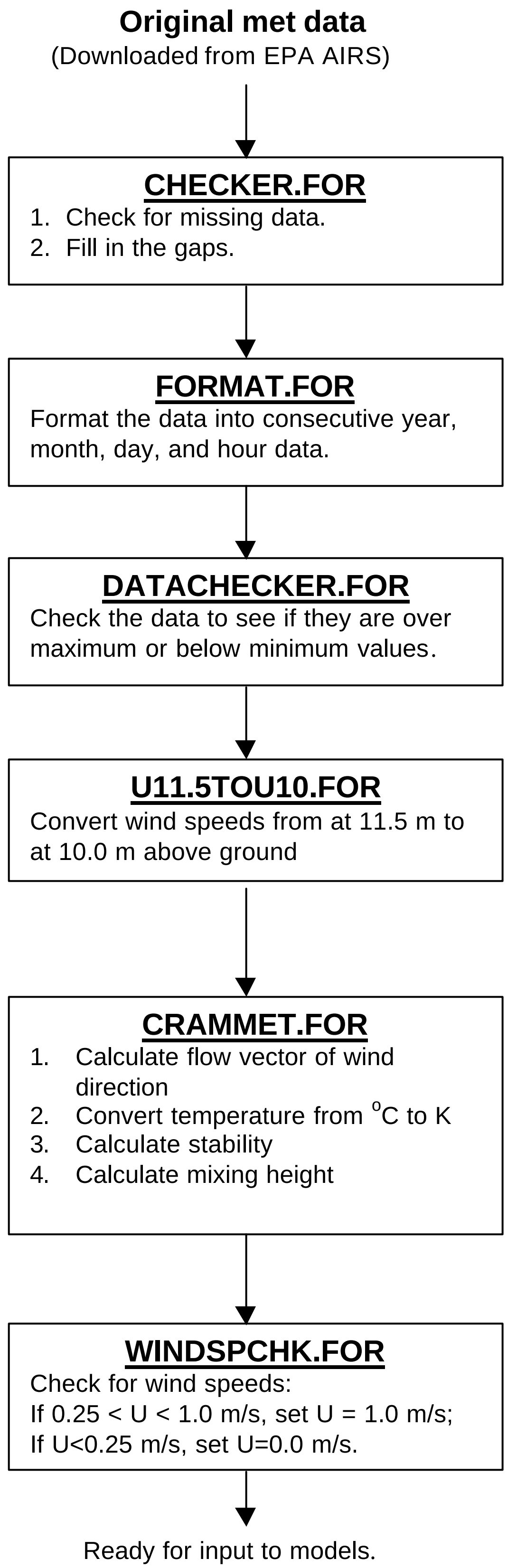


Figure F-8. Meteorological Data Processing Flow Chart

7. Results and Discussion

The meteorological data files for the Roseville, Del Paso Manor, and Folsom stations have been processed. As part of the evaluation of the meteorological data, the wind speed and wind direction were compared amongst the Roseville, Del Paso Manor, and Folsom monitoring stations for 1999. The wind roses were previously presented in Figures 5 to 7. Note that the wind direction in these graphs is from which wind is blowing. We can see that for the three monitoring stations, there was a dominant wind direction toward the northwest. The annual average wind speeds were 2.39, 1.99, and 2.22 m/s for the Roseville, Del Paso Manor, and Folsom monitoring stations, respectively. For the Roseville monitoring station, the wind speeds and wind directions exhibited a very similar pattern for each year of 1996 to 1999. The annual average wind speeds were 2.45, 2.38, 2.35, and 2.39 m/s for 1996 through 1999. The wind directions for the four-year period are presented in Figure F-9. Note that the wind direction on Figure 5 is presented in the wind direction category. There are 36-wind direction categories (1-36) ranging from 10 to 360 degree in 10-degree increments. The zero category represents calm condition in which both wind speed and direction are zero. We can see that there were only small variations in wind directions during the time period of 1996 and 1999. Nevertheless, the meteorological data from these stations has limitations. The wind speed collected was a vector averaged wind speed. U. S. EPA recommends that scalar wind speeds should be used for Gaussian plume modeling. Scalar wind speeds are generally greater than vector average winds and as a result, there may be a bias in the estimated concentrations as discussed in previous sections.

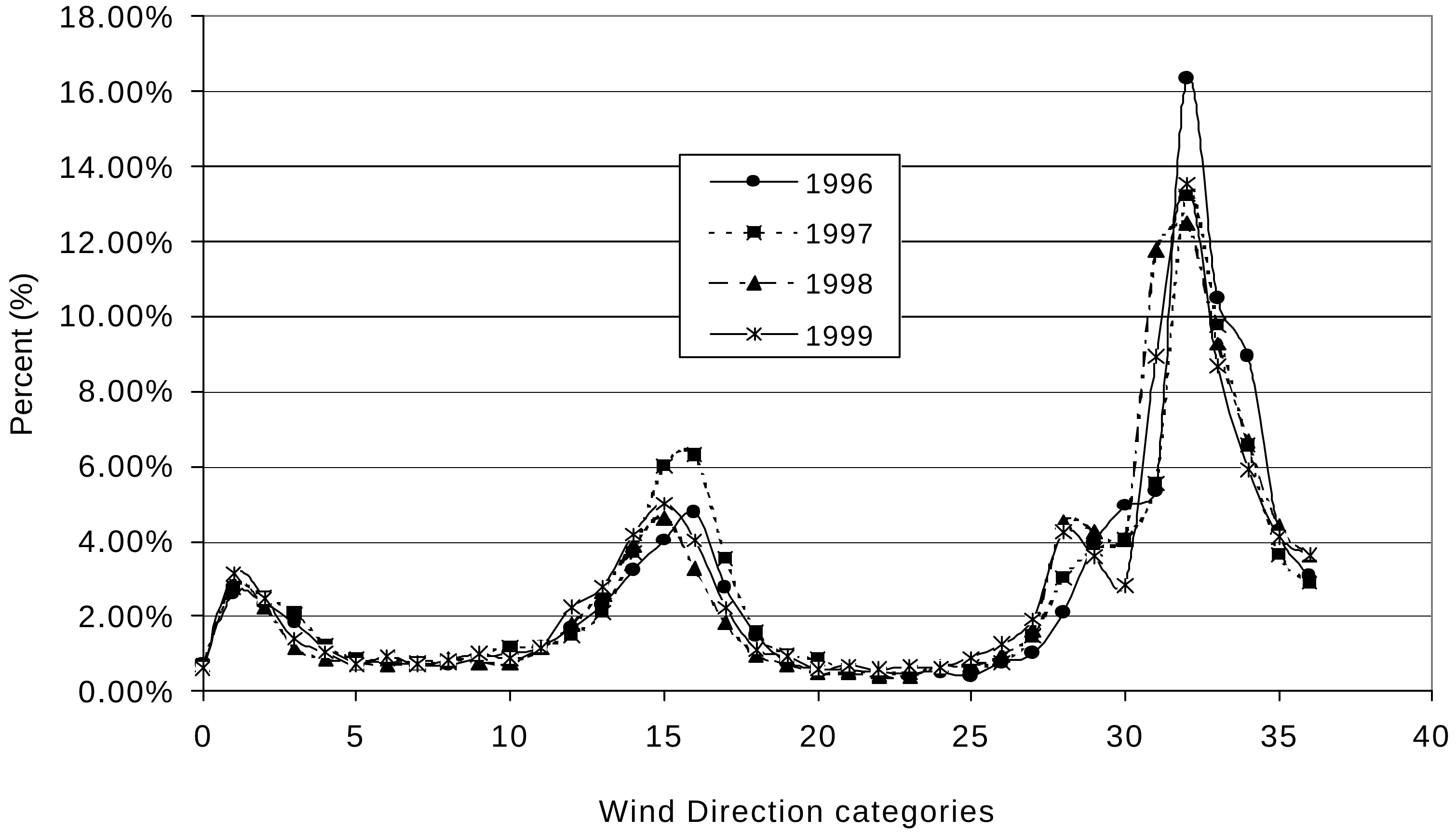


Figure F-9. Wind Direction Categories for Roseville Station During 1996 - 1999

APPENDIX G

Adjustments for Modeling Parameters

Appendix G presents the methodology used to estimate the plume rises for different locomotive types and notch settings at stabilities of D and F. The stability of D represents daytime (6am to 6pm) atmospheric conditions; while the stability of F represents night-time (6pm to 6am) atmospheric situation. The estimated plume rises were used to adjust the initial plume release heights and the initial vertical dispersion for locomotive movements within the Yard and locomotive movements in and out of the Yard when they were modeled as the volume sources.

In the Yard, most locomotives were assumed to be travelling at a setting of notch 1 or notch 2. For the "through" trains, the speeds were limited to 15 mph, or a setting of notch 3. Since most locomotive's exhaust temperatures were higher than the ambient air, a buoyancy would be produced, or a plume rise will be formed. The option of volume source in ISC models can not account for the effects. Alternatively, we used the SCREEN3 to estimate the plume rises for different locomotive types and notch settings of 1 to 3 at the stabilities of D and F. To do so, the following assumptions were made:

(1) The wind speeds used in the SCREEN3 were equal to the locomotive's movement speeds;
(2) The stack of a locomotive was located on the top of the roof for consideration of building downwash effects resulting from the locomotive itself;
(3) The stack information for different locomotives and notch settings was the same as those presented in Section B of Chapter III; and
(4) The locomotives' speeds at notches 1, 2, and 3 are as follows:

Notch setting	Speed (mph)	Speed (m/s)
1	6	2.68
2	12	5.36
3	18	8.05

The calculated plume rises are presented in the TableG:1. Note that for stability F, the maximum acceptable wind speed to the SCREEN3 is 4.0 m/s. If the wind speed was over the threshold, the plume rise calculated by the model was adjusted to the corresponding wind/locomotive speed assuming that the plume rise was proportional to $(1/U)^{(1/3)}$ (User's Guide for the Industrial Source Complex (ISC3) Dispersion Models, Volume II – Description of Model Algorithms, EPA-454/B-95-003b, p. 1-9 to 1-11).

Table G:1: Calculations of Plume Rise for Different Locomotives and Notch Settings at Stabilities of D and F

Locomotive Model	Engine Model	Locomotive Composition (%)	Plume Rise at Stability D Notch 1 (m)	Plume Rise at Stability D Notch 2 (m)	Plume Rise at Stability D Notch 3 (m)	Plume Rise at Stability F Notch 1 (m)	Plume Rise at Stability F Notch 2 (m)	Plume Rise at Stability F Notch 3 (m)
Switcher	12-645E	0.89%	0.11	0.05	0.06	3.63	4.72	5.94
GP-3X	16-645E	3.55%	0.78	0.24	0.10	6.86	7.48	6.97
GP-4X	16-645E3B	51.40%	2.69	1.33	0.73	10.00	10.88	10.98
GP-5X	16-645F3B	1.59%	2.69	1.33	0.73	10.00	10.88	10.98
GP-6X	16-710G3A	10.47%	2.69	1.33	0.73	10.00	10.88	10.98
SD-70	16-710G3B	4.99%	2.67	0.87	1.06	9.94	9.77	12.01
SD-90	16V265H	1.27%	2.67	0.87	1.06	9.94	9.77	12.01
C30-7	Dash-7	1.29%	2.67	0.87	1.06	9.94	9.77	12.01
C40-8	Dash-8	16.22%	0.69	0.49	0.32	6.55	8.28	8.71
C50-9	Dash-9	7.54%	0.25	0.09	0.15	6.74	8.28	8.71
C60-A	GE HDL	0.78%	0.25	0.09	0.15	6.74	8.28	8.71
Composite		**100.00%**	**2.07**	**1.01**	**0.61**	**9.00**	**9.98**	**10.31**

Note:

1. The SCREEN 3 was used to estimate the plume rises;
2. The train speeds were used as the wind speeds in SCREEN3;
3. For stability F, the maximum acceptable wind speed to SCREEN3 is 4.0 m/s. The plume rises at the wind speed of over 4 m/s were adjusted to the corresponding train speeds assuming the plume rise is proportional to (1/U)^(1/3);
4. The locimotive composition was based on the distribution at Receiving/Deparature Yard;
5. The plume rise didn't include the stack's physical heights.
6. The trains' speeds at notches 1, 2, and 3 are as follows:

Train Speed	(mph)	(m/s)
Notch 1	6	2.68
Notch 2	12	5.36
Notch 3	18	8.05

APPENDIX H

Isopleth Plots for Risk Exposures
and Sensitivity Studies

Appendix H provides supporting data for the risk characterization. This appendix includes

(1) Estimated Diesel PM Cancer Risks for Roseville and McClellan Met Data for the 95^{th} and 65^{th} percentile breathing rates. (Figures H1-H4 and Tables H1-H2)

(2) Temporal Variation of Annual Average Concentrations based on McClellan Met Data (Figures H5-H8)

(3) Risk Contribution from Idling and Non-idling Activities (Figures H-9 – H10)

(4) Risk Contribution from Three Major Areas (Figures H11 – H13)

(5) Risk/Concentration Changes with Downwind Distance (Figure H14)

(6) Zone Average Concentrations/Risk (Figures H15 – H16)

A. Estimated Exposures Based on Roseville Meteorological Data

Figure H-1 shows the risk isopleths for the coarse domain. In this scenario, the modeling conditions, (i.e., Roseville meteorological data, rural dispersion coefficients, and the 95th percentile breathing rate) represent the "upper-bound" (i.e., 95% confidence that the risk will not exceed this level) of the cancer risk associated with exposure to diesel exhaust from the Yard. In the upwind direction, the risk contour of 100/million is crossing highway I-80, which is about one mile from the Yard boundary. In the downwind direction, the risk contour of 100/million reaches up to 4.5 miles from the Yard boundary. The area with predicted cancer risk levels in excess of 100/million is estimated to be about 4 miles by 4 miles. The area with predicted cancer risk level in excess of 10/million is about 10 miles by 10 miles.

The risk isopleths of 10/million and 100/million for the coarse domain using Roseville meteorological data with urban dispersion coefficients and the 95th percentile breathing rate are presented in Figure H-2. The estimated offsite risk levels and the estimated impacted areas for different modeling conditions in the coarse modeling domain using Roseville meteorological data, are listed in Table H-1.[1]

Table H-1. Estimated offsite risk and the size of the impacted area for various breathing rates and dispersion coefficients (Roseville meteorological data)

Estimated Risk (per million)	Rural Disp, 95th percentile BR (acres)	Rural Disp, 65th percentile BR (acres)	Urban Disp, 95th percentile BR (acres)	Urban Disp, 65th percentile BR (acres)
Risk ≥ 10 and < 100	45,900	45,500	35,300	29,300
Risk ≥ 100 and < 500	10,500	5,840	2,360	1,260
Risk ≥ 500	120	10	50	20

The potential cancer risks based on two dispersion coefficients (rural and urban) and two breathing rates (65th and 95thpercentiles) for the medium modeling domain are also estimated. The potential risk of 200/million in the predominant wind direction can extend 1.5 to 2.5 miles from the Yard boundary for the 65th to 95th percentile breathing rates. The potential risk of 500/million extends to about 300 m to 750 m away from the Yard boundary.

The magnitude of the estimated potential cancer risk and the size of the impacted area decreases when urban dispersion coefficients are used. This is because that the urban dispersion coefficients are assumed to have a greater surface roughness (due to buildings and other structures) and thus increased dispersion as compared with rural dispersion coefficients. The increased dispersion results in a larger but less concentrated plume. (i.e., lesser risk impacts in the nearby areas of the Yard). As the

[1] Modeling inputs placing idling emissions at specific locations (e.g., at the west end of the Departure Yard), may cause modeling artifacts that are not representative of actual conditions. Such artifacts appear as high estimated concentrations in localized areas near the Yard boundary that is less than 100m across. Since such idling emissions actually occur at locations along a longer section of the track, the peak off-site concentrations may be lower.

distance from the emissions source increases, the predicted concentrations (and risk), using either the urban or rural dispersion coefficient, will tend to converge.

For all scenarios presented above, using the Roseville meteorological data the maximum potential cancer risks exceed 1000/million, but the magnitude and location vary with changes in the modeling assumptions.

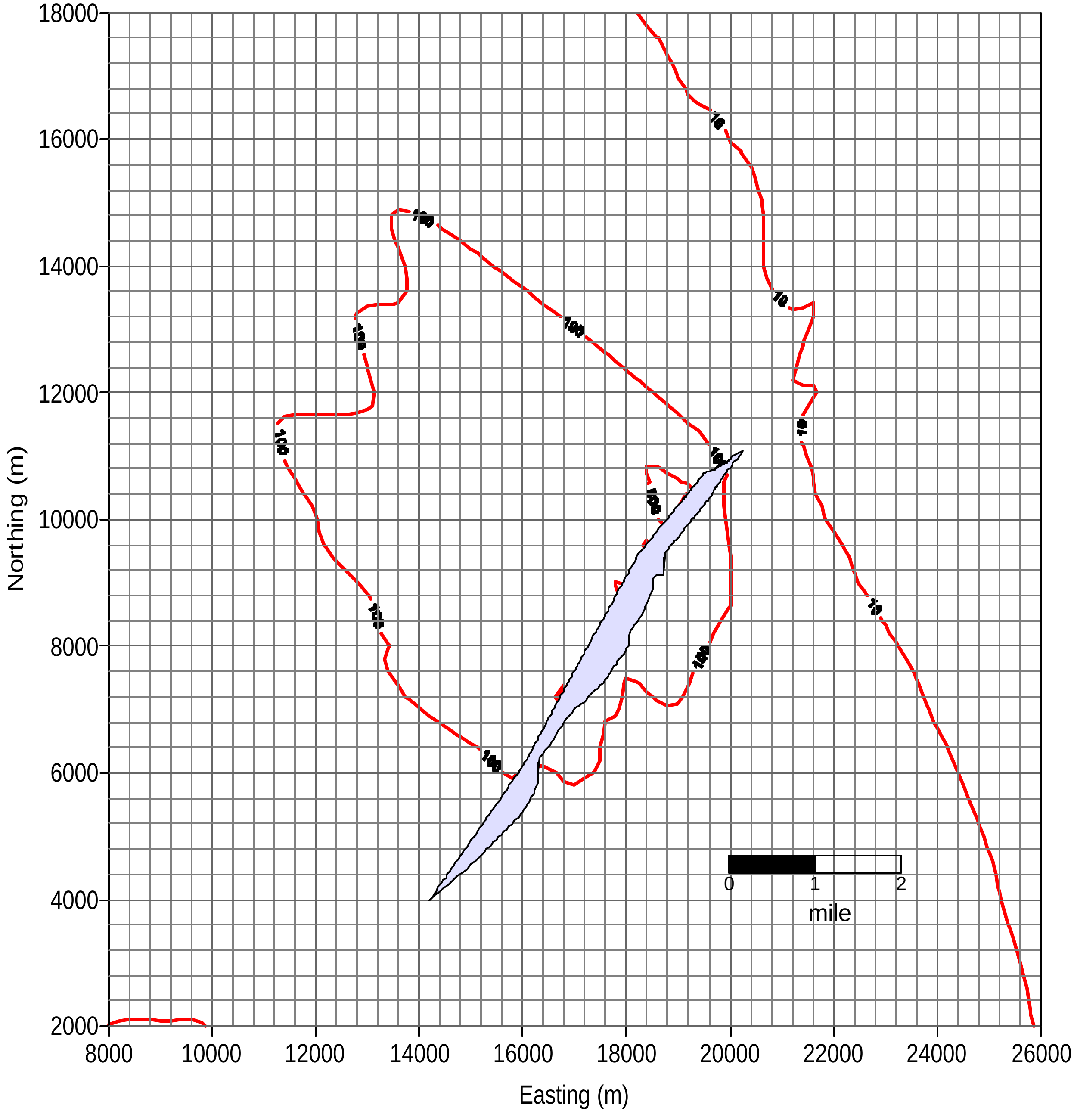


Figure H-1. Estimated Diesel PM Cancer Risk (Roseville Meteorological Data, Rural Dispersion Coefficients, 95th Percentile Breathing Rate, All Locomotive Activities [23 TPY], Modeling Domain = 10mi x 11mi, Resolution = 200m x 200m)

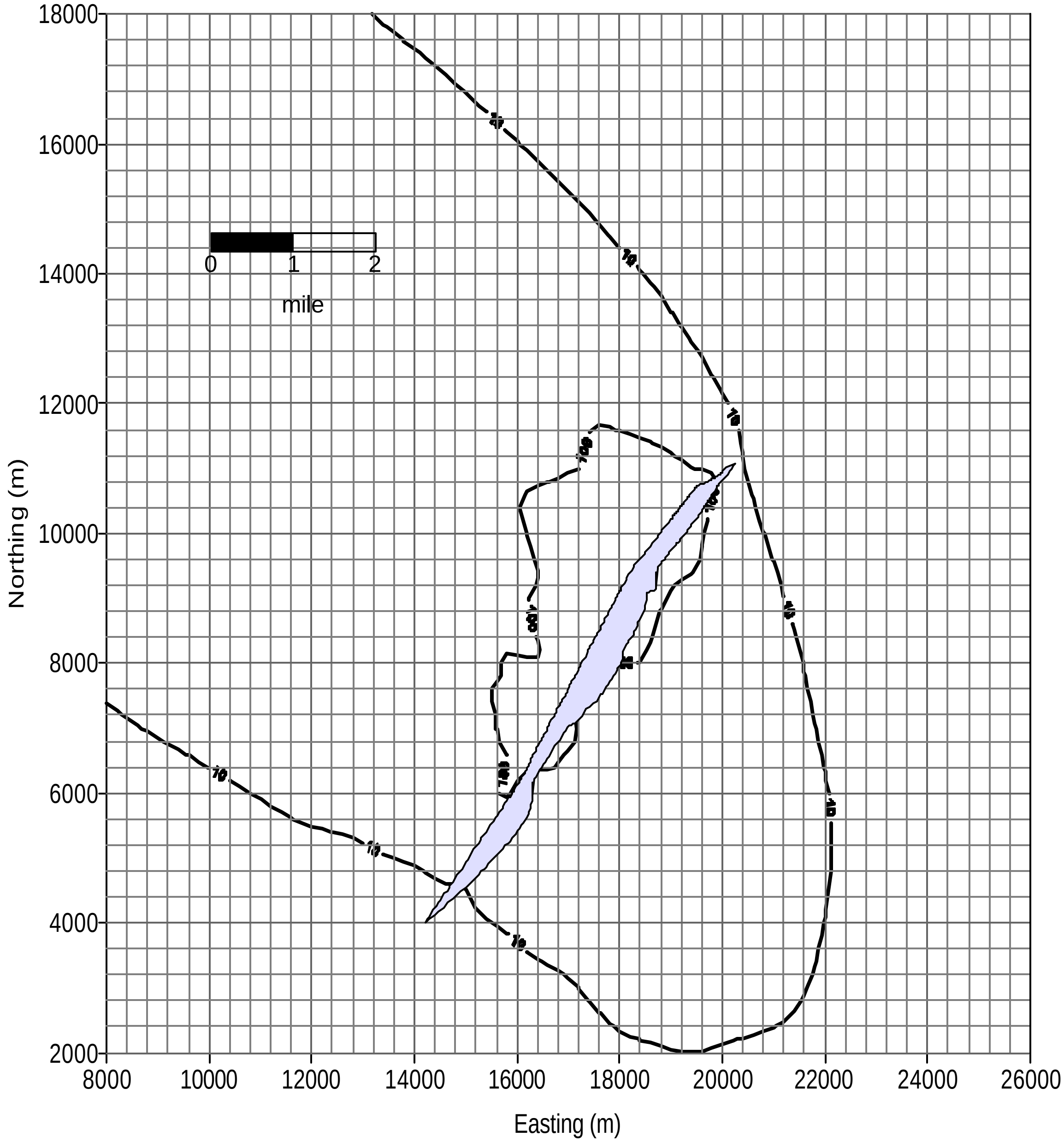


Figure H-2 . Estimated Diesel PM Cancer Risk (Roseville Meteorological Data, Urban Dispersion Coefficients, 95th Percentile Breathing Rate, All Locomotive Activies [23 TPY], Modeling Domain = 10mi x 11mi, Resolution = 200m x 200m)

B. Estimated Exposures Based on McClellan AFB Meteorological Data

Figure H-3 presents the risk distribution for the coarse modeling domain using McClellan Air Force Base (McClellan AFB) meteorological data with rural dispersion coefficients and the 95th percentile breathing rate.

The estimated cancer risk of 100/million in the predominant wind direction extends to about two miles from the Yard boundary. The area with predicted risk level in excess of 100/million is about 2 by 4 miles. The area with the predicted risk levels exceeding 10 potential cancer cases per million accounts for about 92 percent of the modeling domain, or about 10 by 10 miles.

The risk isopleths of 10/million and 100/million for the coarse modeling domain using McClellan meteorological data with urban dispersion coefficients and the 95th percentile breathing rate are presented in Figure H-4. The estimated offsite risk levels and the estimated impacted areas for different modeling conditions using McClellan AFB meteorological data in the coarse modeling domain are summarized in Table H-2.

Table H-2. Estimated offsite risk and the size of the impacted area for various breathing rates and dispersion coefficients (McClellan AFB meteorological data coarse modeling domain)

Estimated Risk (per million)	Rural Disp, 95th percentile BR (acres)	Rural Disp, 65th percentile BR (acres)	Urban Disp, 95th percentile BR (acres)	Urban Disp, 65th percentile BR (acres)
Risk ≥ 10 and < 100	61,250	52,300	29,150	18,800
Risk ≥ 100 and < 500	4,840	2,425	1,080	485
Risk ≥ 500	40	10	10	0

The predicted risk levels at all locations in the medium modeling domain exceed 10 potential cancer cases per million. The risk of 200/million in the predominant wind direction can extend to about 0.75 mile. The estimated risk of 500/million extends to about 250 to 400 m away from the Yard boundary for the 65th to 95th percentile breathing rates.

In the fine modeling domain, an area with elevated risks, 1000 cases per million, is near the *Service Area* (Area 3). The area with predicted cancer risk level between 500 to 1000 per million is about 40 acres.

Similar to the results using the Roseville meteorological data, the maximum risk for all scenarios using McClellan AFB meteorological data set exceeds 1000/million, and the magnitude and location also vary with the changes in the modeling assumptions.

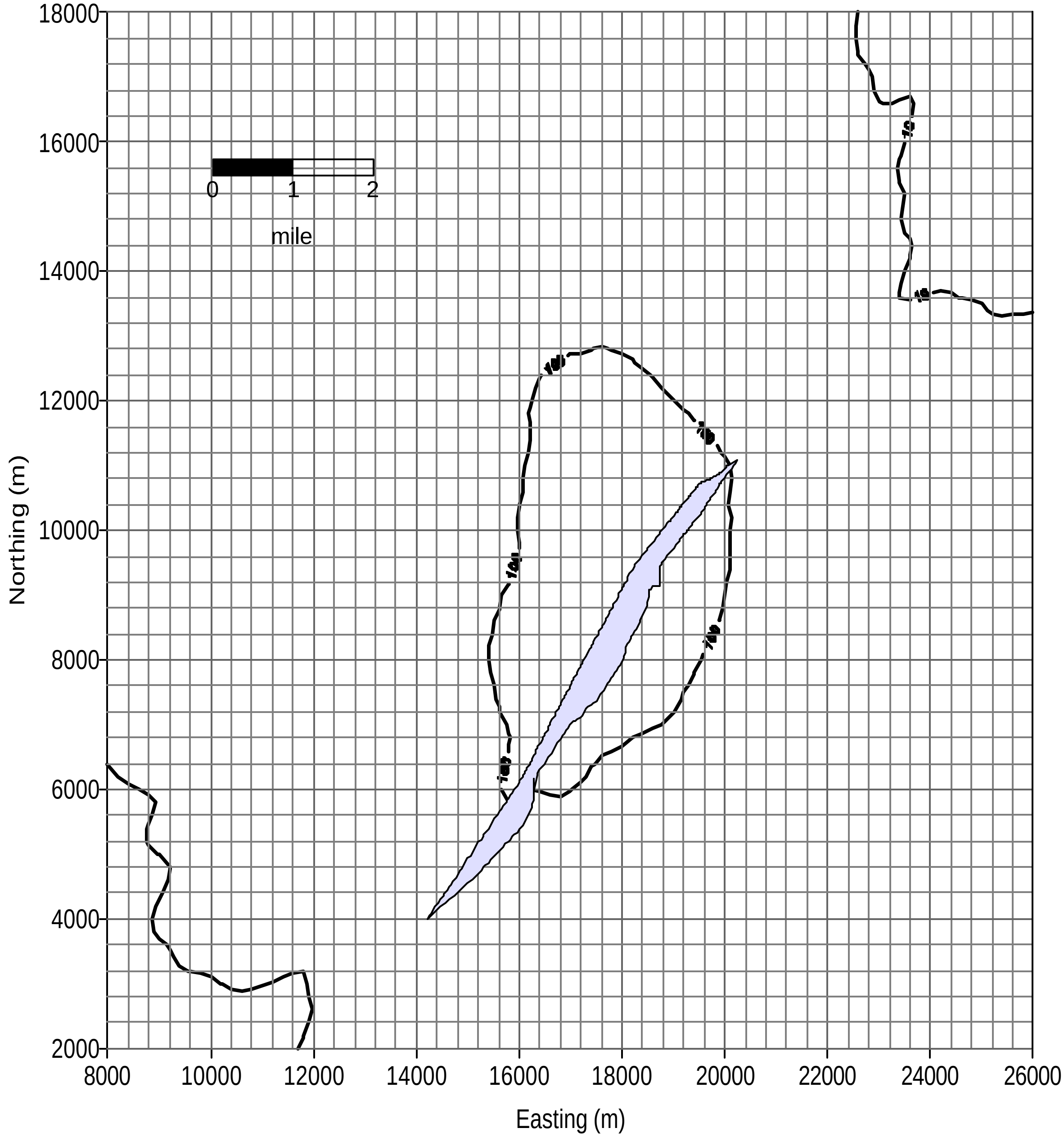


Figure H-3 . Estimated Diesel PM Cancer Risk (McClellen Meteorological Data, Rural Dispersion Coefficients, 95th Percentile Breathing Rate, All Locomotive Activies [23 TPY], Modeling Domain = 10mi x 11mi, Resolution = 200m x 200m)

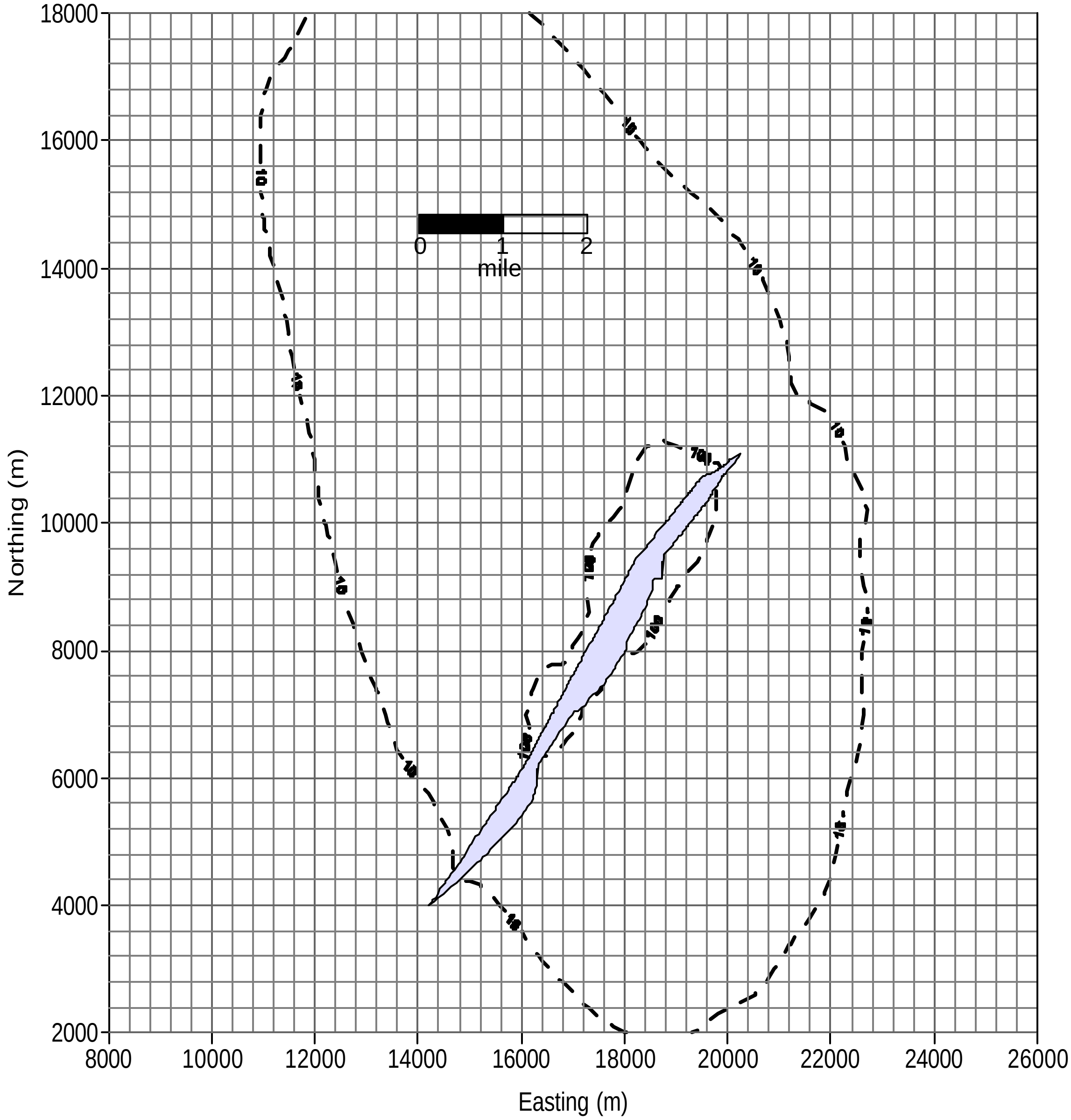


Figure H-4 . Estimated Diesel PM Cancer Risk (McClellen Meteorological Data, Urban Dispersion Coefficients, 95th Percentile Breathing Rate, All Locomotive Activies [23 TPY], Modeling Domain = 10mi x 11mi, Resolution = 200m x 200m)

C. Temporal Variation of Annual Average Diesel PM Concentrations Based on McClellan Meteorological Data

Figures H-5 (a & b) present the diurnal contributions to the annual average diesel PM concentration over a year with different receptor distances in the predominant wind direction for McClellan meteorological data with rural and urban dispersion coefficients, respectively. The receptors used in the Figures H-5 (a & b) are selected in the predominant wind direction at the distances of 200, 500, 1000, and 5000 meters from the Yard boundary near the *Service Area*. As it can be seen, the hourly contribution to annual average concentration exhibits strong diurnal effects and the effects are greater closer to the Yard boundary.

Figure H-6 shows the bimodal contribution to the annual average concentration for daytime (6am to 6pm) and night-time (6pm to 6am) emissions as a function of downwind distance. As seen in Figure H-6, the contribution to annual average concentration for receptors, kilometers away is greatest for nighttime conditions. This phenomenon has been explained in the Section 2 of Chapter VI.

The monthly contributions to the annual average diesel PM concentrations are shown in Figures H-7 and H-8 for rural and urban dispersion coefficients, respectively, at various downwind receptor distances. The summer season has higher contributions to annual average, predominantly for shorter receptor distances. This is likely due to the longer daylight hours during the summer time, which results in more unstable atmospheric conditions.

Figure H-5a: Diurnal Contribution to Avg. Conc. vs. Receptor Distance (Annual Average: 1.62 mg/m^3 at 200m, 1.03 mg/m^3 at 500m, 0.62 mg/m^3 at 1km, and 0.16 mg/m^3 at 5km. McClellan Met Data, Rural Dispersion Coefficient)

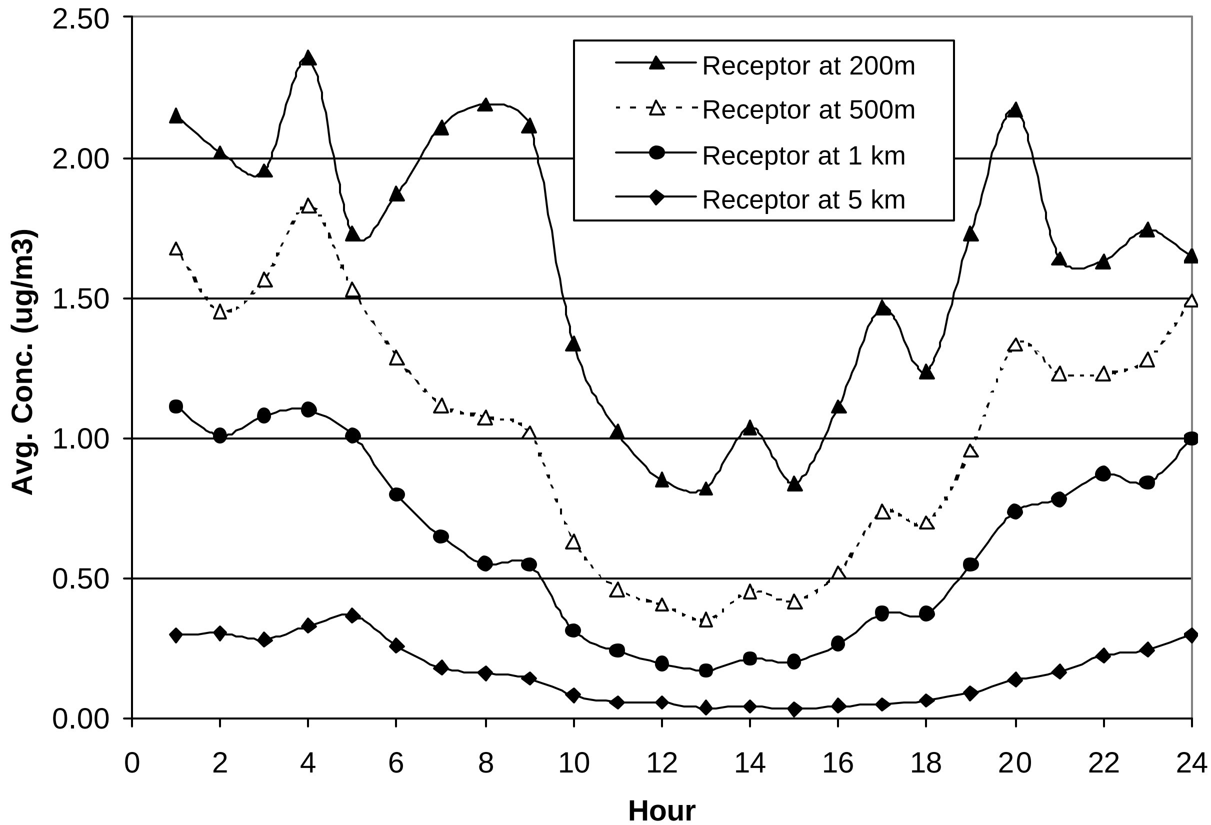


Figure H-5b: Diurnal Contribution to Avg. Conc. vs. Receptor Distance (Annual Average: 1.01 mg/m^3 at 200m, 0.51 mg/m^3 at 500m, 0.26 mg/m^3 at 1km, and 0.06 mg/m^3 at 5km. McClellan Met Data, Urban Dispersion Coefficient)

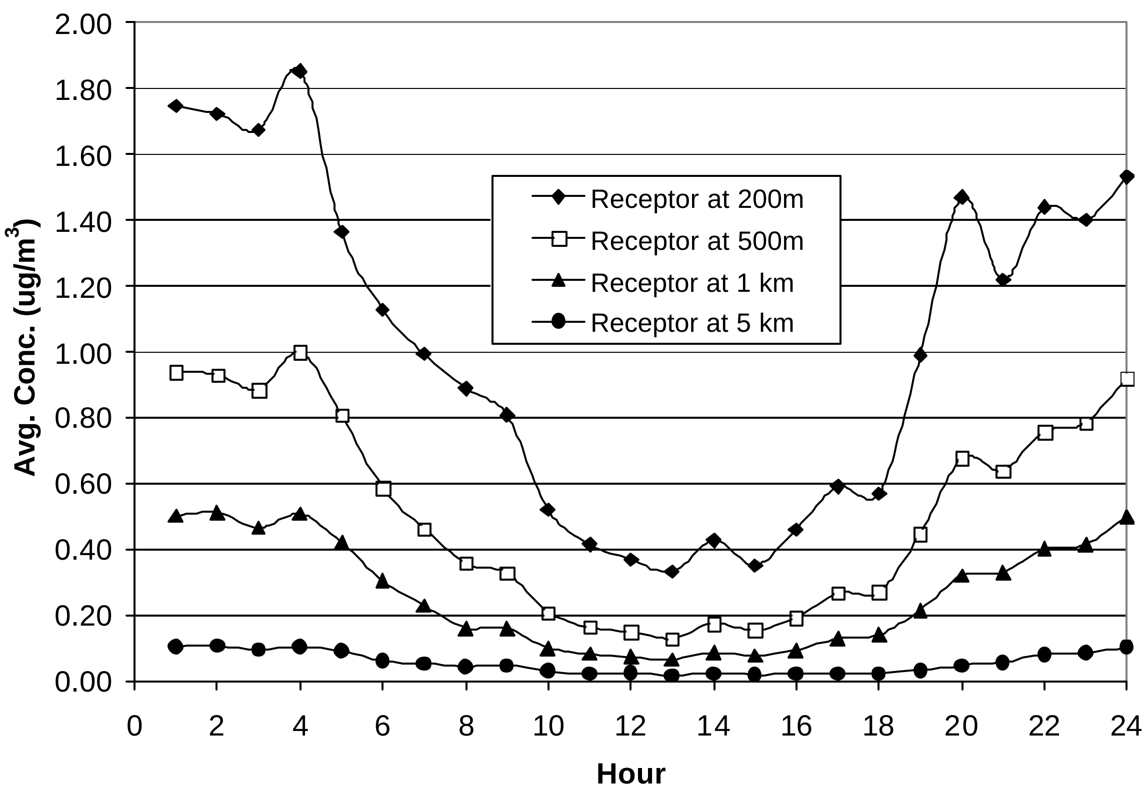


Figure H-6: Contribution to Annual Avg. Conc. (%) from Day Time (6am – 6pm) and Night Time (6pm – 6am) Emissions vs. Receptor Distance (McClellan Meteorological Data)

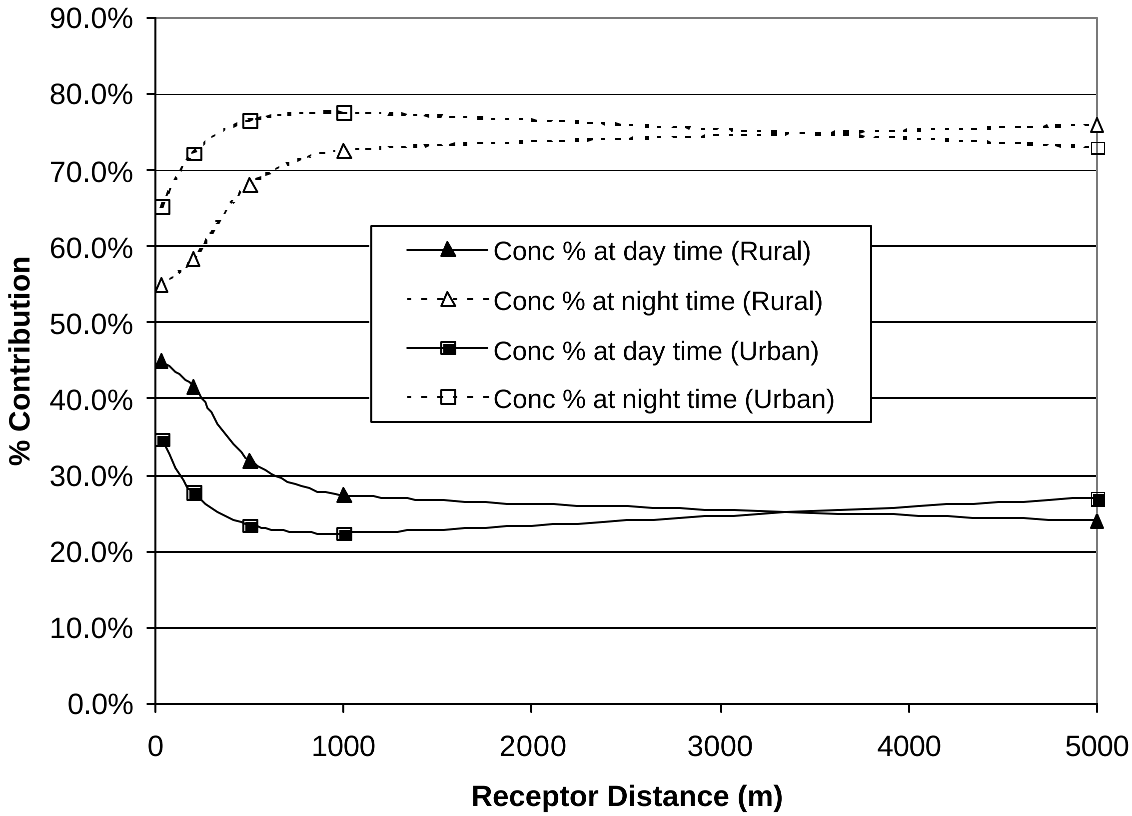


Figure H-7: Monthly Contribution to Conc. for Various Receptor Distances (McClellan Meteorological Data, Rural Dispersion Coefficient)

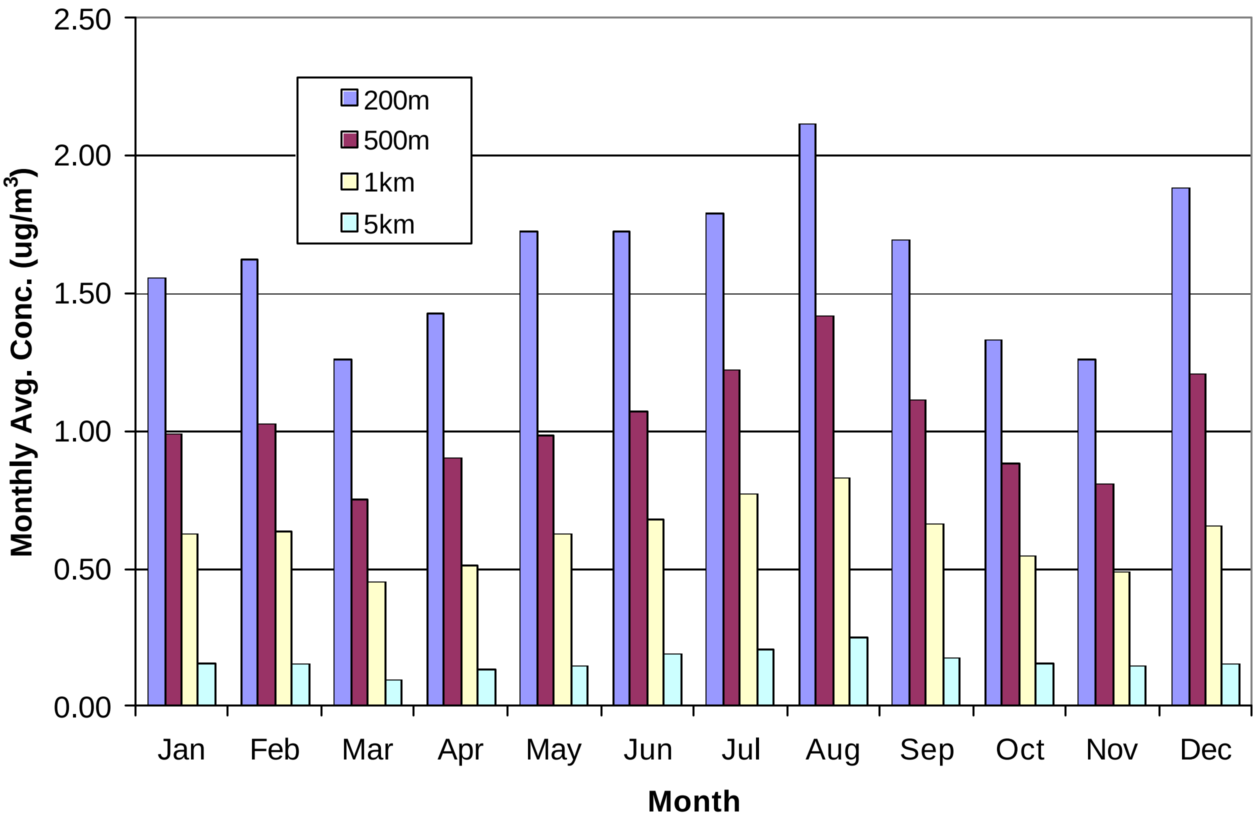
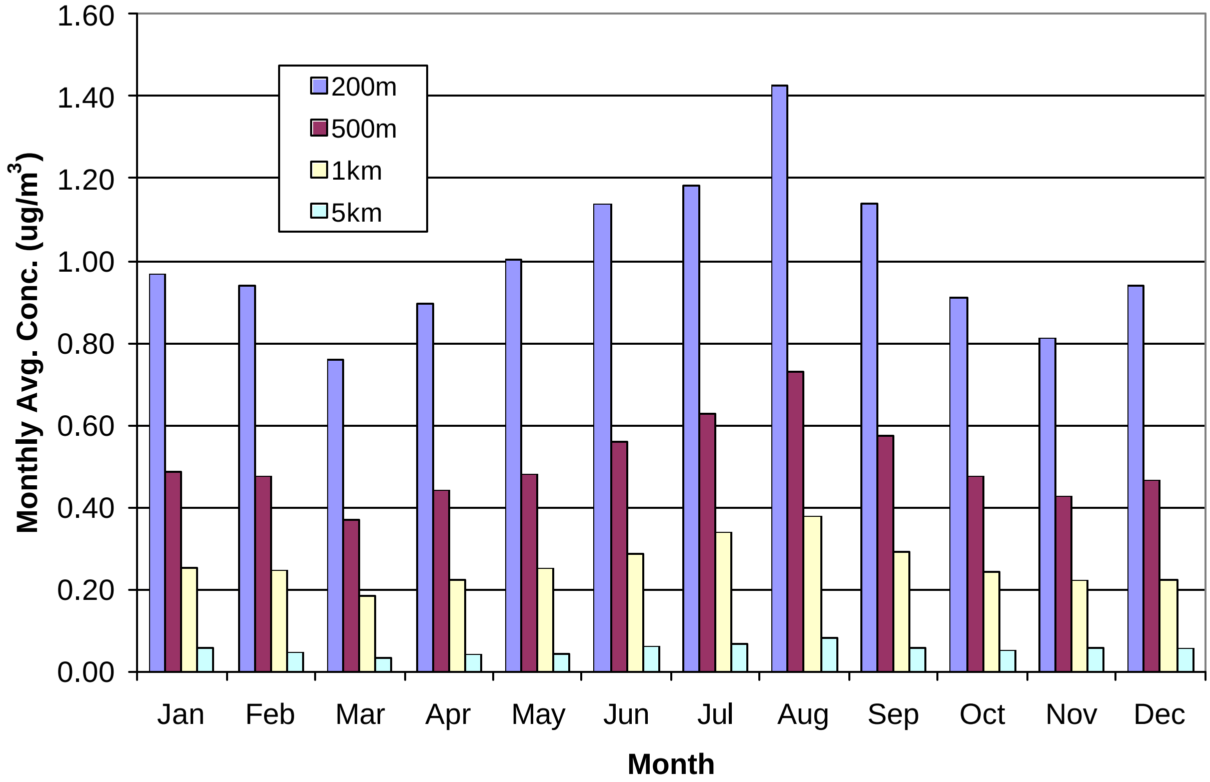


Figure H-8: Monthly Contribution to Conc. for Various Receptor Distances (McClellan Meteorological Data, Urban Dispersion Coefficient



D. Risk Associated with Movement and Idling Activity

Figures H9 and H-10 present the risk impacts associated with two major types of sources within the Yard, idling activity and movement activity. The annual emissions for the two sources are about 10.3 and 12.1 TPY, respectively. Note that the emission of testing activity in the Yard (about 1.6 TPY) is included in the idling activity. For simplicity of modeling and comparison, we only considered the modeling domain of 6km x 8km and the resolution of 50m x 50m. The meteorological data set of Roseville with rural dispersion coefficients is used in these modeling exercises.

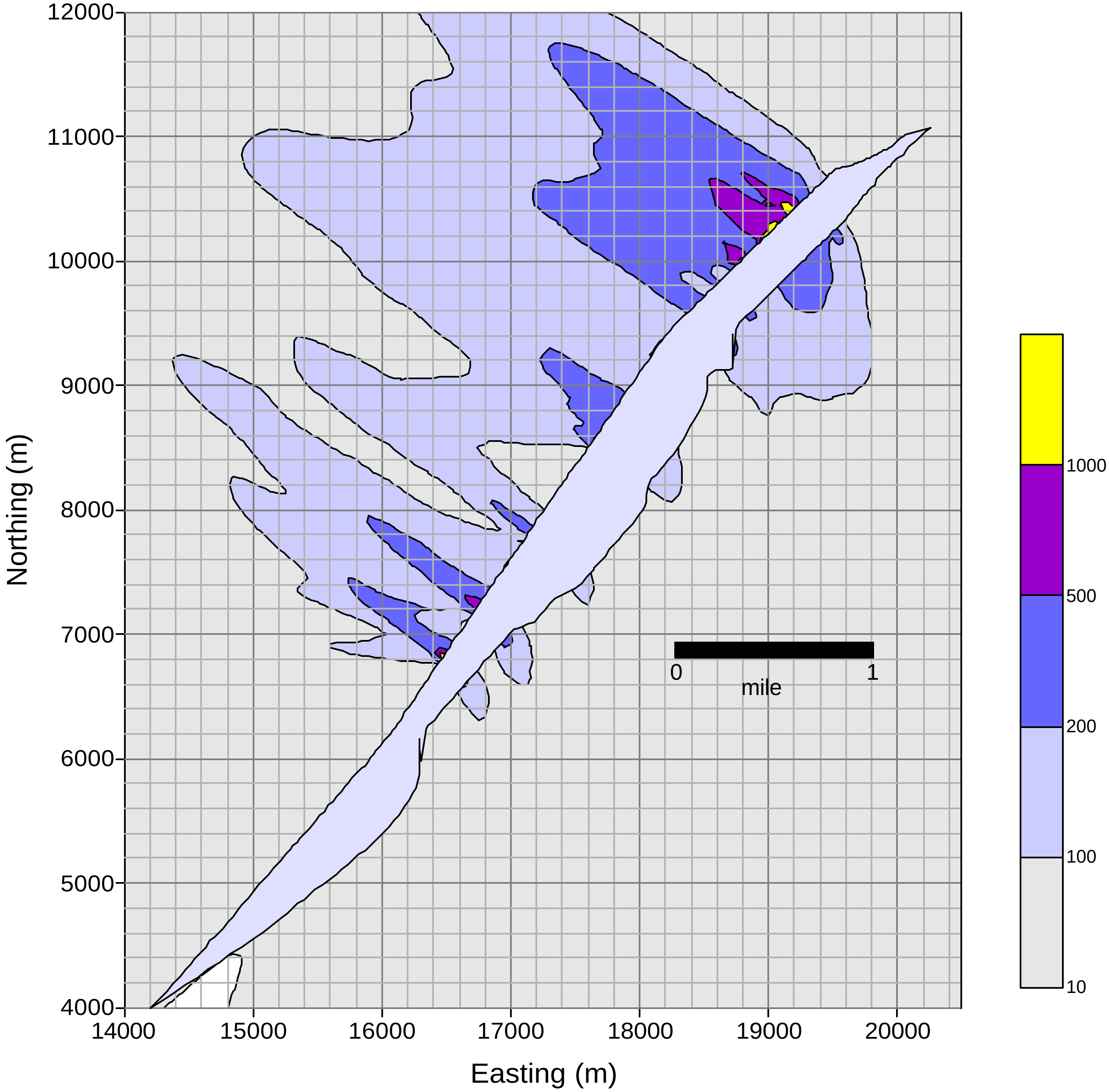


Figure H-9. All Idling Activitity's Contribution To Risk (Roseville Meteorological Data, Rural Dispersion Coefficients, 95th Percentile Breathing Rate, Total Idling Diesel PM = 12 TPY, Modeling Domain = 6km x 8km, Resolution = 50m x 50m)

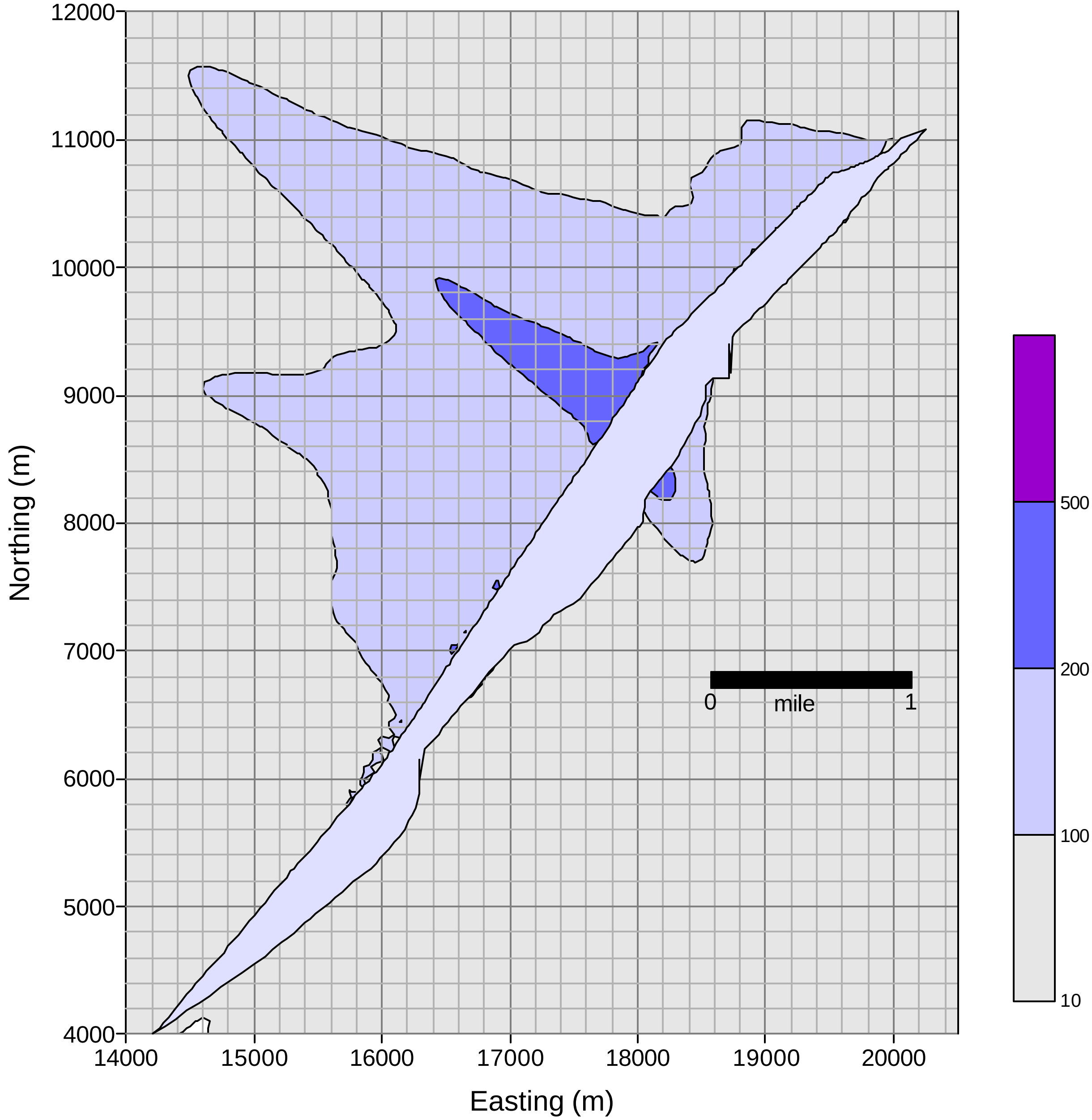


Figure H-10. All Movement's Contribution To Risk (Roseville Meteorological Data, Rural Dispersion Coefficients, 95th Percentile Breathing Rate, Total Idling Diesel PM = 12 TPY, Modeling Domain = 6km x 8km, Resolution = 50m x 50m)

E. Risk Associated with Major Activity Areas within the Yard

As documented in Chapter VI, we conducted individual air dispersion modeling runs for three major activity areas: *Service Area*, *Hump and Trim Operations*, and *Receiving and Departure Yard*. In these modeling runs, we used the modeling domain of 6km x 8km and the modeling resolution of 50m x 50m as well as Roseville meteorological data set with rural dispersion coefficients. Figures H-11 to H-13 presents the risks associated with the three major activity areas.

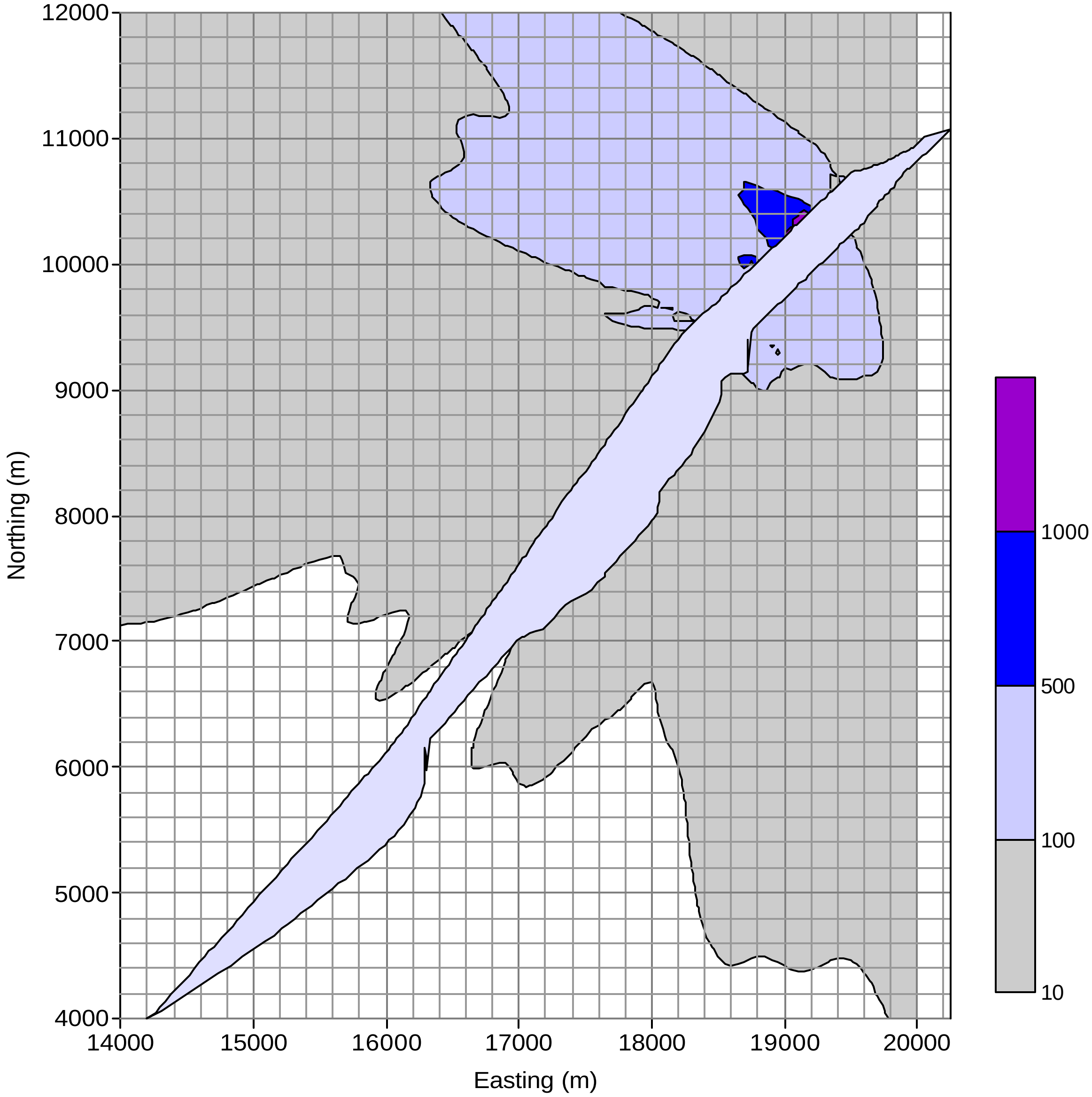


Figure H-11. Estimated Diesel PM Cancer Risk, Locomotive's Activity from Service Area (Roseville Meteorological Data, Rural Dispersion Coefficients,, 95th Percentile Breathing Rate, Modeling Domain = 6km x 8km, Resolution = 50m x50m)

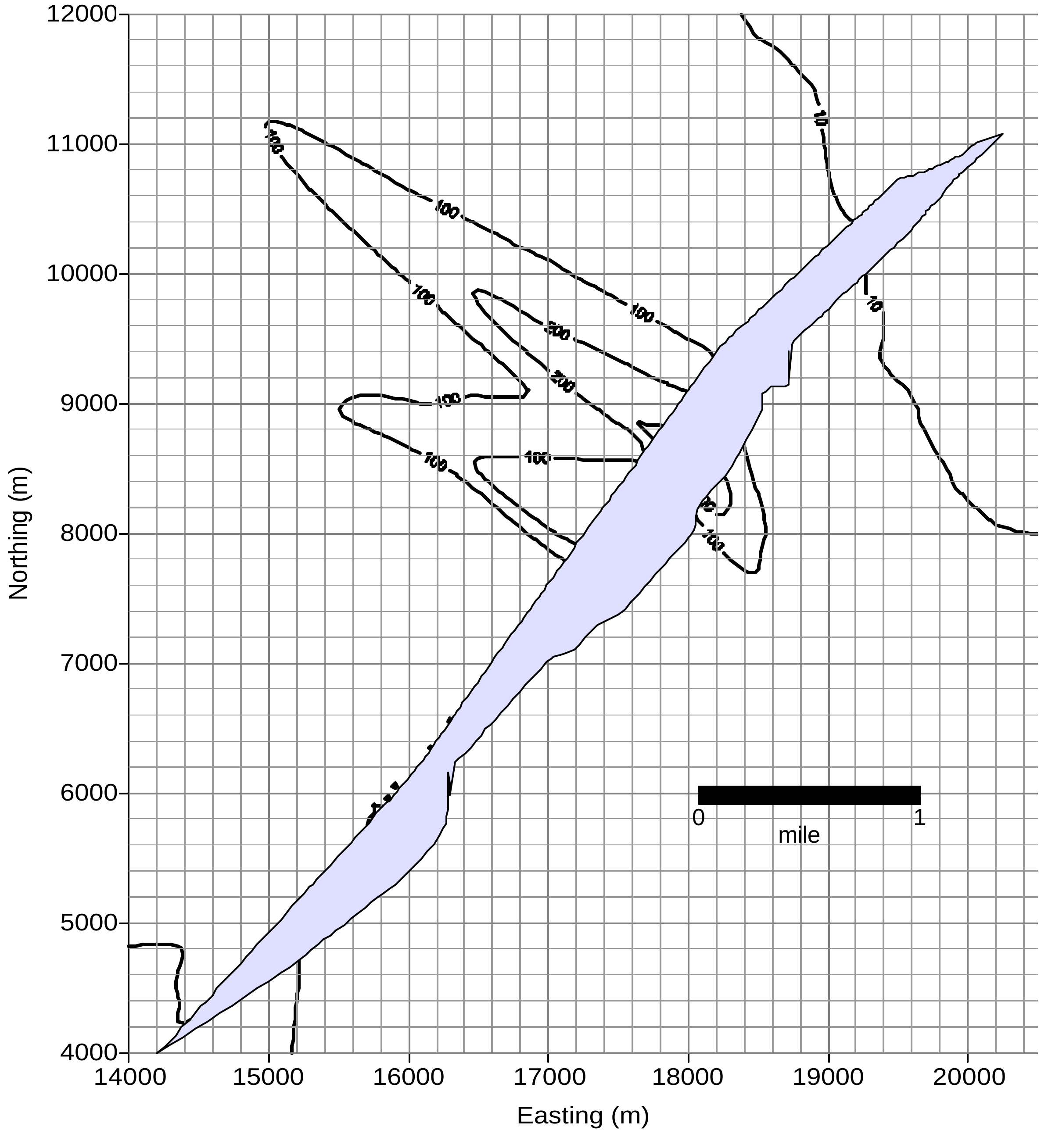


Figure H-12. Diesel PM Risk, Locomotive's Activity from Hump and Trim Operations (Roseville Meteorological Data, Rural Dispersion Coefficients, 95th Percentile Breathing Rate, Modeling Domain = 6km x 8km, Resolution = 50m x 50m)

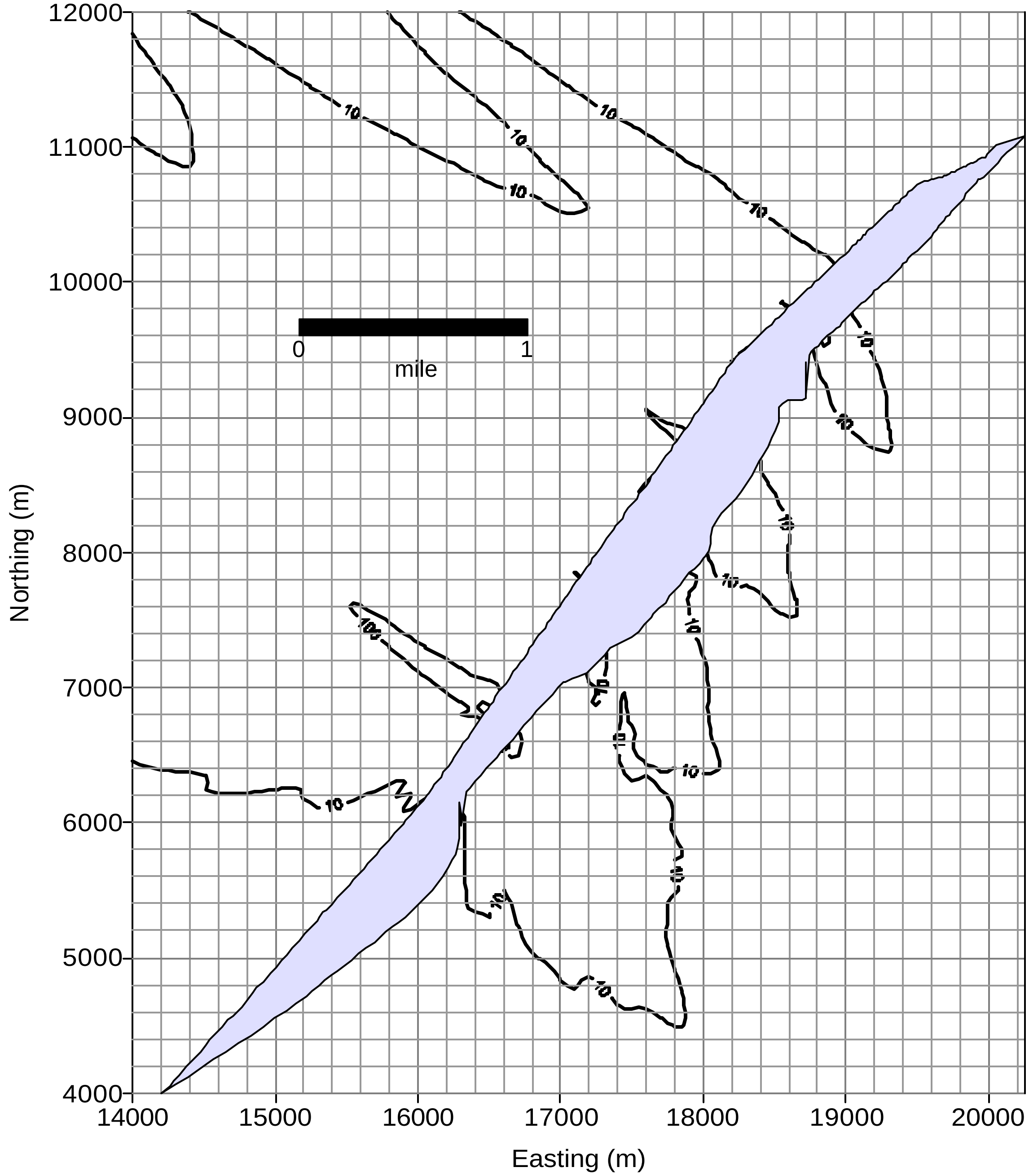


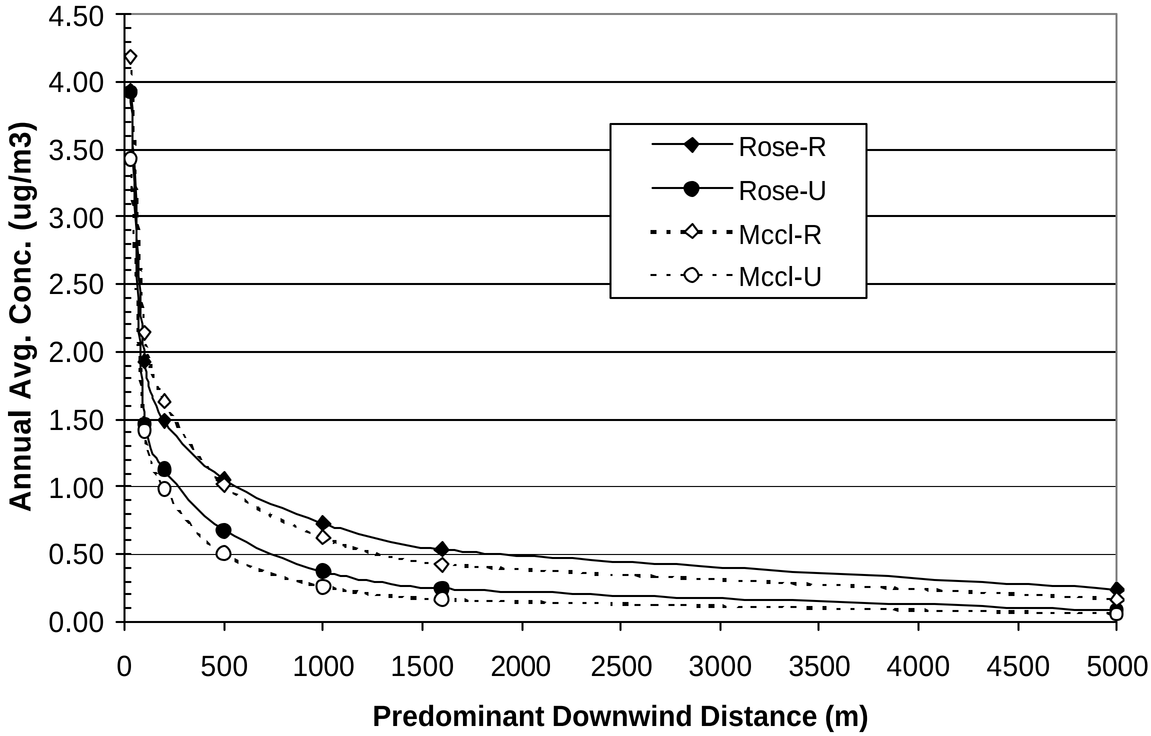
Figure H-13. Estimated Diesel PM Cancer Risk, Locomotive's Activity from Receiving and Departure Yard (Roseville Meteorological Data, Rural Dispersion Coefficients, 95th Percentile Breathing Rate, Modeling Domain = 6km x 8km, Resolution = 50m x 50m)

F. Risks vs. Downwind Distance

To quantitatively estimate how the annual average diesel PM concentration/risk changes with the downwind distance, we selected seven receptors in the predominate wind direction at distances of 30, 100, 200, 500, 1000, 1600, and 5000 meters from the Yard boundary near Area 3. The annual average concentration values for these receptors are presented in Figure H-14.

As shown in Figure H-14, the rate of the concentration change varies with downwind distance. As the distance increases from zero (the Yard boundary) to about 200m, the curve exhibits the greatest change in concentration with downwind distance; as the distance increases from 200 to about 1500 m. The curve has a modest rate of change. After 1500m, the change in concentration with distance becomes small. Figure H-14 also reveals that there is a greater slope (indicating a faster decrease in concentration with distance) using McClellan AFB or urban dispersion coefficient as compared to Roseville meteorological data or rural dispersion coefficient.

Figure H-14: Annual Average Diesel PM Concentration vs. Downwind Distance for Roseville AQM and McClellan AFB Meteorological Data Sets



G. Zone Average Concentrations

To investigate the distribution of diesel PM concentrations in residential blocks, zone average concentrations were calculated and are presented in Figures H-15 and H16 for Roseville and McClellan AFB meteorological data, respectively. For a residential block located between 500 to 1000 meters from the Yard boundary nearest the *Service Area*, the zone average concentration is about 0.6 $\mu g/m^3$ based on Roseville meteorological data with rural dispersion coefficients. This concentration is equivalent to about 250 potential cancer cases per million when the Roseville meteorological data with rural dispersion coefficients are used and the 95th percentile breathing rate is assumed. For all receptors in the medium modeling domain (about 18 square miles excluding the Yard property), the zone average risks are about 110-160 (0.384 $\mu g/m^3$) and 80-110 (0.270 $\mu g/m^3$) potential cancer cases per million people for the 65th to 95th percentile breathing rates for Roseville and McClellan AFB meteorological data with rural dispersion coefficients, respectively.

Figure H-15: Spatial Area Average Concentration Around Service Area vs. Radial Range (Roseville Met Data, 50m x 50m Resolution, and 6km x 8km Domain)

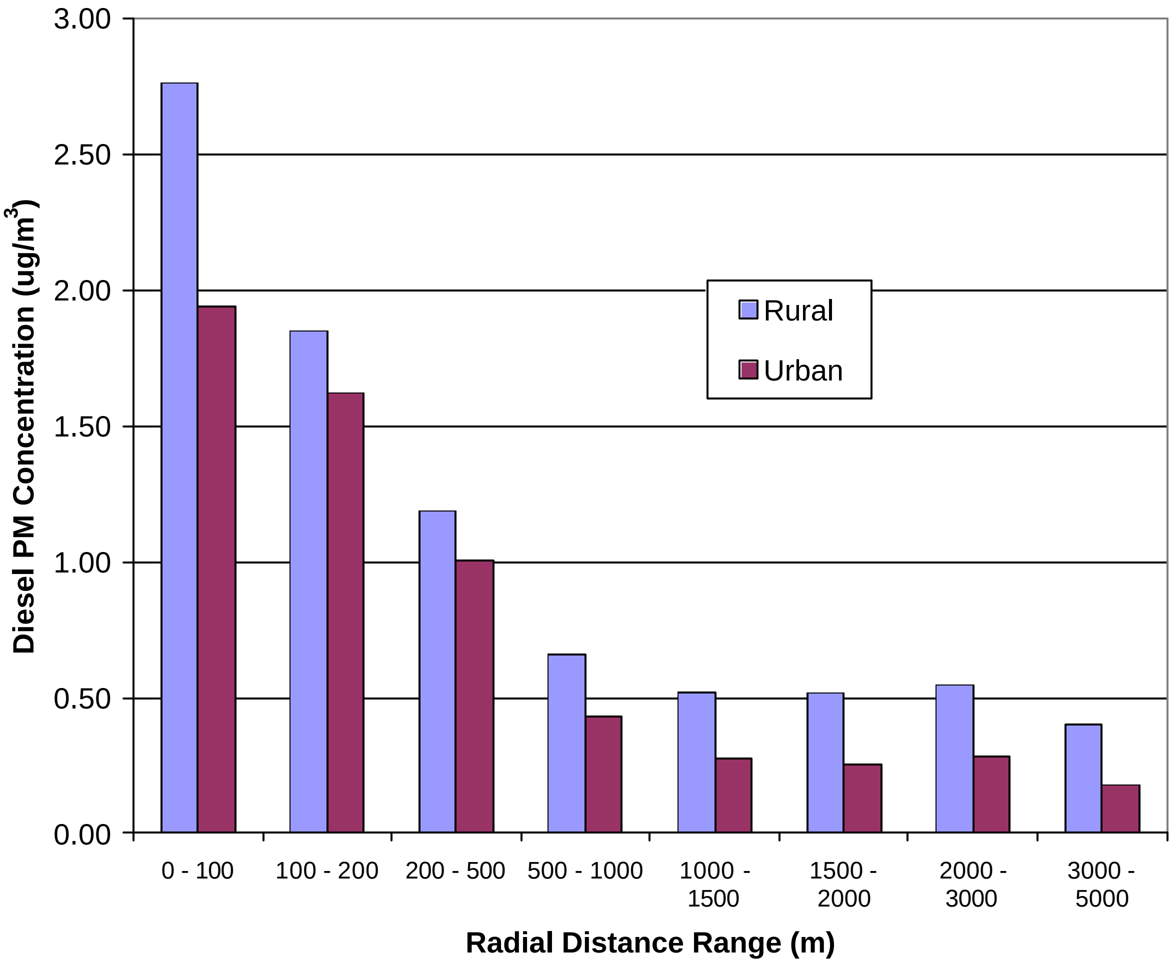
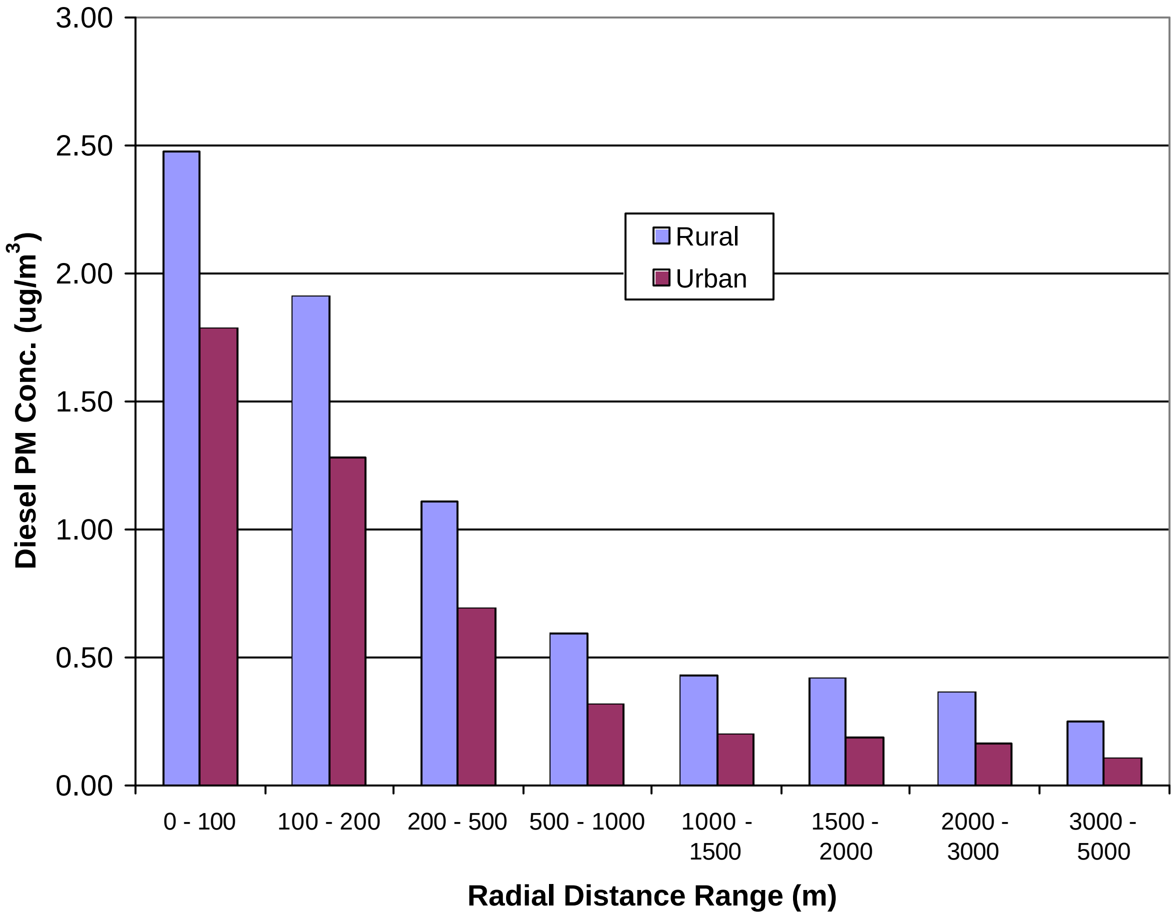


Figure H-16: Spatial Area Average Concentration Around Service Area vs. Radial Range (McClellan Met Data, 50m x 50m Resolution, and 6km x 8km Modeling Domain)



APPENDIX I

Calculation of Potential Inhalation
Cancer Risk for Diesel PM

Calculation of Potential Inhalation Cancer Risk for Diesel PM

This appendix illustrates the procedures to estimate potential inhalation cancer risk for exposure to diesel PM from the Roseville Rail Yard. The Tier 1 methodology developed by the OEHHA is used to estimate the potential cancer risk. Noncancer acute hazard risk will not be considered. The 70-year exposure duration is assumed.

1. Determine the annual average concentration and inhalation cancer factor for diesel PM.

We would obtain the annual average concentrations from the air dispersion modeling. This step has been completed in Chapter VI. The inhalation cancer potency factor (CPF) for diesel PM has been determined by the OEHHA, which is 1.1 $(mg/kg\text{-}d)^{-1}$.[1]

2. Determine the Inhalation Dose for Diesel PM.

The inhalation dose can be calculated using the following equation:

$$Dose-Inh = \frac{(C_{air})(DBR)(A)(EF)(ED)\left(1x10^{-6}\right)}{AT}$$

Where:

Dose-Inh	= Dose through inhalation (mg/kg-d)
$1x10^{-6}$	= Micrograms to milligrams conversion, liters to cubic meter conversion
C_{air}	= concentration in air ($\mu g/m^3$)
DBR	= Daily breathing rate (L/kg-day)
A	= Inhalation absorption factor
EF	= Exposure frequency (days/year)
ED	= Exposure duration (years)
AT	= Averaging time period over which exposure is averaged, in days

For the 95th percentile breathing rate (393 L/kg-day for adults) over 70-year exposure duration, the inhalation dose of diesel PM is:

$$Diesel\ PM\ (dose-inh) = \frac{(C_{air})\left(\frac{393 liters}{kg-day}\right)(1)\left(\frac{350\,days}{year}\right)(70\,years)\left(1x10^{-6}\right)}{25{,}550\,days}$$

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[1] The unit risk factor (URF) for diesel PM (300 cancers/ $\mu g/m^3$) has been replaced with a new risk assessment factor called the “inhalation cancer potency factor” (CPF). The CPF for diesel PM is 1.1 cancers /mg/kg-day. The inhalation CPF is derived from the URF by assuming that the average individual weighs 70 kilograms (154 pounds) and breaths 20 cubic meters of air per day.

$$Diesel\ PM\ (dose - inh) = 376.85\, x 10^{-6} C_{air}\ \ mg/kg - day$$

Similarly, for the mean breathing rate (271 L/kg-day for adults) over 70-year exposure duration, the inhalation dose of diesel PM is:

$$Diesel\ PM\ (dose - inh) = 259.86\, x 10^{-6} C_{air}\ \ mg/kg - day$$

3. Determine potential inhalation cancer risk

Potential cancer risk can be calculated by multiplying the dose by the inhalation cancer potency factor (CPF) as shown below.

$$Inhalation\ potential\ cancer\ risk = (inhalation\ dose)\, x\, (inhalation\ cancer\ potency\ factor)$$

For diesel PM the inhalation cancer potency factor is 1.1 $(mg/kg\text{-}d)^{-1}$. Thus the inhalation potential cancer risk for diesel PM is as follows:

$$Potential\ cancer\ risk = 414.55\, x\, C_{air}\ x 10^{-6} \qquad for\ 95th\ percentile\ breathing\ rate$$

$$Potential\ cancer\ risk = 285.85\, x\, C_{air}\ x 10^{-6} \qquad for\ mean\ breathing\ rate$$

From the prospective of the unit risk factor (URF), the above potential cancer risk for diesel PM can be expressed as the follows:

$$Potential\ cancer\ risk = 1.38\, x\, URF\ x\, C_{air}\ x 10^{-6}$$
$$= 1.38\, x\, 300\, x\, C_{air}\ x 10^{-6} \qquad for\ 95th\ percentile\ breathing\ rate$$

$$Potential\ cancer\ risk = 0.95\, x\, URF\ x\, C_{air}\ x 10^{-6}$$
$$= 0.95\, x\, 300\, x\, C_{air}\ x 10^{-6} \qquad for\ mean\ breathing\ rate$$

It is common to express potential cancer risk for the purposes of risk communication as cancer cases per million. Multiply the cancer risk by 10^6 to get this expression.