AIR DISPERSION MODELING ASSESSMENT OF AIR TOXIC EMISSIONS FROM BNSF RICHMOND RAIL YARD

Submitted to:
California Air Resources Board

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ACRONYMS

ARB	Air Resources Board
BAAQMD	Bay Area Air Quality Management District
BNSF	BNSF Railway Company
BPIP-PRIME	Building Profile Input Program – Plume Rise Model Enhancement
CalEPA	California Environmental Protection Agency
CalOSHA	California Occupational Safety and Health Administration
CAPCOA	California Air Pollution Control Officers Association
CARDS	Comprehensive Aerological Reference Dataset
DPM	Diesel particulate matter
ENVIRON	ENVIRON International Corporation
GE	General Electric
GIS	Geographic Information Systems
HD	Heavy-duty
HRA	Health Risk Assessment
I	Interstate
ISC	Industrial Source Complex
IGRA	Integrated Global Radiosonde Archive
LD	Light-duty
MATES	Multiple Air Toxics Exposure Study
MOU	Memorandum of Understanding
MTBE	Methyl t-butyl ether
NAS	Naval Air Station
NCDC	National Climactic Data Center
NLCD	National Land Cover Data
NRC	National Research Council
NWS	National Weather Service
OEHHA	Office of Environmental Health Hazard Assessment
PM	Particulate matter
PMI	Point of maximum impact
POLA	Port of Los Angeles
POLB	Port of Long Beach
RAAC	Risk Assessment Advisory Committee
SCRAM	Support Center for Regulatory Atmospheric Modeling
TAC	Toxic Air Contaminant
ULSD	Ultra low sulfur diesel

UPPR	Union Pacific Railroad Company
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VMT	Vehicle miles traveled
WBAN	Weather Bureau Army Navy

ABREVIATIONS

%	percent
AERMAP	AERMOD Terrain Processor
AERMET	AERMOD Meteorological Preprocessor
AERMOD	American Meteorological Society/Environmental Protection Agency Regulatory Model
COOP	Cooperative Station (NWS)
kg	kilogram
km	Kilometer
L	liter
m^3	cubic meter
µg	microgram

1.0 INTRODUCTION

In June 2005, BNSF Railway Company (BNSF) and Union Pacific Railroad Company (UPRR) entered into a mutual agreement (ARB/Railroad Statewide Agreement, 2005b or the "Agreement") with the California Air Resources Board (ARB) to reduce particulate emissions from their respective rail yards that are owned and operated within the State of California. Under provisions of the Agreement, ARB staff will be performing Health Risk Assessments (HRAs) at 17 rail yards ("Designated Rail Yards") within California. The HRAs will consider emissions of toxic air contaminants (TACs) from emission sources at each Designated Rail Yard including resident and transient locomotives, on- and off-road equipment, and stationary equipment.

Generally, an HRA consists of three major parts: (1) an air emissions inventory for TAC emission sources, (2) air dispersion modeling to evaluate off-site airborne concentrations due to TAC emissions from these sources, and (3) the assessment of risks associated with these predicted airborne concentrations. The UPRR and BNSF are required to complete the first two parts of the risk assessment process under the Agreement. Under the MOU, ARB will conduct the assessment of risks part of the HRA process using the results of air dispersion exposure analyses conducted for each Designated Rail Yard. As noted in the MOU, specific objectives of these risk assessments include developing a basis for risk mitigation and risk communication, including developing information to place the estimated risks in appropriate context. To aid in developing information for risk communication, ARB will also be conducting health risk assessments for other significant sources of TACs within the vicinity of each Designated Rail Yards.

BNSF has retained ENVIRON International Corporation (ENVIRON) to assist it with the development of TAC emissions inventories and in conducting the air dispersion modeling for each of their Designated Rail Yards. Under the current draft Health Risk Assessment Guidance for Rail Yard and Intermodal Facilities (the "draft Guidelines", (ARB 2006a)), emission inventories and air dispersion modeling results for the following BNSF Designated Rail Yards are scheduled to be submitted by September 30, 2006: Commerce/Eastern Intermodal, Commerce/Mechanical, Los Angeles Intermodal (Hobart), Richmond, Stockton, and Watson/Wilmington (the "2006 BNSF Designated Rail Yards"). However, since the release of the draft Guidelines, ARB agreed to change the timeline for submission of the emissions and air dispersion modeling results to October 31, 2006 for Commerce/Mechanical and Richmond and November 30, 2006 for Commerce/Eastern, Hobart, Watson/Wilmington, and Stockton. These submission timelines were adjusted to accommodate ARB's request for changes to previously completed emission inventories to reflect previously unreleased ARB models. This report presents the methods and results of the air dispersion modeling analysis conducted to evaluate TAC emissions from operations at the Richmond rail yard located in Richmond, California ("Richmond").

1.1 Objectives

The purpose of this report is to summarize ENVIRON's methods used to conduct the air dispersion exposure assessment of TAC emissions from the BNSF Richmond Yard and to provide the results of this analysis to ARB for their completion of the HRA for this rail yard. As discussed in the draft Guidelines (ARB 2006a), the air dispersion modeling exposure assessment requires the selection of the dispersion model, the data that will be used in the dispersion model (pollutants to be modeled with appropriate averaging times, source characterization, building downwash, terrain, meteorology) and the identification of receptors whose potential exposure will be considered in ARB's HRA. ENVIRON previously provided to ARB a report that described ENVIRON's model selection, meteorological data selection, and meteorological data processing methodologies for all the 2006 BNSF Designated Rail Yards (ENVIRON 2006). ARB approved these aspects of the air dispersion modeling analysis on August 3, 2006.[1] The remainder of this introduction section summarizes ENVIRON's selection of the air dispersion model to provide the modeling context for the methods discussed in the remainder of this report.

1.2 Methodologies

As discussed in the draft Guidelines, "air dispersion modeling uses mathematical formulations to characterize the atmospheric processes that disperse a pollutant emitted by a source" (ARB 2006a). The Agreement currently requires that air dispersion modeling be performed to estimate airborne concentrations from the dispersion of TAC and particulate matter emissions from relevant sources at each Designated Rail Yard. The emissions of diesel particulate matter (DPM) are separated from other particulate related TAC emission data in the model input and output (ARB 2006a). Air dispersion modeling requires the selection of an appropriate dispersion model and input data based on regulatory guidance, common industry standards/practice, and/or professional judgment. In general, ENVIRON performed air dispersion modeling for the BNSF Designated Rail Yards consistent with previous studies and/or guidance documents prepared by ARB (ARB 2004, 2005a, 2005c, 2006a) and the United States Environmental Protection Agency (USEPA 2000, 2004a, 2004b, 2005a, 2005b).

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[1] Personal communication, J. Yuan of ARB by e-mail to D. Daugherty of ENVIRON on August 3, 2006.

ENVIRON used the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD version 04300) to estimate airborne concentrations resulting from TAC emissions from the BNSF Richmond Yard. The AERMOD model was developed as a replacement for USEPA's Industrial Source Complex (ISC) air dispersion model to improve the accuracy of air dispersion model results for routine regulatory applications and to incorporate the progress in scientific knowledge of atmospheric turbulence and dispersion. Both models are near-field, steady-state Gaussian plume models, and use site-representative hourly surface and twice-daily upper air meteorological data to simulate the effects of dispersion of emissions from industrial-type releases (e.g., point, area, and volume) for distances of up to 50 kilometers (USEPA 2005b).

For the past 20 years, refined near-field air dispersion modeling has typically been conducted using USEPA's Industrial Source Complex (ISC) model. However, on November 9, 2005, the USEPA promulgated final revisions to the federal Guideline on Air Quality Models (USEPA 2005a). These revisions recommend that AERMOD, including the PRIME building downwash algorithms, be used for dispersion modeling evaluations of criteria air pollutant and toxic air pollutant emissions from typical industrial facilities. A one-year transition period commenced from the promulgation date of November 9, 2005. AERMOD provides better characterization of plume dispersion than does ISC, according to USEPA (USEPA 2003). AERMOD also is the model recommended by ARB in the draft Guidelines (ARB 2006a).

1.3 Report Organization

This report is divided into six sections as follows:

Section 1.0 – Introduction: describes the purpose and scope of this report and outlines the report organization.

Section 2.0 – Site Description: provides a brief description of the Richmond Facility and its operations.

Section 3.0 – Emission Inventory Summary: summarizes the TAC emission inventory results that were previously submitted to ARB under a separate report (included as Appendix A).

Section 4.0 – Air Dispersion Modeling: describes the air dispersion modeling methods used to estimate air chemical concentrations.

Section 5.0 –Uncertainties: summarizes the uncertainties resulting from various assumptions used in the air dispersion evaluation as well as from those used in the emission inventory development.

Section 6.0 – References: includes all references cited in this report.

The appendices include supporting information as follows:

Appendix A: provides ENVIRON's previous report to ARB on the emission estimation methodologies and results.

Appendix B: provides the tables of hourly, daily, and seasonal temporal information for source activities

Appendix C: provides the electronic SCREEN3 input and output files for plume rise adjustments for locomotive movement activities

Appendix D: provides the electronic AERMOD-ready meteorological data files and raw surface and upper air meteorological data files

Appendix E: provides the electronic building downwash input and output files

Appendix F: provides the electronic digital elevation model (DEM) files

Appendix G: provides the electronic shapefiles containing census data for the Richmond area

Appendix H: discusses the sensitivity analysis used to determine the spacing and extents of the receptor grids

Appendix I: provides the electronic input and output files for AERMOD

Appendix J: provides the electronic air concentration tables in Microsoft Access database file

2.0 SITE DESCRIPTION

The Richmond site description incorporated in this evaluation is based primarily on information provided by BNSF and its contractors' staff. The following information is included to facilitate understanding of this site's operations as evaluated by this work.

2.1 Site Setting and Description

Richmond is located at 303 South Garrard Boulevard in Richmond, California and is approximately 20 kilometers north-east of San Francisco. As shown in Figure 2-1, Richmond is located in a predominantly commercial area/industrial with several residential areas located within two kilometers. Richmond is bordered by commercial properties to the north, Interstate-580 (I-580) to the south, industrial properties to the west, and residential properties to the east. The San Francisco Bay is located within two kilometers of the western and southern boundaries of the Richmond Yard, and within five kilometers of the northern boundary of the Richmond Yard. I-80 is located approximately five kilometers to the east of the Richmond Yard. Figure 2-2 depicts available land use data from the United States Geological Survey's (USGS's) National Land Cover Dataset (USGS 2006) within 20 kilometers (km) of Richmond, as required by the draft Guidelines (ARB 2006a). Table 2-1 summarizes the percentage of each land use category within this 20-km radius.

The Facility generally runs northeast and southwest and consists of a locomotive staging area, locomotive fueling area, freight car repair building, a locomotive repair shop, train master facility, and administrative offices for the intermodal and mechanical areas of the Facility. A storm water tank and a diesel storage tank are also located at the Facility.

2.2 Facility Operations

Activities at Richmond include locomotive maintenance, locomotive line haul, locomotive switching, cargo handling equipment, track maintenance, portable engines, on-road fleet vehicles, on-road container trucks, transportation refrigeration units (TRUs), and stationary source activities. The approximate locations of these activities at the Facility are shown in Figures 2-3 through 2-5.

The Richmond Rail Yard is generally divided into two operational areas: the locomotive and freight repair areas located predominantly in the south and east portions of the Facility, and the intermodal area located in the north and west portions of the Facility. The emission activities (and emission category, as designated in Appendix A) occurring in these two operational areas are outlined below:

Facility Operational Areas

Locomotive & Freight Repair Yard

- A. Basic Service/Maintenance
- D. Switching
- E. Arriving/Departing Line Haul
- K1b. Boxcar TRUs
- K2. Track Maintenance
- K3. Portable Engines
- L. Stationary Sources

Intermodal Facility

- H. Cargo Handling Equipment
- I. On-Road Container Trucks
- K1a. Container TRUs

Other Operations

- J. On-Road Fleet Vehicles

As indicated above, the locomotive and freight repair areas contain the locomotive maintenance, locomotive switching, locomotive line haul (i.e., arriving and departing locomotives), boxcar TRUs , track maintenance, portable engine, and stationary source activities. Locomotive maintenance activities include sand, fuel, and lubricant services, basic engine inspections, and in-consist. These activities occur near the central portion of the Yard as shown in Figures 2-3a and 2-3b, with locomotives moving into and out of the maintenance areas along a segment of rail originating at the south end of the line haul operating area, described below. Locomotive switching occurs along two rail lines which extend inside the freight car repair buildings in the north central part of the Facility, as shown in Figures 2-3a and 2-3b. Arriving and departing locomotive emissions predominantly occur along approximately 1000 meters of rail running along the southeast border of the Facility, as indicated in Figure 2-3a. Track maintenance and boxcar TRU activities occur over almost the entire locomotive and railcar repair area, as shown in Figure 2-4. Portable engine activities occur inside the two freight car repair buildings, as indicated in Figure 2-4. Stationary source activities at Richmond include three emergency generators and a gasoline storage and dispensing facility. The largest of the three emergency generators (approximately 600 kW) and the gasoline dispensing and storage facility are located in the central part of the Facility near the locomotive maintenance activities, as shown in Figure

2-4. The other two emergency generators (250 – 300 kW) are located near the BNSF intermodal administration office at the south end of the Facility and north of the freight car repair buildings, as shown in Figure 2-4.

The intermodal area includes cargo handling equipment, container TRUs, and on-road container truck activities. Cargo Handling Equipment (CHE) is used to handle intermodal freight at the Richmond site and includes lift machines, yard vehicles and hostlers, cranes, and other types of container handling equipment (e.g., side picks and top picks). Lift machine activities occur only in the central portion of the intermodal area, however, other CHE activities may occur throughout the entire intermodal area of Facility (i.e., the north and western portions of the yard), as shown in Figure 2-4. According to BNSF personnel, on-road container trucks enter the Facility at the south-west gate and follow a specific travel route to the intermodal area, as shown in Figure 2-5. Once the container trucks have reached the intermodal area, their activity may occur throughout the entire intermodal area. Similarly, container TRU activities may occur anywhere in the intermodal area, as shown in Figure 2-4.

BNSF on-road fleet activities occur along travel routes from the gate at the northeast corner of the Facility to the parking area south of the Mechanical Office in the central part of the Facility and from the gate near the southeast corner of the Facility to the parking area north of the Intermodal Administration Office, as shown in Figure 2-5.

3.0 EMISSION INVENTORY SUMMARY

ENVIRON estimated emissions for BNSF Richmond Yard activities and provided this to ARB previously (Appendix A). The methodology used to calculate the DPM and gasoline TAC emission factors were described in this previous submission to ARB. Detailed calculation methodologies and the resulting emission factors are included as Appendix A. The remainder of this section provides a brief summary of the Richmond activities for which TAC emissions were estimated.

3.1 Locomotive DPM Emissions

ENVIRON described Richmond locomotive operations by dividing the emissions activities into three emissions categories: basic locomotive services, switching, and arriving & departing line haul (designated as activity categories A, D, and E, respectively, in Appendix A). ENVIRON further subdivided the main operation into activity subcategories to describe the emission modes and spatial allocation, such as locomotive movements, idle, and in-consist. The activity categories and subcategories thus established for the locomotive emission activities were as follows:

A. Basic Services

- A1. Movement into Yard
- A2. Idling while Refueling
- A3. In-consist
- A5. Movement out of Yard

D. Switching Engine Idling and Movement

E. Arriving/Departing Line Haul

From data provided by BNSF and through discussions with BNSF operations staff, ENVIRON determined the overall activity of locomotive operations. The locomotive operations data, detailed in Appendix A, included the number of engines serviced, and the typical time in notch setting for those engines receiving service. ENVIRON inferred locomotive movements and time in engine notch settings based on the type of service provided for each engine. For instance, basic service included typical time in notch for refueling, in-consist, and movements in and out of the service building. See Appendix A for a detailed description of the information and estimates used to define operations and resulting emissions within activity categories A, D, and E. Temporal emission profiles were developed for each locomotive activity based on hourly locomotive counts. Variable hourly, daily, and seasonal emission factors were applied in the air dispersion modeling to approximate the temporal variations in emissions from locomotive activities, as discussed in Section 4.3. These temporal emission factors are presented in electronic tables in Appendix B.

3.2 DPM Emissions from Cargo Handling Equipment

Cargo handling equipment (designated as activity category H in Appendix A) consisted of equipment that was used to handle intermodal freight at the Richmond site and included lift machines and yard vehicles and hostlers. DPM emissions due to cargo handling equipment activities were estimated using the emission factors determined using the equipment population list and default activity data from the draft EMFAC2005 model provided by ARB (2006c). Additional details regarding the emission calculation methodology are discussed in Appendix A.

3.3 DPM Emissions from On-Road Container Trucks

On-Road container trucks (designated as activity category I in Appendix A) included tractor-trailers trucks that receive or deliver containers to the container yard (i.e., the intermodal area) at Richmond. DPM emissions due to on-road container truck travel at Richmond were estimated using emission factors from the draft EMFAC2005 model provided by ARB (2006c) and an average on-site travel distance. Truck counts at the facility entrance and exit gates, entrance and exit queuing time (used in the calculation of idling emissions at the entrance and exit gates), and average speed and distance on site were determined from a sample chase truck study at the Richmond Yard. Additional details regarding the emission calculation methodologies are discussed in Appendix A.

3.4 DPM and Gasoline TAC Emissions from On-Road Fleet Vehicles

On-road fleet vehicles (designated as activity category J in Appendix A) included employee vehicles owned by BNSF and road-legal vehicles owned by BNSF (i.e., passenger vehicles and small trucks) used for both on-site and off-site travel. DPM and gasoline TAC emissions due to on-road fleet vehicle activities were estimated using the emission factors from the draft EMFAC2005 model provided by ARB (2006c) and an average on-site travel distance. Appendix A presents additional details regarding the methods used to estimate emissions from these vehicle activities.

3.5 DPM and Gasoline TAC Emissions from Off-Road Equipment

ENVIRON categorized Off-Road Equipment at the Facility into three main types of equipment: TRUs, track maintenance equipment, and portable engines (designated as activity category K in Appendix A). TRUs are used to regulate temperatures during the transport of products with temperature requirements. For BNSF operations, temperatures are regulated by TRUs in shipping containers and in railcars when the material being shipped require such temperature regulation. TRU emissions were estimated using the draft version of the OFFROAD model provided by ARB (2006c). TRU yearly activity was estimated using the time onsite by TRU configuration (either railcar or shipping container) and mode of transport. This activity data was used along with ARB default age, horsepower, and load factor input estimates in the OFFROAD model to estimate TRU emissions. Additional details regarding the emission calculation methodologies are discussed in Appendix A.

Track maintenance equipment included equipment used to service tracks and included a variety of large and small engines and equipment. BNSF California track maintenance equipment can be used on any or all tracks within California to maintain the network. Therefore, DPM and gasoline TAC emissions for a given facility were estimated by apportioning the sum of emissions from all track maintenance equipment in California by site using the relative track mileage (including all tracks, main line and other tracks) at the site to the California total track mileage. Total exhaust emissions from track maintenance equipment were estimated using the draft version of the OFFROAD model (ARB 2006c). Additional details regarding the emission calculation methodologies are discussed in Appendix A.

Portable engines included forklifts, welders, leaf blowers, pressure washers, lawn and garden equipment, and other general industrial equipment. Emissions were estimated based on equipment specific emission factors from the draft OFFROAD model provided by ARB (2006c), annual hours of usage, and load factors. Appendix A presents additional details regarding the methods used to estimate emissions from these equipment types.

3.6 DPM and Gasoline TAC Emissions from Stationary Sources

Stationary sources at the Facility (designated as activity category L in Appendix A) included a gasoline dispensing and storage facility and three emergency generators. TAC emissions from the gasoline dispensing and storage facility were estimated based upon the emissions methodology in the Bay Area Air Quality Management District (BAAQMD) permit application (Application #23575) for this emission source. The BAAQMD methodology contained emission factors and followed guidance from the Gasoline Service Station Industry-Wide Risk Assessment Guidelines (CAPCOA 1997) prepared by the Toxics Committee of the California Air Pollution Control Officers Association (CAPCOA). This methodology accounted for TAC emissions from filling/working, dispensing, spillage, and breathing. Additional details regarding the emission calculation methodologies are discussed in Appendix A.

DPM emissions from the three emergency generators were estimated based upon manufacturer PM certification levels and the estimated hours of usage from the BAAQMD permit application (Application # 7577) for these sources. Source parameter information was available from this BAAQMD permit application.

3.7 Emission Estimates Summary

Tables 3-1a and 3-1b summarize the total annual emissions, operating hours, and the emission rate (in grams per second or grams per square meter per second) for each emission source by activity subcategory for DPM and gasoline emission sources, respectively. ENVIRON performed the air dispersion modeling to estimate period-average DPM and gasoline concentrations using χ/Q emission rates (i.e., one gram per second per source for point and volume sources and one gram per second divided by the total surface area of the source group for each area source), resulting in period-average dispersion factors. Tables 3-1a and 3-1b include the emission rates (in grams per second) applied to the period-average dispersion factors from the air dispersion model to calculate period-average air concentrations. Table 3-1b also includes the maximum hourly TOG emission rates for gasoline sources used to estimate maximum one-hour TAC concentrations.

Table 3-2 outlines the annual DPM and TAC emissions estimated for each of the main source categories described in this section and their contribution to the total DPM and gasoline TOG and PM emissions. The emissions for each of the activities were distributed spatially and temporally over the range of operations as described in more detail in Section 4.

4.0 AIR DISPERSION MODELING

ENVIRON performed air dispersion modeling to estimate exposure concentrations from the dispersion of DPM and TAC emissions from routine operational sources at Richmond. ENVIRON evaluated DPM emissions from locomotive and on- and off-road diesel engines as well as TAC emissions from gasoline engines and on-site permitted stationary sources. Air dispersion modeling requires the selection of an appropriate dispersion model and input data based on regulatory guidance, common industry standards/practice, and/or professional judgment. As stated previously, ENVIRON performed air dispersion modeling generally consistent with previous studies and guidance documents (ARB 2004, 2005a, 2005c, 2006a and USEPA 2000, 2004a, 2004b, 2005a, 2005b) based on the information available at the time of the assessment. The type of air dispersion model and modeling inputs (i.e., pollutants to be modeled with appropriate averaging times, source characterization and parameters, meteorological data, building downwash, terrain, land use, and receptor locations) that we used in the air dispersion modeling for Richmond are discussed below.

4.1 Model Selection and Model Control Options

As discussed in the Introduction, ENVIRON used the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD version 04300) to estimate airborne concentrations resulting from DPM and TAC emissions from the BNSF Richmond Yard as recommended in the draft Guidelines (ARB 2006a) and USEPA air dispersion modeling guidelines (2005b). AERMOD was developed as a replacement for USEPA's Industrial Source Complex (ISC) air dispersion model to improve the accuracy of air dispersion model results for routine regulatory applications and to incorporate the progress in scientific knowledge of atmospheric turbulence and dispersion. This change was made in November 2005 (USEPA 2005a). After a one-year transition period for the change in model (i.e., as of November 9, 2006), ISC will no longer be considered a USEPA-approved model for certain regulatory applications. Both models are near-field, steady-state Gaussian plume models, and use site-representative hourly surface and twice-daily upper air meteorological data to simulate the effects of dispersion of emissions from industrial-type releases (e.g., point, area, and volume) for distances of up to 50 kilometers (USEPA 2005b).

AERMOD is appropriate for use in estimating ground-level short-term ambient air concentrations resulting from non-reactive buoyant emissions from sources located in simple and complex terrain. ENVIRON conducted the air dispersion analysis using AERMOD in the regulatory default mode, which includes the following modeling control options:

- adjusting stack heights for stack-tip downwash (except for building downwash cases),
- incorporating the effects of elevated terrain,
- employing the calms processing routine, and
- employing the missing data processing routine.

4.2 Modeled Pollutants and Averaging Periods

Calculation of chemical concentrations for use in exposure analysis requires the selection of appropriate concentration averaging times. ENVIRON based the selection of appropriate averaging times on the toxicity criteria data developed by the California Environmental Protection Agency (CalEPA).

For DPM, CalEPA has developed toxicity criteria for both carcinogenic and chronic non-carcinogenic effects (CalEPA 2005a, 2005b) Therefore, ENVIRON estimated the annual average DPM concentration over the span of the meteorological data for ARB's use in estimating cancer and chronic non-cancer risk. ENVIRON did not calculate maximum short-term concentrations (one-hour averages) for DPM as an acute toxicity criteria for DPM has not been developed by the CalEPA (i.e., no acute reference exposure level (REL) is listed) (CalEPA 2000).

ENVIRON evaluated a large number of non-DPM TACs in this assessment from non-DPM sources (mainly from gasoline engine emissions) as identified in the speciation profiles discussed in Appendix A. ENVIRON estimated both annual-average and maximum one-hour concentrations for each non-DPM TAC. In order to substantially reduce modeling complexity and run time, maximum one-hour TOG exhaust, TOG evaporative, and PM exhaust emission rates (as opposed to maximum one-hour individual TAC emission rates) were input into the air dispersion model. Speciation profiles containing the fractions of individual TACs for TOG exhaust, TOG evaporative, and PM exhaust emissions (discussed in Appendix A) were then applied to the TOG exhaust, TOG evaporative, and PM exhaust concentrations estimated by the dispersion model to calculate concentrations of individual TACs. This methodology resulted in conservative estimates (i.e., over-predictions) of the maximum one-hour concentrations for individual TACs.

4.3 Source Characterization and Parameters

Source characterization, location, and parameter information is necessary to model the dispersion of air emissions. ENVIRON modeled DPM and other TAC emissions from operational sources at Richmond, as described above. In general, we determined source locations from the activity information discussed in Section 2, facility plot plans, information provided by BNSF personnel and contractors, and/or recent aerial photographs of the facility and surrounding areas. ENVIRON accounted for temporal (i.e., hourly, daily, and/or seasonal) variations in activities and emissions from each source by using variable hourly, daily, and seasonal emission factors where available. ENVIRON represented emissions from locomotive sources, vehicular sources, mobile equipment sources, and stationary sources as one of the following source types, and generally consistent with the draft Guidelines (ARB 2006a), where possible:

- Point source (a source with emissions emanating from a known point, with buoyancy due to either thermal or mechanical momentum). A point source is characterized by a height, diameter, temperature, and exit velocity.
- Volume source (a source with emissions that have no buoyancy and are emanated from a diffuse area). A volume source is characterized by an initial lateral and vertical dimension (initial dispersion) and a release height.
- Area source (a source with emissions that have no buoyancy and are emanated from a diffuse plane or box). An initial vertical dimension and release height may also be specified for an area source.

ENVIRON used point sources to model emissions from stationary idling locomotive source activities and most other stationary permitted sources. We used volume sources to represent emissions from moving sources along specific pathways (e.g., moving locomotives, trucks, and cars). ENVIRON used area sources to represent emissions from mobile equipment and vehicles operating over large areas. Additional details regarding the characterization of sources, source locations, and modeling parameters for each source category discussed in Section 3.0 are described below.

4.3.1 Locomotives at the Facility

4.3.1.1 Stationary Idling Locomotives

ENVIRON represented DPM emissions from stationary idling locomotives by point sources spaced approximately every 50 meters similar to ARB's Roseville Study (ARB 2004). ENVIRON placed point sources along railway lines at Richmond in areas where stationary idling activities occur, staggering point sources on adjacent parallel railway lines. ENVIRON placed overlapping point sources on rail lines that have converged to account for the amount of locomotives along the converged line relative to the multiple individual rail lines feeding into the converged line (e.g., for locomotive in-consist activities). The locations of point sources representing stationary locomotives are shown in Figures 4-1a and 4-1b. ENVIRON distributed emissions uniformly among the point sources comprising each stationary idling activity. ENVIRON assumed that emissions from stationary locomotive activities occur 24 hours per day, seven days per week based on information from BNSF personnel. Table 3-1a summarizes the emissions and operating hours for each stationary locomotive activity. Variable hourly, daily, and seasonal emission factors were also applied to approximate the temporal variations in emissions from these sources. These variable emission profiles are summarized in electronic tables in Appendix B.

Facility personnel provided source parameter information (i.e., release height, velocity, temperature, and diameter), which was based on the specific locomotive types and notch settings for each stationary locomotive activity (e.g., idling or load testing). ENVIRON performed fleet-averaging of locomotive source parameters as recommended by the draft Guidelines (ARB 2006a) to reduce the large number (from approximately 420 to 75) of potential source parameter configurations related to the stationary locomotive activities at Richmond. Fleet-averaging of source parameters was performed by weighting the source parameters for each locomotive model type by the percentage of emissions from each locomotive model type for a given locomotive activity. Table 4-1 summarizes the fleet-average source parameters for stationary locomotive activities at Richmond.

4.3.1.2 Locomotive Movement

ENVIRON represented moving locomotive DPM sources by individual volume sources spaced approximately every 50 meters similar to ARB's Roseville Study (ARB 2004). ENVIRON placed sources along railway lines at Richmond where movement activities occur. Figures 4-2a, 4-2b, and 4-2c show the locations of modeled volume (movement) sources at the Facility. ENVIRON distributed emissions evenly among the volume sources comprising each movement activity. ENVIRON assumed that emissions from locomotive movement activities occur 24 hours per day, seven days per week based on information from BNSF personnel. Table 3-1a summarizes the emissions and operating hours for each locomotive movement activity. Variable hourly, daily, and seasonal emission factors were also applied to approximate the temporal variations in emissions from these sources. These variable emission profiles are summarized in electronic tables in Appendix B.

For locomotive movement sources occurring along single rail lines, ENVIRON set the length of side for each volume source equal to the width of the fleet-average locomotive. In order to reduce modeling complexity and decrease model run-times, and in order to reduce the number of volume sources required to represent multiple parallel rail lines, ENVIRON used larger volumes with the length of side equal to the combined width of the rail lines plus the width of a locomotive. ENVIRON used a similar methodology (i.e., volumes with the length of side equal to the combined width of the rail lines plus the width of a locomotive) to represent converging or diverging rail lines, resulting in progressively smaller volumes as the rail lines converged and progressively larger volumes as rail lines diverged. ENVIRON performed sensitivity analyses to evaluate the use of a single set of larger volume sources versus multiple sets of smaller volume sources along multiple parallel rail lines and converging rail lines. These sensitivity analyses demonstrated that the use of larger volume sources with 50-meter source spacing generally resulted in receptor concentrations within five percent of the receptor concentrations predicted by the multiple sets of smaller volume sources and smaller source spacing. The results of these sensitivity analyses are discussed in more detail in Appendix C of ENVIRON's Air Dispersion Modeling Assessment of Air Toxic Emissions from BNSF Commerce/Mechanical Rail Yard ("BNSF Commerce/Mechanical") Report (ENVIRON 2006b). ENVIRON calculated the corresponding initial lateral dimension of each volume source from USEPA guidance (USEPA 2004b).

ARB accounted for buoyancy effects of exhaust from locomotive movement activities by calculating plume rise adjustments to the release height using USEPA's SCREEN3 model for all 11 different locomotive models considered in the study (ARB 2004). Due to variability in locomotive travel speeds, hourly wind speeds, and hourly stability class, a potentially large uncertainty is associated with these plume rise adjustments. ENVIRON also calculated plume rise adjustments to the release height using the

SCREEN3 model and a methodology similar to that of ARB (ARB 2004). Due to the uncertainty associated with variable locomotive speeds, hourly wind speeds, and hourly stability class, plume rise adjustments were calculated based on fleet-average locomotive parameters for individual locomotive activities. For source activities with multiple notch settings (e.g., Locomotive Switching), ENVIRON selected plume rise predictions based on fleet-average source parameters for the single notch setting with the highest percentage of activity emissions. For movement activities with a range of locomotive speeds, the wind speed in SCREEN3 was set equal to the maximum locomotive speed, resulting in lower, more conservative plume rise adjustments. ENVIRON calculated the corresponding initial lateral dimension of each volume source from USEPA (USEPA 2004b) guidance. Tables 4-1 and 4-2 summarize the modeling source parameters, approximate travel speeds, and plume rise adjustments used for locomotive movement sources at Richmond. Electronic SCREEN3 input and output files used to determine plume rise adjustments are attached in Appendix C.

4.3.2 Cargo Handling Equipment

4.3.2.1 Lift Machines

As lift machines operations may occur over a large section of the intermodal area of the Facility, and as specific modeling source parameters were not available for the lift machines, ENVIRON conservatively represented DPM emissions from lift machines by area sources as recommended by the draft Guidelines (ARB 2006a). ENVIRON placed area sources over areas where lift machine activities occur. According to BNSF facility personnel, all lift machine activities occur along an area approximately 30 to 40 meters wide in the central and southern portions of the intermodal area of the Facility. The locations of area sources representing lift machines are shown in Figure 4-3. Emissions within this operating area were distributed uniformly based on information from BNSF personnel. ENVIRON assumed that emissions from lift machine activities occur 24 hours per day, seven days per week based on information from BNSF personnel. Table 3-1a summarizes the DPM emissions and operating hours for lift machines at Richmond.

Model-specific source parameter information (i.e., release height, velocity, temperature, and diameter) for lift machines obtained from BNSF personnel varied considerably (e.g., release heights varied between 2.9 meters and 15.4 meters). Therefore, ENVIRON conservatively selected the upper end of the range of release heights (3.9 meters) from ARB's Port of Los Angeles/Port of Long Beach (POLA/POLB) Study (ARB 2005c) for use in the air dispersion modeling. ENVIRON did not consider plume rise for lift machines due to the large variation in measured release temperatures and velocities reported by BNSF personnel. The use of a potentially lower release height based on information from the ARB POLA/POLB Study and the exclusion of plume rise adjustments to the release height result in higher (more conservative) predictions of receptor concentrations. ENVIRON calculated the corresponding initial vertical dimension of each area source from USEPA (USEPA 2004b) guidance. Table 4-3 summarizes the modeling source parameters for lift machine activities at Richmond.

4.3.2.2 Yard Vehicles and Hostlers

As yard vehicles and hostlers may operate throughout the intermodal area of the Facility, and as specific modeling source parameters were not available for yard vehicles and hostlers, ENVIRON conservatively represented DPM emissions from yard vehicles and hostlers by area sources as recommended by the draft Guidelines (ARB 2006a). ENVIRON placed area sources over areas where yard vehicles and hostler activities occur. According to BNSF facility personnel, yard vehicles and hostlers operate over the entire intermodal area of the Facility. The locations of area sources representing yard vehicles and hostlers are shown in Figure 4-3. Emissions within this operating area were distributed uniformly based on information from BNSF personnel. ENVIRON assumed that emissions from yard vehicle and hostler activities occur 24 hours per day, seven days per week based on information from BNSF personnel. Table 3-1a summarizes the DPM emissions and operating hours for yard vehicles and hostlers at Richmond.

Model-specific source parameter information (i.e., release height, velocity, temperature, and diameter) for yard vehicles and hostlers was not available from BNSF personnel. Therefore, ENVIRON assumed that emissions release characteristics for yard vehicles and hostlers were similar to on-road fleet vehicles, and used a release equal to 0.6 meters (i.e., the same release height as on-road fleet vehicles). ENVIRON also assumed that exhaust emissions from yard vehicles and hostlers were released horizontally, and that plume rise due to differences in temperature between the vehicle exhaust and ambient air was negligible. ENVIRON calculated the corresponding initial vertical dimension of each area source from USEPA (USEPA 2004b) guidance. Table 4-3 summarizes the modeling source parameters for yard vehicle and hostler activities at Richmond.

4.3.3 On-Road Container Trucks

ENVIRON represented DPM emissions from on-road container trucks by a combination of volume and area sources as recommended by the draft Guidelines (ARB 2006a) and in discussions with ARB staff.[2] ENVIRON represented on-road container truck movements along specified travel pathways (i.e., along the pathway from the southeast entrance to the intermodal area) by individual volume sources spaced approximately every 50 meters, similar to locomotive movement activities. ENVIRON used areas sources to represent on-road container truck travel and idling in areas of the Facility where the travel path(s) and idling areas were not well-defined (i.e., in the intermodal area). ENVIRON used individual volume sources to represent on-road container truck idling at the entrance and exit at the gate near the southeast corner of the Facility. The locations of volume and area sources representing on-road container truck travel paths/areas and idling areas are shown in Figure 4-4. In order to apportion movement emissions between the travel path consisting of volume sources from the gate near the southeast corner of the Facility to the intermodal area and travel within the intermodal area, ENVIRON assumed an average travel path length within the intermodal area and calculated a ratio of the lengths of the two travel paths (i.e., within the intermodal area and outside the intermodal area). This ratio was then used to apportion the total on-road container truck movement emissions between truck travel in the intermodal area and outside the intermodal area. Movement emissions within each travel path or travel area were distributed uniformly. Based on information from BNSF personnel, ENVIRON assumed that on-site idling emissions (except emissions at the entrance and exit) occurred throughout the intermodal area, and were distributed uniformly. ENVIRON assumed that emissions from on-road container truck activities occur 24 hours a day, seven days per week based on information from BNSF personnel. Table 3-1a summarizes the DPM emissions and operating hours for on-road container trucks.

Model-specific source parameter information (i.e., release height, velocity, temperature, and diameter) for BNSF on-road fleet vehicles was not available from BNSF personnel. Based on information from a previous ARB study (ARB 2000) and recommendations by ARB staff,[3] ENVIRON used a release height of 4.0 meters for on-road container truck idling and travel during the daytime (i.e., 6 a.m. to 6 p.m.) and a release height of 6.0 meters for nighttime (i.e., 6 p.m. to 6 a.m.) to account for plume rise. ENVIRON calculated the corresponding initial vertical dimension of each volume and area source from USEPA (USEPA 2004b) guidance. Table 4-4 summarizes the modeling source parameters for on-road container truck activities at Richmond.

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[2] Personal communication. Gavin Hoch of ENVIRON by telephone with Jing Yuan of ARB on August 31, 2006.
[3] Personal communication. Gavin Hoch of ENVIRON by telephone with Pingkuan Di of ARB on August 24, 2006.

4.3.4 Off-Road Equipment

4.3.4.1 Boxcar TRUs

As boxcar TRUs may be located throughout the locomotive and freight repair area of the Facility, and as specific modeling source parameters were not available for each engine, ENVIRON conservatively represented DPM emissions from boxcar TRUs by area sources as recommended by the draft Guidelines (ARB 2006a). ENVIRON placed area sources over areas where boxcar TRU activities occur. According to BNSF facility personnel, boxcar TRUs may be located anywhere where locomotive activities occur (i.e., throughout the locomotive and freight repair area of the Facility). The locations of area sources representing boxcar TRUs are shown in Figure 4-3. Emissions were distributed uniformly throughout the locomotive and freight repair area of the Facility based on information from BNSF personnel. ENVIRON assumed that emissions from boxcar TRUs occur 24 hours per day, seven days per week, based on information from BNSF personnel. Table 3-1a summarizes the DPM emissions and operating hours for boxcar TRUs at the Facility.

Source parameter information (i.e., release height, velocity, temperature, and diameter) for boxcar TRUs was not available from BNSF personnel. ENVIRON assumed that the release height of a boxcar TRU is the same as a container TRU (1.0 meters). ENVIRON conservatively estimated the release height of a container TRU, described below, based on photographs of container TRUs, and did not account for the elevated release height for multiple, vertically stacked containers or the height of the base of the container TRUs above the ground (i.e., the release height was based on the release point above the base of the container, not above the ground). This conservative assumption resulted in over-predictions of receptor concentrations. ENVIRON calculated the corresponding initial vertical dimension of each area source from USEPA (USEPA 2004b) guidance. Table 4-3 summarizes the modeling source parameters for boxcar TRUs at Richmond.

4.3.4.2 Container TRUs

As container TRUs may be located throughout the intermodal area of the Facility, and as specific modeling source parameters were not available, ENVIRON conservatively represented DPM emissions from container TRUs by area sources as recommended by the draft Guidelines (ARB 2006a). ENVIRON placed area sources over areas where container TRU activities occur. According to BNSF facility personnel, container TRUs may be located anywhere where intermodal activities occur (i.e., throughout the intermodal area of the Facility). The locations of area sources representing container TRUs are shown in Figure 4-3. Emissions were distributed uniformly throughout the locomotive and freight repair area of the Facility based on information from BNSF personnel. ENVIRON assumed that emissions from container TRUs occur 24 hours per day, seven days per week, based on information from BNSF personnel. Table 3-1a summarizes the DPM emissions and operating hours for container TRUs at the Facility.

Model-specific source parameter information (i.e., release height, velocity, temperature, and diameter) for container TRUs was not available from BNSF personnel. ENVIRON conservatively assumed the release height of a container TRU (1.0 meters) based on photographs of container TRUs, and did not account for the elevated release height for multiple, vertically stacked containers or the height of the base of the container TRUs above the ground (i.e., the release height was based on the release point above the base of the container, not above the ground). This conservative assumption likely results in over-predictions of receptor concentrations. ENVIRON calculated the corresponding initial vertical dimension of each area source from USEPA (USEPA 2004b) guidance. Table 4-3 summarizes the modeling source parameters for container TRUs at Richmond.

4.3.4.3 Track Maintenance Equipment

As track maintenance equipment operations may occur over a large section of locomotive and freight repair area of the Facility, and as specific modeling source parameters were not available for track maintenance equipment, ENVIRON conservatively represented DPM and gasoline TAC emissions from track maintenance equipment by area sources as recommended by the draft Guidelines (ARB 2006a). ENVIRON placed area sources over railway lines at Richmond in areas where track maintenance activities occur. The locations of area sources representing track maintenance equipment are shown in Figure 4-3. Emissions within this operating area were distributed uniformly based on information from BNSF personnel. ENVIRON assumed that emissions from track maintenance activities occur weekdays (i.e., Monday through Friday) from 7 a.m. to 7 p.m. based on information from BNSF personnel. Tables 3-1a and 3-1b summarize the DPM and gasoline emissions, respectively, and operating hours for track maintenance equipment.

Model-specific source parameter information (i.e., release height, velocity, temperature, and diameter) for track maintenance equipment was not available from BNSF personnel. Because track maintenance equipment generally appeared to be similar in height to locomotives and have vertical emissions releases, ENVIRON assumed an average release height corresponding to the lowest moving locomotive release height adjusted for plume rise (i.e., the lowest adjusted release height in Table 4-2). ENVIRON calculated the corresponding initial vertical dimension of each area source from USEPA (USEPA 2004b) guidance. Table 4-3 summarizes the modeling source parameters for track maintenance equipment activities at Richmond.

4.3.4.4 Portable Engines

As portable engines were used over large areas of the Facility, and as specific modeling source parameters were not available for each engine, ENVIRON conservatively represented DPM and gasoline TAC emissions from portable engines by area sources as recommended by the draft Guidelines (ARB 2006a). ENVIRON placed area sources over areas where portable engine activities occur. According to BNSF facility personnel, all portable engine activities occur in the two Freight Car Repair Buildings. The locations of area sources representing portable engines are shown in Figure 4-3. Emissions within each of these two operating areas were distributed uniformly based on information from BNSF personnel. ENVIRON assumed that emissions from portable engine activities occur weekdays (Monday through Friday) from 7 a.m. to 3:30 p.m., based on information from BNSF personnel. Tables 3-1a and 3-1b summarize the DPM and gasoline emissions, respectively, and operating hours for portable engines at the Facility.

Model-specific source parameter information (i.e., release height, velocity, temperature, and diameter) for portable engines was not available from BNSF personnel. ENVIRON assumed a release height equal to half the building height (i.e., a release height of 4.66 meters) for portable engines operating inside the Freight Car Repair Buildings due to the large open doors on both ends of the building. ENVIRON calculated the corresponding initial vertical dimension of each area source from USEPA (USEPA 2004b) guidance. Table 4-3 summarizes the modeling source parameters for portable engine activities at Richmond.

4.3.5 On-Road Fleet

ENVIRON represented DPM and gasoline TAC emissions from BNSF on-road fleet vehicles by a combination of volume and area sources as recommended by the draft Guidelines (ARB 2006a) and in discussions with ARB staff.[4] ENVIRON represented on-road fleet vehicle movements along specified travel pathways by individual volume sources spaced approximately every 50 meters, similar to locomotive movement activities. ENVIRON used areas sources to represent on-road fleet vehicle travel in areas of the Facility where the travel path(s) were not well-defined. The locations of volume and area sources representing on-road fleet vehicle travel paths/areas are shown in Figure 4-4. Because Facility personnel did not have information specifying the approximate number of fleet vehicles or approximate percentage of emissions associated with any particular travel path and/or travel area, ENVIRON assumed that a similar number of fleet vehicles traveled over each travel path and within each travel area and apportioned total fleet vehicle emissions based on the length of the travel paths. For travel areas represented by area sources, an average path length within the area was assumed in order to apportion emissions. Emissions within each travel path or travel area were distributed uniformly. ENVIRON assumed that emissions from on-road fleet vehicle activities occur 24 hours a day, seven days per week based on information from BNSF personnel. Tables 3-1a and 3-1b summarize the DPM and gasoline emissions, respectively, and operating hours for BNSF on-road fleet vehicles. Model-specific source parameter information (i.e., release height, velocity, temperature, and diameter) for BNSF on-road fleet vehicles was not available from BNSF personnel. Based on information from a previous ARB study (ARB 2000) and recommendations by ARB staff,[5] ENVIRON used a release height of 0.6 meters for on-road fleet vehicles. ENVIRON assumed that exhaust emissions from on-road fleet vehicles were released horizontally, and that plume rise due to differences in temperature between the vehicle exhaust and ambient air was negligible. ENVIRON calculated the corresponding initial vertical dimension of each volume and area source from USEPA (USEPA 2004b) guidance. Table 4-4 summarizes the modeling source parameters for BNSF on-road fleet vehicle activities at Richmond.

4.3.6 Permitted Stationary Sources

4.3.6.1 Emergency Generators

ENVIRON represent DPM emissions from the three diesel-fueled emergency generators as point sources, based information in BAAQMD Permit Application # 7577 and consistent with the draft Guidelines (ARB 2006a). ENVIRON placed individual point sources at the locations of the three emergency generators, as shown in Figure 4-5. Although emissions from the three emergency generators occurred over only 26 hours each, the exact hours or times when the generators were operating was unknown, and

[4] Personal communication. Gavin Hoch of ENVIRON by telephone with Jing Yuan of ARB on August 24, 2006.
[5] Ibid.

emissions could occur during any hour of the year. Thus, ENVIRON assumed that emissions from the three emergency generators could occurr 24 hours per day, seven days per week, and were distributed uniformly over all hours of the year. Table 3-1b summarizes the DPM emissions and operating hours for the three emergency generators.

Engine-specific source parameter information (i.e., release height, velocity, temperature, and diameter) was also available from BAAQMD Permit Application # 7577 for the three emergency generators. Table 4-5 summarizes the modeling source parameters for the three emergency generators at Richmond.

4.3.6.2 Gasoline Dispensing and Storage Facility

ENVIRON represented gasoline TAC emissions from the gasoline dispensing and storage facility as a volume source based on plot plans and above-ground storage tank diagrams in BAAQMD Permit Application # 23575 and consistent with the draft Guidelines (ARB 2006a). The location of the volume source representing the gasoline dispensing and storage facility is shown in Figure 4-5. ENVIRON assumed that emissions from the gasoline dispensing and storage facility (from fueling activities and breathing and working losses) occur 24 hours per day, seven days per week based on information from BNSF personnel. Table 3-1b summarizes the gasoline emissions and operating hours for the gasoline dispensing and storage facility.

Source parameter information (i.e., release height for evaporative losses from the storage tank and release height, velocity, temperature, and diameter for dispensing equipment) was not available for emission sources at the gasoline dispensing and storage facility. However, based on aerial photographs and discussions with BNSF personnel, the storage tank and dispensing equipment are both located above ground. In addition, the filling area and equipment is very similar to the equipment at a typical commercial filling station. Although evaporative emissions from the storage tank and dispensing equipment occur above ground level, the exact height of the release points for the emissions is unknown. Therefore, ENVIRON assumed a conservative release height of zero meters for emissions from the gasoline dispensing and storage facility. ENVIRON calculated the corresponding initial vertical dimension of the volume source from USEPA (USEPA 2004b) guidance. Table 4-5 summarizes the modeling source parameters for the gasoline dispensing and storage facility at Richmond.

4.4 Meteorological Data

AERMOD requires a meteorological input file to characterize the transport and dispersion of pollutants in the atmosphere. Surface and upper air meteorological data inputs as well as surface parameter data describing the land use and surface characteristics near the site are first processed using AERMET, the meteorological preprocessor to AERMOD. The output file generated by AERMET is the meteorological input file required by AERMOD. Details of AERMET and AERMOD meteorological data needs are described in USEPA guidance documents (USEPA 2004a, 2004b). As ENVIRON previous received ARB approval of meteorological data selection and processing methods (ENVIRON 2006a), the remainder of this section only briefly describes the following two key aspects of the AERMET analysis: the surface and upper air meteorological data selected and the surface parameter evaluation for Richmond. ENVIRON has provided the raw meteorological data and the AERMOD model-ready meteorological data file as an electronic attachment in Appendix D.

4.4.1 Surface and Upper Air Meteorological Data

The focus of the HRA to be conducted by ARB is the characterization of risk in the areas immediately surrounding Richmond. As such, ENVIRON selected meteorological data for air dispersion modeling based upon their spatial and temporal representativeness of conditions in the immediate vicinity of the rail yard. As described in ENVIRON's report on meteorological data selection and processing methods previous approved by ARB (ENVIRON 2006a), ENVIRON selected the wind speed, wind direction, and temperature data from the Chevron Refinery on-site met station for the five years from 2001 to 2005 as the most representative available wind speed, wind direction, and temperature data for use in the air dispersion analysis of the BNSF Richmond Rail Yard. ENVIRON used cloud cover, and pressure data (as Chevron Refinery did not have a record of pressure measurements) from the National Weather Service's (NWS's) Oakland Metropolitan Airport station from 2001 to 2005. Upper air data from the Oakland Airport was used in AERMET processing for Richmond (ENVIRON 2006a).

4.4.2 Surface Parameters

Prior to running AERMET, it is necessary to specify the surface characteristics for the meteorological monitoring site and/or the project area. The surface parameters include surface roughness, Albedo, and Bowen ratio, and are used to compute fluxes and stability of the atmosphere (USEPA 2004a) and require the evaluation of nearby land use and temporal impacts on these surface parameters. Surface parameters supplied to the model will be specified for the area surrounding the meteorological monitoring site, rather than the project area (rail yard), as recommended by USEPA (USEPA 2005a) and ARB[6]. Because the selected meteorological station is in very close proximity to the BNSF Richmond Yard and the land use surrounding the meteorological station is very similar to the land use surrounding Richmond Yard, surface parameters calculated for the meteorological station should be representative of Richmond Yard.

In general, ENVIRON determined radial land-use sectors around the meteorological monitoring site using USGS land cover maps in conjunction with recent aerial photographs. ENVIRON then specified surface parameters for each sector using default seasonal values adjusted for the local climate. When a radial land-use sector consisted of multiple land-use types, ENVIRON, in general, used an area-weighted average of each surface parameter as recommended by USEPA (2004a) with a few exceptions as noted below. Because of the meteorological monitoring station's proximity to the shoreline, ENVIRON made additional considerations of the appropriateness of using default methods in assigning surface roughness to radial sectors surrounding the facility. The locale-specific surface parameters used in this evaluation were described in ENVIRON's previous report to ARB (ENVIRON 2006a).

In general, default land-use analysis is performed such that concentrations estimated in a sector downwind of a source are based on surface characteristics upwind from the source. However, for shoreline sources, sectors can be comprised of both land and water, where land-use types can vary by a few orders of magnitude in surface roughness. The assignment of surface parameters to such a mixed-use sector containing significant amounts of both land and water based on upwind surface characteristics can significantly over- or under-predict concentrations depending on the configuration of the land-use, source, and receptors. The approach adopted in "Wind Flow and Vapor Cloud Dispersion at Industrial and Urban Sites" (Hanna and Britter 2002) only includes the effects of roughness downwind of the source, because the distance to achieve a new equilibrium boundary layer is typically much less than distances of interest. Thus, for the Richmond Yard, ENVIRON performed an evaluation of the assignment of upwind or downwind land-use patterns for each sector as recommended by Hanna and Britter (2002).

Figure 4-6 shows the sectors ENVIRON selected around Richmond for use in the AERMET processing and the USEPA land-use types within each sector. Before assigning surface parameters for each sector, ENVIRON evaluated the appropriateness of using land-use characteristics upwind of the source for estimating concentrations downwind of the source:

- **Sectors 2 and 3:** Concentrations estimated in Sectors 2 and 3 are based on winds flowing from the sector comprised of Sub-sectors 5a through 5o and Sector 6,

[6] Personal communication, J. Yuan of ARB by e-mail to D. Daugherty of ENVIRON on August 3, 2006.

respectively. Sector 6 and the sector comprised of Sub-sectors 5a through 5o have large amounts of water while Sectors 2 and 3 are largely urban in land use. Since the surface roughness differences between the upwind and downwind sectors are more than two orders of magnitude in difference, concentrations in Sectors 2 and 3 would be significantly overestimated if concentrations in these sectors were estimated using land-use upwind of the source. Thus, land-use characteristics for concentrations estimated for Sectors 2 and 3 are based on land-use downwind of the source using the methodology of Hanna and Britter (2002).

- **Sector comprised of Sub-sectors 5a through 5o:** A similar consideration is made for the land-use parameters that are used to estimate concentrations in the sector comprised of Sub-sectors 5a through 5o. Receptors representing populations are likely to be located on the southwest corner of this area. Winds going to this portion will have traveled over a significant stretch of water before reaching these receptors. Upwind of the source (represented by Sector 2) is primarily classified by urban land-use. Thus, using upwind surface parameters to calculate concentrations for these receptors would significantly under-predict concentrations. Using downwind surface parameters to calculate concentrations for these receptors would take into account the water characteristics that the wind would travel across before reaching the receptors, as per the Hanna and Britter method (2002) discussed above.
- **Sector 6:** Concentrations estimated in Sector 6 are based on winds flowing from Sector 3. The water-land configuration in Sector 6 is such that the inner part of the sector is land, while the outer portion is primarily water. Thus, winds traveling towards the receptors from the source will not have traveled over any water nor through surface roughness changes of two orders of magnitude. Using land-use parameters downwind of the source to calculate concentrations at receptors downwind of the source would inappropriately take into account the significant amount of water in Sector 6 and thus significantly over-predict concentrations at land-based receptors. Hence, land-use parameters upwind of the source are used to calculate concentrations at receptors in Sector 6 as per the default methodology.
- **Sector 1:** Concentrations estimated in Sector 1 are based on winds flowing from Sector 4. Land-use in Sector 4 is primarily urban with a small amount of water close to the center of the 3-km circle. Land-use in Sector 1 is primarily urban, with less water. With the majority of the receptors in Sector 1 located such that the winds traveling towards them from the source will have traversed a significant amount of urban land-use, downwind land-use characteristics are used for concentrations predicted for this sector as per the Hanna and Britter methodology (2002) discussed above.

- **Sector 4:** Concentrations estimated in Sector 4 are based on winds flowing from Sector 1. As described above, land-use in Sector 4 is primarily urban with a small amount of water close to the center of the 3-km circle while land-use in Sector 1 is primarily urban, with less water. Receptors in Sector 4 are located such that wind traveling towards them from the source will have traveled over a small patch of water before reaching them. Thus, downwind land-use characteristics are used for concentrations predicted for this sector, as per the Hanna and Britter methodology (2002) discussed above.

Another consideration made for the Richmond Yard is that the division of the project area into radial sectors does not account for transitions in surface parameters that occur normal to the sector boundaries. Specifically, analyses of the effect of cross-wind transitions in surface roughness (the surface parameter that can influence AERMOD predicted airborne concentrations most significantly (ENVIRON 2005; Long 2004)), indicate that changes more than two orders of magnitude can result in significant over-estimates or under-estimates of concentrations (Hanna and Britter 2002). In such cases, applying a distance-weighted average based on zones defined in the radial direction from the project area can result in surface roughness estimates which, when used for dispersion modeling applications, produce more representative results. In practice, changes of several orders of magnitude in surface roughness most frequently occur in transitions between water and land. The sector comprised of Sub-sectors 5a – 5o is the only sector in this analysis that has a significant transition in surface parameters that occurs normal to the sector boundaries and contains receptors such that concentrations predicted would be significantly impacted by this arrangement. Thus, ENVIRON employed a distance-weighted average for the calculation of the surface roughness for this sector using methodology suggested by Hanna and Britter (2002) for sectors with surface roughness that varies a few orders of magnitude in the radial direction. Distance-weighting is not required for sectors that are relatively homogeneous or do not have surface roughness varying by a few orders of magnitude. Table 4-6 summarizes the sector-specific surface parameters (surface roughness, Albedo, and Bowen ratio) determined for each of these sectors.

4.5 Building Downwash

Building downwash is the effect of structures on the dispersion of emissions from nearby point (stack) sources. As several point sources at Richmond were identified as adjacent to buildings, ENVIRON considered building downwash in this assessment. ENVIRON estimated building dimensions (i.e., location of building corners) based on information provided by BNSF personnel and contractors. Building heights were not available for buildings and structures at the Richmond Yard, therefore ENVIRON estimated building heights using building height information for similar building types at other BNSF rail yards. Figure 4-7 shows the buildings evaluated as part of the building downwash analysis at Richmond. ENVIRON input building dimension information, summarized in Table 4-7, into USEPA's Building Profile Input Program – Plume Rise Model Enhancements (BPIP-PRIME) to account for potential building-induced aerodynamic downwash effects. The electronic input and output files for BPIP are provided in Appendix E. A sensitivity analysis was conducted in ENVIRON's BNSF Commerce/Mechanical Report (ENVIRON 2006b) to estimate the impact of building downwash from locomotive engines on stationary locomotive sources. This sensitivity analysis indicated that, at receptor distances close to the sources (i.e., within 100 meters), building downwash may have a large impact on the modeled concentrations. However, at distances further away from the sources (i.e., 400 to 700 meters), receptor concentrations for model runs with and without building downwash were similar (i.e., within 10% of each other). Based on the results of the sensitivity analysis, and the uncertainty in placing structures corresponding to stationary locomotives in areas where stationary locomotives occur, and the inherent uncertainty in concentration predictions near to stationary and mobile sources, as discussed in Section 5.0, building downwash effects from stationary locomotives were not considered in this assessment. The results of the sensitivity analysis are discussed in more detail in the Appendix F of ENVIRON's BNSF Commerce/Mechanical Report (ENVIRON 2006b).

4.6 Terrain

Another important consideration in an air dispersion modeling analysis is whether the terrain in the modeling area is simple or complex (i.e., terrain above the effective height of the emission point). ENVIRON used the following USGS 7.5 Minute digital elevation model (DEMs) information to identify terrain heights within the modeling domain:

- San Quentin
- San Francisco North
- Richmond
- Mare Island
- Oakland West
- Petaluma Point

The electronic DEM files in the North American Datum (NAD) 1983 projection are provided in Appendix F. ENVIRON provided terrain elevation data to the AERMOD model using version 04300 of AERMAP, AERMOD's terrain preprocessor. Due to discontinuities at the boundaries between some of the DEMs, AERMAP was not able to estimate the terrain elevations for five receptor locations. Using the known terrain elevation at adjacent receptors, ENVIRON estimated the terrain elevations at these six receptors using a linear interpolation methodology.

4.7 Land Use

AERMOD can evaluate heat island effects from urban areas to atmospheric transport and dispersion using an urban boundary layer option. ENVIRON used Auer's method of classifying land-use as either rural or urban to analyze the urban nature of the region in which the primary project area is located (Auer 1978). This method calls for analysis of the land within a three-kilometer radius from the primary project area to determine if the majority of the land can be classified as either rural (i.e. undeveloped) or urban. If more than fifty percent of the area circumscribed by this three-kilometer radius circle consists of Auer land-use industrial, commercial or residential urban land types, then the urban boundary layer option is used in modeling. ENVIRON used both the USGS National Land Cover Data and the most recent USGS aerial photograph of the area surrounding the facility to determine that more than fifty percent of the area within three-kilometers of Richmond Yard is urban, see Figure 4-8. Therefore, ENVIRON selected the urban boundary layer option for this analysis.

Selection of the urban boundary layer option in AERMOD requires also requires an estimate of the population of the urban area in order to make adjustments to the urban boundary layer. ENVIRON used published census data for the City of Richmond to determine population values as recommended by USEPA (USEPA 2005a). ENVIRON also provides electronic census data for the modeling domain (described in the next section) as an electronic attachment in Appendix G, as required in the draft Guidelines.

4.8 Receptor Locations

ENVIRON used gridded receptor points surrounding the BNSF Richmond Yard in the air dispersion analysis. These gridded receptor points represent the general population in the vicinity of the BNSF Richmond Yard, which includes both residential and commercial populations. However, these receptors do not necessarily represent the specific locations of the residential and commercial populations in the vicinity of the BNSF Richmond Yard. ENVIRON used three sets of discrete Cartesian receptor grid points around the Facility in the air dispersion modeling. The spacing and sizes of the Cartesian receptor grids were determined based on a screening sensitivity analysis, discussed in more detail in Appendix H. The Cartesian receptors included a fine receptor grid with spacing of 50 meters out to a distance of approximately 750 meters from the Facility boundary, a medium receptor grid with spacing of 250 meters out to a distance of approximately 1,500 meters from the Facility boundary, and a coarse receptor grid with spacing of 500 meters out to ten kilometers from the Facility boundary. ENVIRON used Facility plot plans and other information provided by BNSF facility personnel to locate the Facility boundary. Receptors inside the facility boundary and over water in the San Francisco Bay were removed prior to the air dispersion modeling analysis. The locations of the coarse, medium, and fine receptor grid points are shown in Figures 4-9a, 4-9b, and 4-9c, respectively. Discrete receptor points were generated from each of the grids shown in Figures 4-9a, 4-9b, and 4-9c. The air dispersion modeling analysis did not include receptors at the Facility boundary.

In accordance with the draft Guidelines (ARB 2006a), ENVIRON also evaluated individual receptor points at off-site locations within one mile of the Facility corresponding to sensitive receptors, including schools, hospitals, and daycare centers. Sensitive receptor locations were identified from searches of the following sources:

- California Department of Education, California School Directory

  http://www.cde.ca.gov/re/sd/
- The Automated Licensing Information and Report Tracking System (Hospitals and Licensed Care Facilities)
- http://alirts.oshpd.ca.gov/AdvSearch.aspx

  Yellow Pages

  http://yp.yahoo.com

These on-line databases were searched for the following zip codes in the cities of Richmond and San Pablo:

94801 94804 94806 94807

The sensitive receptor locations identified from the search of these data sources and within one mile of the Facility are listed in Table 4-8.

Electronic census data was provided for the modeling domain in accordance with the draft Guidelines (ARB 2006a). These data, provided on a census-block level, were obtained from the

GeoLytics CensusCD 2000 (GeoLytics 2001), and provided in electronic shapefile format in Appendix G.

4.9 Air Dispersion Modeling Results

ENVIRON calculated the air concentration of each TAC at each of the receptor locations discussed in Section 4.8. ENVIRON modeled DPM and TAC sources using unit emission rates (i.e., one gram per second) to estimate period-average dispersion factors for DPM and TACs corresponding to meteorological years 2001 through 2005. These period-average dispersion factors for DPM and TACs were combined with source-specific emission rates to generate period-average concentrations for the meteorological period 2001 through 2005.

ENVIRON modeled all non-DPM TAC sources using hourly-maximum evaporative TOG, exhaust TOG, and exhaust PM emission rates in order to estimate one-hour maximum evaporative TOG, exhaust TOG, and exhaust PM concentrations for the meteorological period 2001 through 2005. ARB speciation profiles for evaporative TOG, exhaust TOG, and exhaust PM were applied to estimate chemical-specific one-hour maximum concentrations at each receptor. It should be noted that this method results in an over-prediction of maximum one-hour concentrations of individual constituents at each receptor, as discussed in the uncertainty section below. Electronic AERMOD input and output modeling files are included in Appendix I. Electronic database tables containing DPM and gasoline TAC period-average concentrations at each receptor and one-hour maximum gasoline TAC concentrations at each receptor for the meteorological period modeled are contained in Appendix J.

5.0 UNCERTAINTIES

Understanding the degree of uncertainty associated with each component of a risk assessment is critical to interpreting the results of the risk assessment. As recommended by the National Research Council (NRC 1994), [a risk assessment should include] "a full and open discussion of uncertainties in the body of each EPA risk assessment, including prominent display of critical uncertainties in the risk characterization." The NRC (1994) further states that "when EPA reports estimates of risk to decision-makers and the public, it should present not only point estimates of risk, but also the sources and magnitude of uncertainty associated with these estimates." Similarly, recommendations to CalEPA on risk assessment practices and uncertainty analysis from the Risk Assessment Advisory Committee (RAAC) were adapted from NRC recommendations (RAAC 1996). Thus, to ensure an objective and balanced characterization of risk and to place the risk assessment results in the proper perspective, the results of a risk assessment should always be accompanied by a description of the uncertainties and critical assumptions that influence the key findings of the risk assessment.

In accordance with the recommendations described above and as required in the draft Guidelines (ARB 2006a), ENVIRON has evaluated the uncertainties associated with the first two steps of an HRA: (1) emissions estimation and (2) air dispersion modeling. The uncertainties and critical assumptions associated with these steps are described below. Consistent with the Agreement, ARB will complete the third major part of the HRA which consists of estimating the risks for each of the designated rail yards and evaluating the uncertainties associated with the risk characterization component of the HRA (ARB 2005b). As noted in the Agreement, specific objectives of the HRAs to be conducted by ARB include developing a basis for risk communication, including describing the uncertainties associated with the key findings of the risk assessment. At the request of ARB, ENVIRON will assist ARB in identifying the critical assumptions and uncertainties associated with the risk characterization step of the HRA. This uncertainty evaluation will be conducted concurrent with the ARB risk characterization activities and will be provided to ARB in a separate submittal.

The following section summarizes the critical uncertainties associated with the emissions estimation and air dispersion modeling components of the risk assessment.

5.1 Estimation of Emissions

The uncertainties associated with emissions estimates and projections include uncertainties in activity and emission rates for the base year as well as projected future years. Although future year emissions were not evaluated in this assessment, the residential and worker risk scenarios will be evaluated for 70-year and 40-year periods, respectively, at a minimum by ARB. Thus, uncertainty due to future changes in activity and emission rates will be generally discussed. The uncertainty in activity and emissions estimates applies to both locomotive and non-locomotive sources.

For locomotive sources, the activity rates include primarily the number of engines operating and time in modes. The number of engines operating in the facility on the mainline are accurately measured and counted at readers, but the readers are not necessarily located exactly at the site under study, and can under certain circumstances produce erroneous duplicate readings that could only be accounted for via rough approximation. A separate and less accurate dataset was used to estimate the number of engines arriving and departing from a site. These data, however, often do not produce matching arrivals and departures. ENVIRON adopted a conservative approach based on using the higher of the arrival or departure numbers, which may have resulted in overestimates of the number of engines arriving.

Uncertainties also exist in estimates of the engine time in mode. Idling is typically the most significant operational mode, but locomotive event recorder data could not distinguish between idling with the engine on and idling with the engine off. As a result, ENVIRON used professional judgment to distinguish between these two modes. In addition, no idle time reduction was assumed in the future year scenarios, despite the fact that BNSF has initiated programs to reduce idling through installation of automatic start/stop devices and other operational changes to reduce idling. So while the current operations may not be precisely known, control measures already being implemented are expected to result in reduced activity levels and lower emissions than are estimated here for future years.

The most significant non-locomotive sources at the rail yards are on-road trucks, cargo handling equipment, and transport refrigeration units used at intermodal facilities. Activity levels of these vehicles and equipment are estimated relatively accurately, however the duty cycles (engine load demanded) are less well characterized. Default estimates of the duty cycle may not accurately reflect the typical duty demanded from these vehicles and equipment at any particular site. New emissions models for these sources have recently been provided for use in this study by ARB. In many cases, these revised models reflect a dramatic change in emission factors from previous versions of the models and it is therefore reasonable to expect that future revisions to these models may result in further changes to emission estimates for on-road and off-road engines. In addition, national and state regulations have targeted these sources for emission reductions. Implementation of these rules and fleet turnover to newer engines meeting more strict standards should significantly reduce emissions at these rail sites in future years. The effects of these regulations have, for the most part, not been incorporated in the emission estimates, and so estimated emissions are greater than those expected for future years at the same activity level.

5.2 Estimation of Exposure Concentrations

5.2.1 Estimates from Air Dispersion Models

As discussed in Section 4.0, USEPA-recommended dispersion model AERMOD was used to estimate annual average off-site chemical exposure concentrations at the various off-site receptor locations. This model uses the Gaussian plume equation to calculate ambient air concentrations from emission sources. For this model, the magnitude of error for the maximum concentration is estimated to range from 10 to 40% (USEPA 2005b). Therefore, off-site exposure concentrations used in this assessment represent approximate off-site exposure concentrations.

5.2.2 Source Placement

Uncertainty exists in the placement of emission sources at the Facility. As a large amount of locomotive and on- and off-road engine activity at a rail yard is engaged in movement, the distribution of emissions during movement in the yards is an important source of uncertainty. Unlike fixed stationary sources, emissions from movement would occur over a continuum rather than as discrete points. However, regulatory approved models were originally developed for the evaluation of fixed stationary sources and the use of a continuum of source locations to model emissions during movement of sources results in an unacceptably large number (in the tens of thousands) of sources that would result in unwieldy post-processing data needs and unacceptable modeling run times (on the order of months rather than hours or days).

In this assessment, point and volume sources were spaced evenly at approximately 50-meter intervals similar to ARB's Roseville Study (ARB 2004) over rail locations where locomotive and on- and off-road activities occurred. Closer spacing between point and volume sources may impact the predicted concentrations at receptor locations near the Facility boundary. Sensitivity analyses performed to determine the potential impact of source placement on predicted concentrations at receptors near the Facility boundary (see Appendix C of ENVIRON's BNSF Commerce/Mechanical Report [ENVIRON 2006b]) indicated that concentrations at receptors nearest to the specific emission sources could be over-predicted by at least 10 percent.

5.2.3 Source Representation

The source parameters (i.e., release velocity and release temperature) used to model stationary locomotive activities are sources of uncertainty. Following ARB guidance (ARB 2006a), fleet-average source parameters were calculated to reduce the large number of potential source parameter configurations related to stationary locomotive activities at Richmond. The specific methodology used for calculating fleet-averaged source parameters is presented in Section 4.3.1.1. The use of fleet-average source parameters for stationary locomotive activities resulted in approximate predictions for these sources.

The release heights and vertical dimensions used for movement sources at the Facility are also sources of uncertainty. ARB calculated adjustments to the release height and vertical dimension for movement sources for individual engine models based on locomotive notch settings (i.e., locomotive travel speeds) and using two different stability classes for their Roseville study (ARB 2004). This methodology resulted in several uncertainties. ARB's methodology assumed that the wind speed was equal to the locomotive speed and did not account for variability in either the locomotive speed or hourly wind speeds. In addition, ARB's methodology assumed only two stability classes (i.e., class "D" for daytime and class "F" for nighttime), and did not account for potential variability in stability class during these time periods based local meteorological data. Nevertheless, ENVIRON calculated plume rise adjustments using a methodology similar to ARB's, described in more detail in Section 4.3.1.2, for locomotive movement activities and on-road diesel and gasoline vehicle movement sources at the Facility. Thus, the use of plume rise adjustments resulted in approximate predictions of receptor concentrations for these sources.

The use of area sources to represent emissions sources operating in areas where travel paths are not well defined or equipment usage may occur over the entire operating area are additional sources of uncertainty related to source representation. At the BNSF Richmond Yard, area sources were used to represent cargo handling equipment, transportation refrigeration units, on-road container truck idling and movement in the intermodal area, on-road fleet vehicle movement activities in and around parking areas, track maintenance equipment, and portable engines, which account for almost 30 percent of total DPM emissions from the Rail Yard. Based on guidance in the draft Guidelines (ARB 2006a), these source activities may be modeled as either area or volume sources. The AERMOD model uses very different methodologies to estimate dispersion from area and volume sources (USEPA 2004c), and the use of area sources generally results in higher (more conservative) concentration estimates. Thus, the use of area sources to represent cargo handling equipment, transportation refrigeration units, on-road container truck idling and movement in the intermodal area, on-road fleet, track maintenance, and portable engine activities at Richmond generally resulted in over-predictions of receptor concentrations for these source activities.

5.2.4 Meteorological Data Selection

Uncertainty also exists in the meteorological data used in the AERMOD air dispersion model. These uncertainties are related to the use of meteorological data that is not site-specific, combination of surface data from two meteorological stations, substitution of missing meteorological data, and use of surface parameters for the meteorological station as opposed to the rail yard.

ENVIRON selected meteorological data for air dispersion modeling based upon their spatial and temporal representativeness of conditions in the immediate vicinity of the rail yard. On-site meteorological data was not available for the rail yard. Therefore, the meteorological data used in this analysis was based on surface meteorological data from BAAQMD's Chevron Refinery station (approximately two kilometers from the rail yard) and the NCDC/NWS station at the Oakland Metropolitan Airport (approximately 25 kilometers from the rail yard) and upper air data from the Oakland Metropolitan Airport. A complete set of surface meteorological data was not available at either the Chevron Refinery or Oakland Metropolitan Airport stations, therefore wind speed, wind direction, and temperature data from the Chevron Refinery station were combined with pressure and cloud cover data from the Oakland Metropolitan Airport station. Meteorological surface measurements from the Chevron Refinery and Oakland Metropolitan Airport stations were not 100% complete for all modeled years, therefore missing data were substituted using procedures outlined in Atkinson & Lee (1992). Surface parameters supplied to AERMET, the meteorological preprocessor to AERMOD, were specified for the area surrounding the meteorological monitoring site (Chevron Refinery station), rather than the project area (rail yard), as recommended by USEPA (USEPA 2005a) and ARB.7 However, because the selected meteorological station is in very close proximity to the Richmond Rail Yard and the land use surrounding the meteorological station is very similar to the land use surrounding Richmond, surface parameters calculated for the meteorological station should be representative of the Richmond Rail Yard. The uncertainties due to the use of non-site-specific meteorological data, combination of surface data from different stations, substitution of missing surface data, and use of surface parameters for the meteorological station resulted in approximate exposure concentrations.

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[7] Personal communication, J. Yuan of ARB by e-mail to D. Daugherty of ENVIRON on August 3, 2006.

5.2.5 Building Downwash

The spacing and placement of point sources relative to buildings or structures results in impacts to building downwash parameters and resulting modeling concentrations. Based on the results of ENVIRON's sensitivity analyses discussed in Appendix G of ENVIRON's BNSF Commerce/Mechanical Report (ENVIRON 2006b), the uncertainty in placing locomotive structures in areas where stationary locomotives occur, and the fact that many of the stationary locomotive activities occur in the interior of the rail yard, ENVIRON did not include building downwash effects due to locomotives in this assessment. Also, because specific locations for most stationary locomotive activities were not available, point sources representing these activities were distributed evenly over the areas where these operations occurred, as described in Section 4.3.1.1. These assumptions and modeling techniques resulted in approximate predictions of receptor concentrations near the facility boundary, as described in further detail below.

5.2.6 Uncertainty in Points of Maximum Impact

Receptor concentration estimates in close proximity to the facility, such as any potential point of maximum impact (PMI), are highly dependent on air dispersion modeling assumptions. That is, different modeling assumptions regarding the spatial and temporal distributions of the emission sources can greatly influence the resulting concentration estimates in proximity to the emission sources, including the magnitude and location of the PMI. As discussed in Section 5.2.2, there is significant uncertainty associated with identification of and estimation of impacts at locations near to a mobile source facility due to the complexity associated with modeling sources that can move (i.e., volume or line sources representing mobile sources). The potential influence of modeling techniques used in this assessment were evaluated in a sensitivity analyses performed for two different movement activities at Commerce/Mechanical, presented in Appendix C of ENVIRON's BNSF Commerce/Mechanical Report (ENVIRON 2006b). These two analyses illustrated the particular sensitivities in assessment of receptors near a rail yard's boundary to source representation (i.e., source spacing, and source sizing for approximation of mobile sources) in the modeling and how source simplification assumptions generally result in over-prediction of concentrations near to the rail yards. Other modeling techniques and assumptions used in this assessment, including fleet-averaging of stationary locomotive activity source parameters, plume rise adjustments to locomotive and on-road diesel and gasoline vehicle movement sources, the use of area sources to represent emissions sources operating in areas where travel paths are not well defined or equipment usage may occur over the entire area, as described above, also contribute to uncertainty to modeling predictions for receptors near the boundary of the rail yard.

Focusing on receptor locations at a greater distance (i.e., one to two kilometers) from the facility reduces the overall influence on the proximity to specific site operations. The two sensitivity analyses discussed above, and presented in more detail in ENVIRON's BNSF Commerce/Mechanical Report (ENVIRON 2006b), indicated that concentrations were over-predicted by 21% and 17% at the PMI. However, at distances one to two kilometers from the facility, receptor concentrations for the two source configurations were all within one to five percent of each other. Thus, the results of these two sensitivity analyses indicated that concentrations at receptors further from the sources are much less sensitive to air dispersion assumptions regarding the spatial and temporal distributions of emission sources.

5.2.7 Estimation of Maximum One-Hour TAC Concentrations

ENVIRON evaluated a large number of non-DPM TACs in this assessment from non-DPM sources (mainly from gasoline engine emissions) as identified in the speciation profiles discussed in Appendix A. In order to substantially reduce modeling complexity and run time, maximum one-hour TOG exhaust, TOG evaporative, and PM exhaust emission rates (as opposed to maximum one-hour individual TAC emission rates) were input into the air dispersion model. Speciation profiles containing the fractions of individual TACs for TOG exhaust, TOG evaporative, and PM exhaust emissions (discussed in Appendix A) were then applied to the TOG exhaust, TOG evaporative, and PM exhaust concentrations estimated by the dispersion model to calculate concentrations of individual TACs. This methodology resulted in conservative estimates (i.e., over-predictions) of the maximum one-hour concentrations for individual TACs.

5.3 Risk Characterization

As stated previously, ARB will conduct the risk characterization part of the HRA based on the results of the emissions estimation and air dispersion modeling provided by ENVIRON. Consistent with the Agreement and draft Guidelines (ARB 2005b, 2006a), the risk characterization activities conducted by ARB will include evaluating and reporting the uncertainties associated with the estimated risks for each designated rail yard. As discussed in detail above, there are many uncertainties associated with the estimation of emissions and exposure point concentrations from rail yard emission sources that would be in addition to the uncertainties associated with the exposure assumptions and toxicity information to be used in ARB's estimation of risks. Many of these uncertainties lead to an over-prediction of the estimated offsite impacts. At the request of ARB, ENVIRON will assist ARB in identifying the critical assumptions and uncertainties associated with the risk characterization step of the HRA. This evaluation will be conducted concurrent with the ARB risk characterization activities and will be provided to ARB in a separate submittal.

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Table 2-1

Percentages of Land Use Categories Within Twenty Kilometers of Facility

BNSF Richmond

Richmond, California

Land Use Category [1]	Percentage (%)
Open Water	42.70%
Low Intensity Residential	20.35%
High Intensity Residential	0.92%
Commercial/Industrial/Transportation	5.50%
Bare Rock/Sand/Clay	0.91%
Quarries/Strip Mines/Gravel Pits	0.06%
Deciduous Forest	0.82%
Evergreen Forest	7.27%
Mixed Forest	3.80%
Shrubland	3.07%
Orchards/Vineyards/Other	0.02%
Grassland/Herbaceous	11.99%
Pasture/Hay	0.93%
Row Crops	0.00%
Small Grains	0.06%
Urban/Recreation Grasses	0.63%
Woody Wetlands	0.03%
Emergent Herbaceous Wetlands	0.94%

Notes:

[1] Land use data are based on National Land Cover Data 1992 from US Geological Survey.

Table 3-1a
Summary of Emissions and Operating Hours for Modeled DPM Emission Sources
BNSF Richmond
Richmond, California

Emission Source	Activity Category	Activity Category Description	Activity Sub-Category	Activity Sub-Category Description	Modeling Source Type	Operation Mode	Modeling Source Group[1]	Total Emissions (g)	Days of Operation per week	Hours of operation per day	Modeled Area (m^2)	Total Emission rate[2,3,4] (g/s) or ($g/m^2/s$)	Number of Modeled Sources	Emission Rate Applied to Period-Average Dispersion Factors[5] (g/s)
Locomotives	A	Basic Locomotive Service	A1	Movement into yard	Volume	Notch 1	A11	15,702	7	24	--	4.98E-04	15	3.32E-05
			A2	Idling while refueling	Point	Idle	A2_i	299,456	7	24	--	9.50E-03	6	1.58E-03
			A3	In-consist	Point	Idle	A3_i	149,728	7	24	--	4.75E-03	35	1.36E-04
			A5	Movement out of yard	Volume	Notch 2	A52	35,598	7	24	--	1.13E-03	15	7.53E-05
	D	Switching	D	Switching	Point	Idle	SP	145,229	7	24	--	4.61E-03	6	7.68E-04
					Volume	Dynamic Braking	SVd	526	7	24	--	1.67E-05	6	2.78E-06
					Volume	Notch 1	SV1	25,146	7	24	--	7.97E-04	6	1.33E-04
					Volume	Notch 2	SV2	88,607	7	24	--	2.81E-03	6	4.68E-04
					Volume	Notch 3	SV3	69,032	7	24	--	2.19E-03	6	3.65E-04
					Volume	Notch 4	SV4	36,930	7	24	--	1.17E-03	6	1.95E-04
					Volume	Notch 5	SV5	18,881	7	24	--	5.99E-04	6	9.98E-05
					Volume	Notch 6	SV6	14,478	7	24	--	4.59E-04	6	7.65E-05
					Volume	Notch 7	SV7	6,196	7	24	--	1.96E-04	6	3.27E-05
					Volume	Notch 8	SV8	34,173	7	24	--	1.08E-03	6	1.81E-04
					Area	Idle	SWITCH	204,003	7	24	7,051	9.17E-07	1	6.47E-03
					Area	Dynamic Braking	SWITCH	739	7	24	7,051	3.32E-09	1	2.34E-05
					Area	Notch 1	SWITCH	35,323	7	24	7,051	1.59E-07	1	1.12E-03
					Area	Notch 2	SWITCH	124,467	7	24	7,051	5.60E-07	1	3.95E-03
					Area	Notch 3	SWITCH	96,970	7	24	7,051	4.36E-07	1	3.07E-03
					Area	Notch 4	SWITCH	51,875	7	24	7,051	2.33E-07	1	1.64E-03
					Area	Notch 5	SWITCH	26,522	7	24	7,051	1.19E-07	1	8.41E-04
					Area	Notch 6	SWITCH	20,337	7	24	7,051	9.15E-08	1	6.45E-04
					Area	Notch 7	SWITCH	8,704	7	24	7,051	3.91E-08	1	2.76E-04
					Area	Notch 8	SWITCH	48,003	7	24	7,051	2.16E-07	1	1.52E-03
	E	BNSF Arriving-Departing Line Haul	E	BNSF Arriving-Departing Line Haul	Point	Idle	LH_I	780,140	7	24	--	2.47E-02	17	1.46E-03
				BNSF Arriving-Departing Line Haul	Volume	Dynamic Braking	LHD	335,499	7	24	--	1.06E-02	17	6.26E-04
				BNSF Arriving-Departing Line Haul	Volume	Notch 1	LH1	114,404	7	24	--	3.63E-03	17	2.13E-04
				BNSF Arriving-Departing Line Haul	Volume	Notch 2	LH2	119,973	7	24	--	3.80E-03	17	2.24E-04
				BNSF Arriving-Departing Line Haul	Volume	Notch 3	LH3	48,106	7	24	--	1.53E-03	17	8.97E-05
Cargo Handling Equipment	H	Cargo Handling: Lift Machines	H	Cargo Handling: Lift Machines	Area	-	Lift	132,801	7	24	48,002	8.77E-08	3	4.21E-03
		Cargo Handling: Hostlers & Yard Vehicles		Cargo Handling: Hostlers	Area	-	Host	118,076	7	24	306,251	1.22E-08	4	3.74E-03
On-Road Container Trucks[6]	I	On-Road Container Trucks: Destination	I	On-Road Container Trucks: Destination	Area	-	CTA	336,349	7	24	306,251	3.48E-08	8	1.07E-02
		On-Road Container Trucks: Path		On-Road Container Trucks: Path	Volume	-	CTV	118,105	7	24	--	3.75E-03	24	1.56E-04
		On-Road Container Trucks: Idle at Entrance		On-Road Container Trucks: Path	Volume	-	CTV_IEN	3,171	7	24	--	1.01E-04	2	5.03E-05
		On-Road Container Trucks: Idle at Exit		On-Road Container Trucks: Path	Volume	-	CTV_IEX	4,292	7	24	--	1.36E-04	2	6.80E-05
On-Road Fleet[6]	J	On-Road Fleet[2]	J	On-Road Fleet[2]	Volume	-	ORV	3,171	7	24	--	1.21E-04	18	6.75E-06
		On-Road Fleet: Destination 1		On-Road Fleet	Area	-	ORA	4,292	7	24	917	4.17E-09	1	3.83E-06
		On-Road Fleet: Destination 2		On-Road Fleet	Area	-	ORA	3,829	7	24	5,422	2.02E-09	1	1.10E-05
Off-Road Equipment	K	Boxcar TRUs	K1a	Boxcar TRUs	Area	-	Box	121	7	24	127,982	2.07E-08	4	2.64E-03
		Container TRUs	K1b	Container TRUs	Area	-	Cont	346	7	24	306,251	3.21E-08	4	9.83E-03
		Track Maintenance Equipment	K2	Track Maintenance Equipment	Area	-	TM	83,400	5	12	132,789	4.70E-09	5	6.24E-04
		Portable Engines	K3	Portable Engines	Area	-	PORTEN	309,879	5	8.5	7,381	4.45E-07	2	3.29E-03
Stationary Sources	L	Emergency Generators	L2	Emergency Generators	Point	-	EG1	19,668	-	-	--	1.84E-05	1	1.84E-05
		Emergency Generators		Emergency Generators	Point	-	EG2	103,609	-	-	--	1.65E-05	1	1.65E-05
		Emergency Generators		Emergency Generators	Point	-	EG3	581	-	-	--	1.11E-04	1	1.11E-04

Notes:
1. "Modeling Source Group" corresponds to the modeling source group name in the AERMOD input and output files.
2. The "Total Emission Rate" is calculated based on the "Total Emissions" divided by the "Days of Operation Per Week" divided by the "Hours of Operation Per Day".
Since the temporal profiles in the model take into account the fluctuations of emission rates throughout the year, we can use 8,760 hours for average emission rates here.
3. The "Total Emission Rate" units are "grams per second" for point and volume sources and "grams per meter squared per second" for area sources.
4. Total emission rate is based on 8,760 hours per year. If source is modeled less than 8,760 hours per year, the temporal profile in the model setup accounts for this with appropriate emission factors. This applies to track maintenance and portable engine sources as well as sources that are modeled for either one of day and night periods.
5. The "Emission Rate Applied to Period-Average Dispersion Factors" is the emission rate applied to the modeled period-average dispersion factors for each source group to estimate air concentrations.
For point and volume sources, the "Emission Rate Applied to Period-Average Dispersion Factors" is equal to the Total Emission Rate" divided by the "Number of Modeled Emission Sources";
For area sources, the "Emission Rate Applied to Period-Average Dispersion Factors" is equal to the Total Emission Rate" multiplied by the modeled area.
6. Both On-Road Fleet and On-Road Container Trucks modeled as volume sources (along distinguishable travel paths) and area sources (for travel in larger areas without distinguishable paths).

Table 3-1b
Summary of Emissions and Operating Hours For Modeled Gasoline Emission Sources
BNSF Richmond
Richmond, California

Activity Subcategory	Activity Subcategory Description	Modeling Source Type	Modeling Source Group[1]	Total Emissions (g)	Days of Operation per week	Hours of operation per day	Modeled Area (m^2)	Total Emission rate[2,3] (g/s) or ($g/m^2/s$)	No. of Emission Sources	Emission Rate Applied to Period-Average Dispersion Factors[4] (g/s)	Hourly Maximum Emission Rate[5] (g/s) or ($g/m^2/s$)
Gasoline PM (ARB Speciate Profile #400)											
K3	Portable Engines	Area	GPM	1940	5	8.5	7,381	8.33E-09	--	6.15E-05	8.33E-09
J[5]	On-Road Fleet	Volume		1357	7	24	--	4.30E-05	18	2.39E-06	2.39E-06
	On-Road Fleet	Area		165	7	24	917	5.72E-09	--	5.25E-06	5.72E-09
K2	Off-Road Track Maintenance	Area		15	5	12	132,789	3.68E-12	--	4.88E-07	3.68E-12
TOG Evaporative (ARB Speciate Profile #422)											
J[5]	On-Road Fleet	Volume	TOG Evap	98428	7	24	--	3.12E-03	18	1.73E-04	1.73E-04
	On-Road Fleet	Area		11997	7	24	917	4.15E-07	--	3.80E-04	4.15E-07
K2	Off-Road Track Maintenance	Area		94	5	12	132,789	2.24E-11	--	2.97E-06	2.24E-11
K3	Portable Engines	Area		56238	5	8.5	7,381	2.42E-07	--	1.78E-03	2.42E-07
L	Gasoline Dispensing Facility	Volume		3316	7	24	--	1.05E-04	1	1.05E-04	1.05E-04
TOG Exhaust (ARB Speciate Profile #2105)											
J[5]	On-Road Fleet	Volume	TOG Exhaust	166785	7	24	--	5.29E-03	18	2.94E-04	2.94E-04
	On-Road Fleet	Area		20329	7	24	917	7.03E-07	--	6.45E-04	7.03E-07
K2	Off-Road Track Maintenance	Area		533	5	12	132,789	1.27E-10	--	1.69E-05	1.27E-10
K3	Portable Engines	Area		68355	5	8.5	7,381	2.94E-07	--	2.17E-03	2.94E-07

Notes:
1. "Modeling Source Group" corresponds to the modeling source group name in the AERMOD input and output files.
2. The "Total Emission Rate" is calculated based on the "Total Emissions" divided by the "Days of Operation Per Week" divided by the "Hours of Operation Per Day".
3. The "Total Emission Rate" units are "grams per second" for point and volume sources and "grams per meter squared per second" for area sources.
4. The "Emission Rate Applied to Period-Average Dispersion Factors" is the emission rate applied to the modeled period-average dispersion factors for each source group to estimate air concentrations.
For point and volume sources, the "Emission Rate Applied to Period-Average Dispersion Factors" is equal to the Total Emission Rate" divided by the "Number of Modeled Emission Sources";
For area sources, the "Emission Rate Applied to Period-Average Dispersion Factors" is equal to the Total Emission Rate" multiplied by the modeled area.
5. The "Hourly Maximum Emission Rate" is the emission rate used to in the air dispersion model. For point and volume sources, the "Hourly Maximum Emission Rate"
is equal to the "Emission Rate Applied to Period-Average Dispersion Factors). For area sources, the "Hourly Maximum Emission Rate" is equal to the "Total Emission Rate."
6. On-Road Fleet modeled as volume sources (along distinguishable travel paths) and area sources (for travel in larger areas without distinguishable paths).

Table 3-2
Summary of Activity Category Total Annual DPM and TOG Emissions at the Facility
BNSF Richmond
Richmond, California

Activity Category	Activity Category Description	Diesel			Gasoline								
		PM Emissions			PM Emissions			TOG Evaporative Emissions			TOG Exhuast Emissions		
		Grams	Metric Tons	Percentage (%)	Grams	Metric Tons	Percentage (%)	Grams	Metric Tons	Percentage (%)	Grams	Metric Tons	Percentage (%)
A	Maintenance	500,484	0.50	11.9%	-	-	-	-	-	-	-	-	-
D	Switching	1,056,140	1.06	25.2%	-	-	-	-	-	-	-	-	-
E	Arriving/Departing Line Haul	1,398,122	1.40	33.3%	-	-	-	-	-	-	-	-	-
H	Cargo Handling Equipment	250,877	0.25	5.98%	-	-	-	-	-	-	-	-	-
I	On-Road Container Trucks	461,916	0.46	11.0%	-	-	-	-	-	-	-	-	-
J	On-Road Fleet Vehicle	4,296	0.00	0.10%	1,523	1.52E-03	43.8%	110,426	1.10E-01	64.9%	187,114	1.87E-01	73.1%
	Off-Road Equipment												
K1a	Boxcar TRUs	83,400	0.08	1.99%	-	-	-	-	-	-	-	-	-
K1b	Container TRUs	309,879	0.31	7.39%	-	-	-	-	-	-	-	-	-
K2	Off-Road Track Maintenance	19,668	0.02	0.47%	15	1.539E-05	0.4%	94	9.373E-05	0.1%	533	0.0005326	0.2%
K3	Portable Engines	103,609	0.10	2.47%	1,940	1.94E-03	55.8%	56,238	5.62E-02	33.1%	68,355	6.84E-02	26.7%
	Stationary Sources												
L1	Gasoline Dispensing Facility	-	-	-	-	-	-	3,316	3.32E-03	1.9%	-	-	-
L2	Emergency Generators	4,611	0.00	0.11%	-	-	-	-	-	-	-	-	-
	TOTAL	4,193,003	4.19	100.0%	3,478	3.48E-03	100.0%	170,073	1.70E-01	100.0%	256,002	2.56E-01	100.0%

Table 4-1
Fleet-Average Source Parameters for Stationary Locomotive Activities
BNSF Richmond
Richmond, California

									Day		Night	
Activity Subcategory	**Activity Subcategory Description**	**Modeling Source Type**	**Operation Mode**	**Stack Height (m)**	**Exit Temperature (K)**	**Exit velocity (m/s)**	**Exit Diameter (m)**	**Initial Lateral Dimension (m)**	**Release Height (m)**	**Initial Vertical Dimension (m)**	**Release Height (m)**	**Initial Vertical Dimension (m)**
A1	Movement into yard	Volume	Notch 1	-	-	-	-	0.50 - 8.79	5.87	1.37	10.98	2.55
A2	Idling while refueling	Point	Idle	4.52	389.11	5.11	0.55	-	-	-	-	-
A3	In-consist	Point	Idle	4.52	389.11	5.11	0.55	-	-	-	-	-
A5	Movement out of yard	Volume	Notch 2	-	-	-	-	0.50 - 8.79	10.05	2.34	14.42	3.35
D	Switching	Point	Idle	4.52	361.60	15.56	0.29	-	-	-	-	-
		Volume	Dynamic Braking	-	-	-	-	0.50 - 1.94	8.04	1.87	13.43	3.12
		Volume	Notch 1	-	-	-	-	0.50 - 1.94	8.04	1.87	13.43	3.12
		Volume	Notch 2	-	-	-	-	0.50 - 1.94	8.04	1.87	13.43	3.12
		Volume	Notch 3	-	-	-	-	0.50 - 1.94	8.04	1.87	13.43	3.12
		Volume	Notch 4	-	-	-	-	0.50 - 1.94	8.04	1.87	13.43	3.12
		Volume	Notch 5	-	-	-	-	0.50 - 1.94	8.04	1.87	13.43	3.12
		Volume	Notch 6	-	-	-	-	0.50 - 1.94	8.04	1.87	13.43	3.12
		Volume	Notch 7	-	-	-	-	0.50 - 1.94	8.04	1.87	13.43	3.12
		Volume	Notch 8	-	-	-	-	0.50 - 1.94	8.04	1.87	13.43	3.12
		Area	Idle	-	-	-	-	-	4.66	2.17	4.66	2.17
		Area	Dynamic Braking	-	-	-	-	-	4.66	2.17	4.66	2.17
		Area	Notch 1	-	-	-	-	-	4.66	2.17	4.66	2.17
		Area	Notch 2	-	-	-	-	-	4.66	2.17	4.66	2.17
		Area	Notch 3	-	-	-	-	-	4.66	2.17	4.66	2.17
		Area	Notch 4	-	-	-	-	-	4.66	2.17	4.66	2.17
		Area	Notch 5	-	-	-	-	-	4.66	2.17	4.66	2.17
		Area	Notch 6	-	-	-	-	-	4.66	2.17	4.66	2.17
		Area	Notch 7	-	-	-	-	-	4.66	2.17	4.66	2.17
		Area	Notch 8	-	-	-	-	-	4.66	2.17	4.66	2.17
E	BNSF Arriving-Departing Line Haul	Point	Idle	4.52	389.11	5.11	0.55	-	-	-	-	-
		Volume	Dynamic Braking	-	-	-	-	0.50	9.53	2.22	18.37	4.27
		Volume	Notch 1	-	-	-	-	0.50	9.53	2.22	18.37	4.27
		Volume	Notch 2	-	-	-	-	0.50	9.53	2.22	18.37	4.27
		Volume	Notch 3	-	-	-	-	0.50	9.53	2.22	18.37	4.27

Table 4-2
Plume Rise Adjustments for Locomotive Movement Sources[1]
BNSF Richmond
Richmond, California

Activity Subcategory	Activity Subcategory Description	Modeled Notch Setting[2]	Locomotive Speed (mph)	Locomotive Speed (m/s)	Modeled Locomotive Type	Plume Height (meters)[3]			Initial Vertical Dimension (meters)		
						Stability D	Stability F	Adjusted F[4]	Stability D	Stability F	Adjusted F[4]
A1	Maintenance: Movement into the Yard	1	10	4.47	Fleet-Average	5.87	15.16	10.98	1.37	3.53	2.55
A5	Maintenance: Movement out of Yard	2	10	4.47		10.05	20.83	14.42	2.34	4.84	3.35
D	Switching	2	10	4.47		8.04	19.19	13.43	1.87	4.46	3.12
E	BNSF Line Haul	DB	5.9	2.64		9.53	18.37	--	2.22	4.27	--

Notes:
1. Plume rise calculated using USEPA's SCREEN3 model using methodology in ARB's Roseville Study (ARB 2004).
2. Due to sensitivity of plume rise to wind speed and locomotive speed, plume rise adjustments calculated for only one notch setting per source subactivity.
For source subactivities with multiple notch settings, the source parameters for the notch setting with the greatest percentage of activity emission were selected.
3. Plume Height = physical height of locomotive plus plume rise.
4. The maximum wind speed for stability category F in SCREEN3 is 4.0 m/s. For locomotive speeds (i.e., effective wind speeds) greater than 4.0 m/s, the plume rise for stability category F was adjusted according to the methodology in the ARB Roseville Study (ARB 2004): adjusted plume rise = plume rise x (1/locomotive speed)^(1/3)

Source:
1. Air Resources Board (ARB). 2004. Roseville Rail Yard Study. October 2004

Table 4-3
Source Parameters for Cargo Handling Equipment, On-Road Container Trucks, and Off-Road Equipment
BNSF Richmond
Richmond, California

				Day		Night	
Activity Subcategory	**Activity Subcategory Description**	**Modeling Source Type**	**Initial Lateral Dimension (m)**	**Release Height[1] (m)**	**Initial Vertical Dimension[2] (m)**	**Release Height[1] (m)**	**Initial Vertical Dimension[2] (m)**
H	Cargo Handling: Lift Machines	Area	-	3.90	0.91	3.90	0.91
	Cargo Handling: Yard Vehicles and Hostlers	Area	-	0.60	0.14	0.60	0.14
I	On-Road Container Trucks: Travel on site (Pathway from entrance to intermodal area)	Volume	3.13	4.00	0.93	6.00	1.40
	On-Road Container Trucks: Travel on site/Idling on site (Intermodal Area)	Area	-	4.00	0.93	6.00	1.40
	On-Road Container Trucks: Idling at entrance	Volume	3.29	4.00	0.93	6.00	1.40
	On-Road Container Trucks: Idling at exit	Volume	3.29	4.00	0.93	6.00	1.40
K1a	TRU-Boxcars	Area	-	1.00	0.23	1.00	0.23
K1b	TRU-Containers	Area	-	1.00	0.23	1.00	0.23
K2	Track Maintenance Equipment	Area	-	5.87	1.37	5.87	1.37
K3	Portable Engines	Area	-	4.66	2.17	4.66	2.17

Notes:
1. Assumed release height for track maintenance equipment equal to the lowest plume height from plume rise adjusments for locomotive sources; assumed release height for portable engines in the Freight Car Repair Building equal to half the height of the Freight Car Repair Building, for portable engines operated outdoors, assumed 0.6 meter release height.
2. Initial vertical dimension for Portable Engines Inside Freight Car Repair Building calculated as release height divided by 2.15 based on USEPA guidance for volume sources on or adjacent to a building.

Source:
1. United States Environmental Protection Agency (USEPA). 2004. User's Guide for the AMS/EPA Regulatory Model -AERMOD. Office of Air Quality Planning and Standards. Emissions Monitoring and Analysis Division. Research Triangle Park, North Carolina. EPA-454/B-03-001. September.

Table 4-4
Source Parameters for On-Road Fleet
BNSF Richmond
Richmond, California

				Day		Night	
Activity Subcategory	Activity Subcategory Description	Modeling Source Type[1]	Initial Lateral Dimension (m)	Release Height[2] (m)	Initial Vertical Dimension[3] (m)	Release Height[2] (m)	Initial Vertical Dimension[3] (m)
J	On-Road Fleet	Volume	1.32	0.60	0.14	0.60	0.14
		Area	-	0.60	0.14	0.60	0.14

Notes:
1. On-Road Fleet modeled as volume sources (along distinguishable travel paths) and area sources (for travel in larger areas without distinguishable paths).
2. Release height based on ARB Risk Reduction Plan (ARB 2000) and recommendations from ARB staff.

Source:
1. Air Resources Board (ARB). 2000. Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles. Appendix VII: Risk Characterization Scenarios. October.

Table 4-5
Source Parameters for Permitted Stationary Sources
BNSF Richmond
Richmond, California

Activity Subcategory	Activity Subcategory Description	Modeling Source Type	Stack Height (m)	Exit Temperature (K)	Exit velocity (m/s)	Exit Diameter (m)	Release Height[1] (m)	Initial Lateral Dimension (m)	Initial Vertical Dimension (m)
L	Gasoline Dispensing Facility	Volume	--	--	--	--	0.00	2.33	0.00
	Emergency Generator, 300 KW[2]	Point	2.44	994	92.9	0.13	--	--	--
	Emergency Generator, 250 KW[2]	Point	2.44	811	60.9	0.13	--	--	--
	Emergency Generator, 600 KW[2]	Point	3.66	879	54.7	0.23	--	--	--

<u>Notes:</u>
1. Release height for the Gasoline Dispensing and Storage Facility conservatively assumed to equal zero.
2. From BAAQMD permit application.

<u>Source:</u>
1. BAAQMD permit application # 7577

Table 4-6
Sector-Specific Surface Roughness, Bowen Ratio, and Albedo
BNSF Richmond
Richmond, California

		2001			2002			2003			2004			2005		
Month	Sector No.	Albedo	Bowen Ratio	Surface Roughness	Albedo	Bowen Ratio	Surface Roughness	Albedo	Bowen Ratio	Surface Roughness	Albedo	Bowen Ratio	Surface Roughness	Albedo	Bowen Ratio	Surface Roughness
Jan		0.16	0.35	0.24	0.16	0.69	0.24	0.16	0.69	0.24	0.16	0.69	0.24	0.16	0.69	0.24
Feb		0.13	0.37	0.24	0.13	0.68	0.24	0.13	0.68	0.24	0.13	0.37	0.24	0.13	0.37	0.24
Mar		0.13	0.37	0.24	0.13	0.68	0.24	0.13	0.68	0.24	0.13	0.37	0.24	0.13	0.37	0.24
Apr		0.13	0.62	0.25	0.13	0.62	0.25	0.13	0.62	0.25	0.13	1.17	0.25	0.13	0.33	0.25
May		0.13	0.62	0.25	0.13	0.62	0.25	0.13	0.62	0.25	0.13	1.17	0.25	0.13	0.33	0.25
Jun	1	0.13	0.62	0.25	0.13	0.62	0.25	0.13	0.62	0.25	0.13	1.17	0.25	0.13	0.33	0.25
Jul		0.14	1.23	0.24	0.14	1.23	0.24	0.14	1.23	0.24	0.14	0.34	0.24	0.14	1.23	0.24
Aug		0.14	1.23	0.24	0.14	1.23	0.24	0.14	1.23	0.24	0.14	0.34	0.24	0.14	1.23	0.24
Sep		0.14	1.23	0.24	0.14	1.23	0.24	0.14	1.23	0.24	0.14	0.34	0.24	0.14	1.23	0.24
Oct		0.14	1.23	0.24	0.14	1.23	0.24	0.14	1.23	0.24	0.14	0.34	0.24	0.14	1.23	0.24
Nov		0.16	0.35	0.24	0.16	0.69	0.24	0.16	0.69	0.24	0.16	0.69	0.24	0.16	0.69	0.24
Dec		0.16	0.35	0.24	0.16	0.69	0.24	0.16	0.69	0.24	0.16	0.69	0.24	0.16	0.69	0.24
Jan		0.16	0.36	0.20	0.16	0.77	0.20	0.16	0.77	0.20	0.16	0.77	0.20	0.16	0.77	0.20
Feb		0.14	0.42	0.21	0.14	0.73	0.21	0.14	0.73	0.21	0.14	0.42	0.21	0.14	0.42	0.21
Mar		0.14	0.42	0.21	0.14	0.73	0.21	0.14	0.73	0.21	0.14	0.42	0.21	0.14	0.42	0.21
Apr		0.13	0.64	0.21	0.13	0.64	0.21	0.13	0.64	0.21	0.13	1.11	0.21	0.13	0.33	0.21
May		0.13	0.64	0.21	0.13	0.64	0.21	0.13	0.64	0.21	0.13	1.11	0.21	0.13	0.33	0.21
Jun	2	0.13	0.64	0.21	0.13	0.64	0.21	0.13	0.64	0.21	0.13	1.11	0.21	0.13	0.33	0.21
Jul		0.14	1.23	0.21	0.14	1.23	0.21	0.14	1.23	0.21	0.14	0.34	0.21	0.14	1.23	0.21
Aug		0.14	1.23	0.21	0.14	1.23	0.21	0.14	1.23	0.21	0.14	0.34	0.21	0.14	1.23	0.21
Sep		0.14	1.23	0.21	0.14	1.23	0.21	0.14	1.23	0.21	0.14	0.34	0.21	0.14	1.23	0.21
Oct		0.14	1.23	0.21	0.14	1.23	0.21	0.14	1.23	0.21	0.14	0.34	0.21	0.14	1.23	0.21
Nov		0.16	0.36	0.20	0.16	0.77	0.20	0.16	0.77	0.20	0.16	0.77	0.20	0.16	0.77	0.20
Dec		0.16	0.36	0.20	0.16	0.77	0.20	0.16	0.77	0.20	0.16	0.77	0.20	0.16	0.77	0.20
Jan		0.19	0.98	0.79	0.19	2.17	0.79	0.19	2.17	0.79	0.19	2.17	0.79	0.19	2.17	0.79
Feb		0.16	1.09	0.79	0.16	2.09	0.79	0.16	2.09	0.79	0.16	1.09	0.79	0.16	1.09	0.79
Mar		0.16	1.09	0.79	0.16	2.09	0.79	0.16	2.09	0.79	0.16	1.09	0.79	0.16	1.09	0.79
Apr		0.17	1.93	0.80	0.17	1.93	0.80	0.17	1.93	0.80	0.17	3.68	0.80	0.17	0.92	0.80
May		0.17	1.93	0.80	0.17	1.93	0.80	0.17	1.93	0.80	0.17	3.68	0.80	0.17	0.92	0.80
Jun	3	0.17	1.93	0.80	0.17	1.93	0.80	0.17	1.93	0.80	0.17	3.68	0.80	0.17	0.92	0.80
Jul		0.18	3.90	0.79	0.18	3.90	0.79	0.18	3.90	0.79	0.18	0.95	0.79	0.18	3.90	0.79
Aug		0.18	3.90	0.79	0.18	3.90	0.79	0.18	3.90	0.79	0.18	0.95	0.79	0.18	3.90	0.79
Sep		0.18	3.90	0.79	0.18	3.90	0.79	0.18	3.90	0.79	0.18	0.95	0.79	0.18	3.90	0.79
Oct		0.18	3.90	0.79	0.18	3.90	0.79	0.18	3.90	0.79	0.18	0.95	0.79	0.18	3.90	0.79
Nov		0.19	0.98	0.79	0.19	2.17	0.79	0.19	2.17	0.79	0.19	2.17	0.79	0.19	2.17	0.79
Dec		0.19	0.98	0.79	0.19	2.17	0.79	0.19	2.17	0.79	0.19	2.17	0.79	0.19	2.17	0.79
Jan		0.18	0.97	0.91	0.18	1.97	0.91	0.18	1.97	0.91	0.18	1.97	0.91	0.18	1.97	0.91
Feb		0.14	0.99	0.91	0.14	1.95	0.91	0.14	1.95	0.91	0.14	0.99	0.91	0.14	0.99	0.91
Mar		0.14	0.99	0.91	0.14	1.95	0.91	0.14	1.95	0.91	0.14	0.99	0.91	0.14	0.99	0.91
Apr		0.16	1.92	0.91	0.16	1.92	0.91	0.16	1.92	0.91	0.16	3.80	0.91	0.16	0.95	0.91
May		0.16	1.92	0.91	0.16	1.92	0.91	0.16	1.92	0.91	0.16	3.80	0.91	0.16	0.95	0.91
Jun	4	0.16	1.92	0.91	0.16	1.92	0.91	0.16	1.92	0.91	0.16	3.80	0.91	0.16	0.95	0.91
Jul		0.17	3.85	0.91	0.17	3.85	0.91	0.17	3.85	0.91	0.17	0.96	0.91	0.17	3.85	0.91
Aug		0.17	3.85	0.91	0.17	3.85	0.91	0.17	3.85	0.91	0.17	0.96	0.91	0.17	3.85	0.91
Sep		0.17	3.85	0.91	0.17	3.85	0.91	0.17	3.85	0.91	0.17	0.96	0.91	0.17	3.85	0.91
Oct		0.17	3.85	0.91	0.17	3.85	0.91	0.17	3.85	0.91	0.17	0.96	0.91	0.17	3.85	0.91
Nov		0.18	0.97	0.91	0.18	1.97	0.91	0.18	1.97	0.91	0.18	1.97	0.91	0.18	1.97	0.91
Dec		0.18	0.97	0.91	0.18	1.97	0.91	0.18	1.97	0.91	0.18	1.97	0.91	0.18	1.97	0.91
Jan		0.18	0.93	0.85	0.18	1.92	0.85	0.18	1.92	0.85	0.18	1.92	0.85	0.18	1.92	0.85
Feb		0.15	0.95	0.86	0.15	1.91	0.86	0.15	1.91	0.86	0.15	0.95	0.86	0.15	0.95	0.86
Mar		0.15	0.95	0.86	0.15	1.91	0.86	0.15	1.91	0.86	0.15	0.95	0.86	0.15	0.95	0.86
Apr		0.16	1.83	0.88	0.16	1.83	0.88	0.16	1.83	0.88	0.16	3.65	0.88	0.16	0.90	0.88
May		0.16	1.83	0.88	0.16	1.83	0.88	0.16	1.83	0.88	0.16	3.65	0.88	0.16	0.90	0.88
Jun	5	0.16	1.83	0.88	0.16	1.83	0.88	0.16	1.83	0.88	0.16	3.65	0.88	0.16	0.90	0.88
Jul		0.17	3.72	0.87	0.17	3.72	0.87	0.17	3.72	0.87	0.17	0.92	0.87	0.17	3.72	0.87
Aug		0.17	3.72	0.87	0.17	3.72	0.87	0.17	3.72	0.87	0.17	0.92	0.87	0.17	3.72	0.87
Sep		0.17	3.72	0.87	0.17	3.72	0.87	0.17	3.72	0.87	0.17	0.92	0.87	0.17	3.72	0.87
Oct		0.17	3.72	0.87	0.17	3.72	0.87	0.17	3.72	0.87	0.17	0.92	0.87	0.17	3.72	0.87
Nov		0.18	0.93	0.85	0.18	1.92	0.85	0.18	1.92	0.85	0.18	1.92	0.85	0.18	1.92	0.85
Dec		0.18	0.93	0.85	0.18	1.92	0.85	0.18	1.92	0.85	0.18	1.92	0.85	0.18	1.92	0.85
Jan		0.18	0.98	0.94	0.18	1.99	0.94	0.18	1.99	0.94	0.18	1.99	0.94	0.18	1.99	0.94
Feb		0.14	0.99	0.94	0.14	1.98	0.94	0.14	1.98	0.94	0.14	0.99	0.94	0.14	0.99	0.94
Mar		0.14	0.99	0.94	0.14	1.98	0.94	0.14	1.98	0.94	0.14	0.99	0.94	0.14	0.99	0.94
Apr		0.16	1.95	0.94	0.16	1.95	0.94	0.16	1.95	0.94	0.16	3.89	0.94	0.16	0.97	0.94
May		0.16	1.95	0.94	0.16	1.95	0.94	0.16	1.95	0.94	0.16	3.89	0.94	0.16	0.97	0.94
Jun	6	0.16	1.95	0.94	0.16	1.95	0.94	0.16	1.95	0.94	0.16	3.89	0.94	0.16	0.97	0.94
Jul		0.17	3.92	0.94	0.17	3.92	0.94	0.17	3.92	0.94	0.17	0.98	0.94	0.17	3.92	0.94
Aug		0.17	3.92	0.94	0.17	3.92	0.94	0.17	3.92	0.94	0.17	0.98	0.94	0.17	3.92	0.94
Sep		0.17	3.92	0.94	0.17	3.92	0.94	0.17	3.92	0.94	0.17	0.98	0.94	0.17	3.92	0.94
Oct		0.17	3.92	0.94	0.17	3.92	0.94	0.17	3.92	0.94	0.17	0.98	0.94	0.17	3.92	0.94
Nov		0.18	0.98	0.94	0.18	1.99	0.94	0.18	1.99	0.94	0.18	1.99	0.94	0.18	1.99	0.94
Dec		0.18	0.98	0.94	0.18	1.99	0.94	0.18	1.99	0.94	0.18	1.99	0.94	0.18	1.99	0.94

Table 4-7
Approximate Dimensions of Buildings at the Facility
BNSF Richmond
Richmond, California

Building/ Structure ID	Structure Name	Approximate Footprint Dimensions[1] (meters)	Height[2] (meters)
1	Freight Car Repair	34 x 107	9.3
2	Freight Car Repair	34 x 108	9.3
3	BNSF Mechanical Office	25 x 30	7.4
4	Storm Water Tank	10 (radius)	9.1
5	Diesel Storage Tank 900,000 Gallons	27 (radius)	14.0
6	Ingress/Egress M&O	44 x 14	4.5
7	Train Master Facility	22 x 27	9.2
8	Locomotive Shop	14 x 23	9.3
9	Truck/Truck Repair Station	26 x 18	6.7
10	BNSF Intermodal Admin Office	22 x 32	6.5
11	BNSF Office	16 x 27	6.5
12	Ingress/Egress Intermodal	104 x 21	4.5

Notes:

1. Approximate footprint dimensions estimated based on aerial photograph of facility.
2. Building heights not available from BNSF personnel; building heights based on heights of similar building and structure types at other BNSF facilities.

Table 4-8
Locations of Sensitive Receptors within One Mile of the Facility
BNSF Richmond
Richmond, California

Sensitive Receptor Name	Address	UTMx (m)	UTMy (m)	Receptor Type
A Solid Foundation	1230 Bissell Ave, Richmond, CA	556426.9	4198681.4	Infant Center
Brookside Community Health Center	1149 Macdonald Ave, Richmond, CA	556360.4	4198903.3	Community Clinic
Cesar E. Chavez Elementary	960 17th St, Richmond, CA	556784.4	4200054.8	Public School
Contra Costa Co. Child Dev. Center - Las Deltas	135 West Grove St, Richmond, CA	555389.9	4201122.5	Child Care/Infant Center
Contra Costa Co. Child Dev. Center - Maritime	217 South 11th St, Richmond, CA	556301.2	4198166.1	Child Care Center
Eagle Eye	517 Nevin St, Richmond, CA	555833.1	4199039.3	Group Home
Gompers (Samuel) Continuation	157 Ninth St, Richmond, CA	556143.2	4198621.3	Public School
GRSSC Child Development Center III	1350 Kelsey St, Richmond, CA	555861.8	4200777.5	Child Care Center
GRSSC Child Development Center V	360 Harbour Way, Richmond, CA	556254.2	4197931.0	Child Care Center
GRSSC Child Development Center-Bissell	1310 Bissell Ave, Richmond, CA	556499.9	4198674.1	Infant Center
GRSSC Child Development Center-Shield Reid	1410 Kelsey St, Richmond, CA	555859.5	4200851.5	Child Care Center
Harbour Way Elem Community Day	214 S. 11th St, Richmond, CA	556331.7	4198168.2	Public School
Jr's North Star, Inc.	1619 Burbeck Ave, Richmond, CA	556716.4	4199715.8	Group Home
Kaiser Foundation Hospital	901 Nevin Ave, Richmond, CA	556163.8	4199032.8	General Acute Care Hospital
Leadership Public Schools: Richmond	715 Chanslor Ave, Richmond, CA	556008.4	4198534.7	Public Charter School
Lincoln Elementary	29 Sixth St, Richmond, CA	555886.4	4198428.4	Public School
Mental Health Svc	1025 Macdonald Ave, Richmond, CA	556259.8	4198902.6	Mental Health Center
NHU/El Nuevo Mundo Children's Center	1707 Pennsylvania Ave, Richmond, CA	556776.5	4199594.1	Child Care Center
Nystrom College Prep Preschool	217 South 11th St, Richmond, CA	556301.2	4198166.1	Child Care Center
Nystrom Elementary	230 Harbour Way, Richmond, CA	556255.3	4198135.6	Public School
Odyssey School	1800 Barrett, Richmond, CA	556899.5	4199165.1	Child Care Center
Otherine Nelson's Small Family Home	816 10th St, Richmond, CA	556240.9	4199877.2	Small Family Home
Peres Elementary	719 Fifth St, Richmond, CA	555830.1	4199675.5	Public School
Richmond College Prep K-5 Charter	125 Park Place, Richmond, CA	554060.5	4197867.6	Public School
Richmond Educational Learning Center	4 Marina Way, Richmond, CA	556598.0	4198406.6	Private School
Washington Elementary	565 Wine St, Richmond, CA	554412.3	4197609.9	Public School
With Loving Care, Inc. - Ansari House	123 12th St, Richmond, CA	556386.3	4198564.8	Group Home
YMCA of the East Bay - 8th St CDC	445 8th St, Richmond, CA	556057.6	4199089.4	Child Care Center
YMCA of the East Bay - Kelsey CDC	1350 Kelsey St, Richmond, CA	555861.8	4200777.5	Child Care/Infant Center
YMCA of the East Bay - MLK Child Development Center	360 South Harbour Way, Richmond, CA	556254.2	4197931.0	Child Care Center
YMCA of the East Bay - Richmond CDC	485 Lucas Ave, Richmond, CA	555820.4	4199853.8	Child Care Center

Notes:
1. Locations of sensitive receptors were obtained from the following databases:
a. California Department of Education, California School Directory (http://www.cde.ca.gov/re/sd/)
b. The Automated Licensing Information and Report Tracking System (Hospitals and Licensed Care Facilities) (http://alirts.oshpd.ca.gov/AdvSearch.aspx)
c. Yellow pages (http://yp.yahoo.com)
d. Community Care Licensing Division, State of California (http://www.ccld.ca.gov/docs/ccld_search/ccld_search.aspx)

Figure 2-1: General Facility Location
BNSF Richmond Rail Yard
Richmond, California

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Figure 2-2: Land Use Within Twenty Kilometers of Facility
BNSF Richmond Rail Yard
Richmond, California

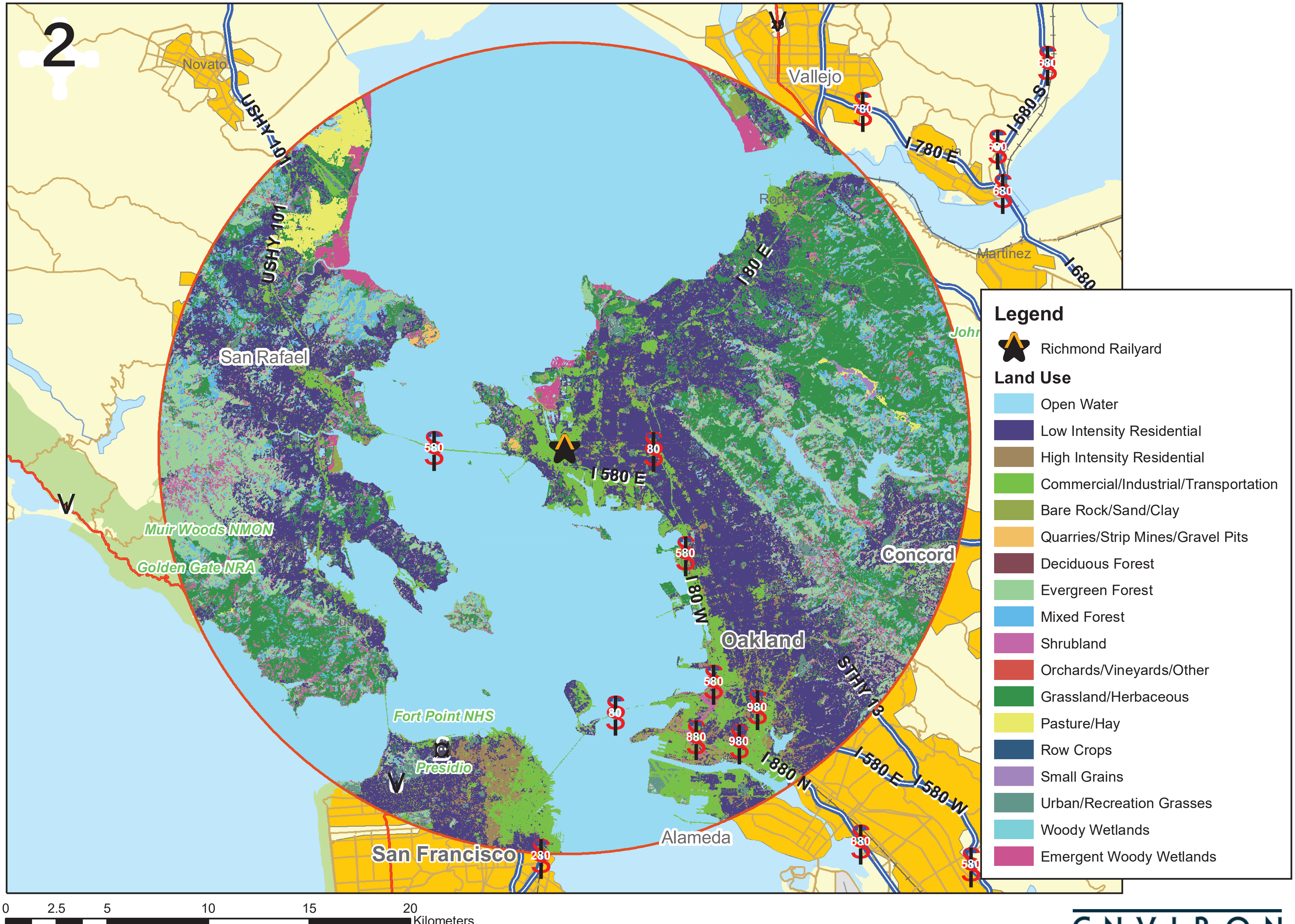

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Figure 2-3a: Stationary Locomotive Activities
BNSF Richmond Rail Yard
Richmond, California

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Figure 2-3b: Locomotive Traffic Flow
BNSF Richmond Rail Yard
Richmond, California

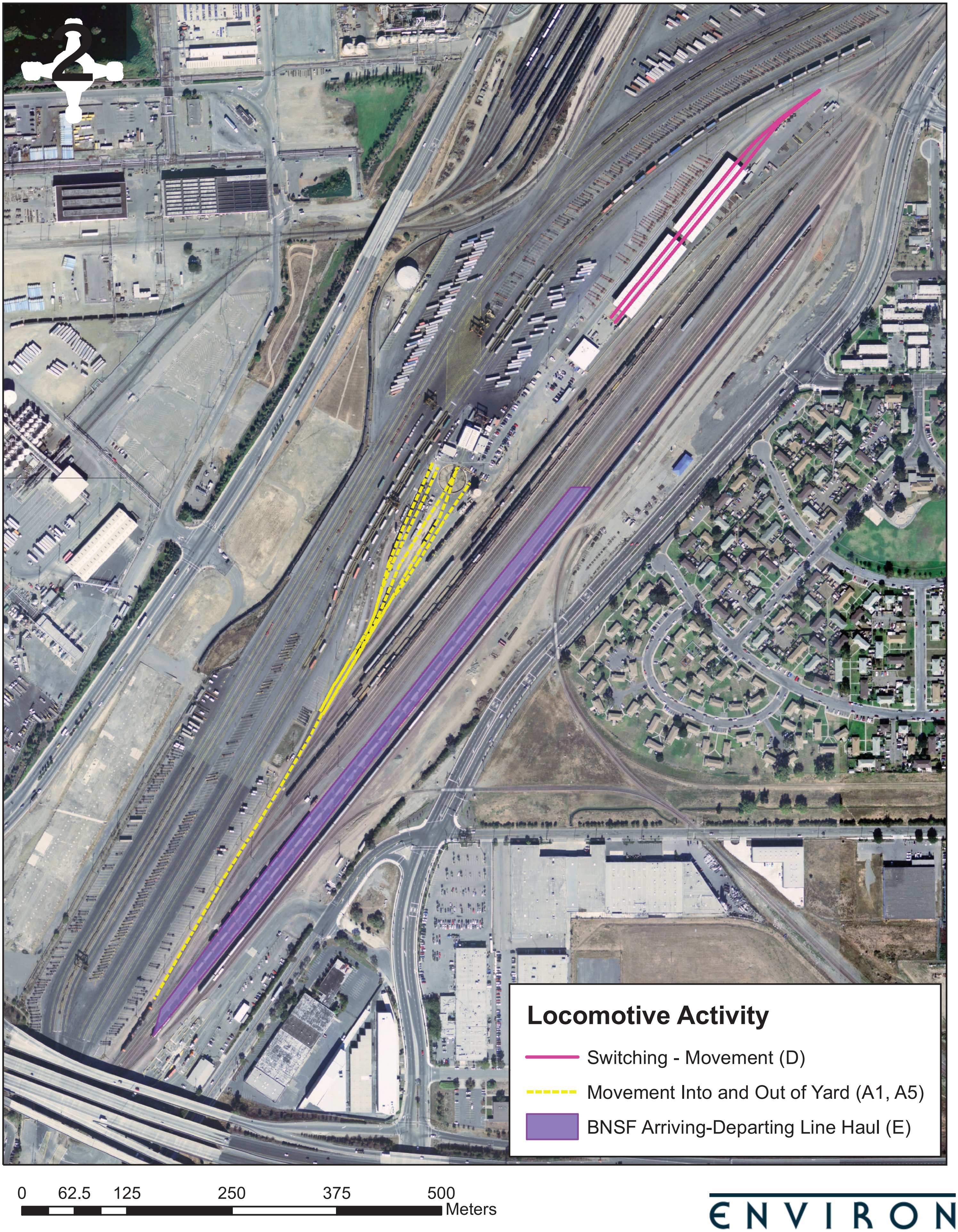

Figure 2-4: Stationary Sources. Cargo Handling, Maintenance, and Other Off-Road Equipment
BNSF Richmond Rail Yard
Richmond, California

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Figure 2-5: Vehicle Travel Routes and Destinations
BNSF Richmond Rail Yard
Richmond, California

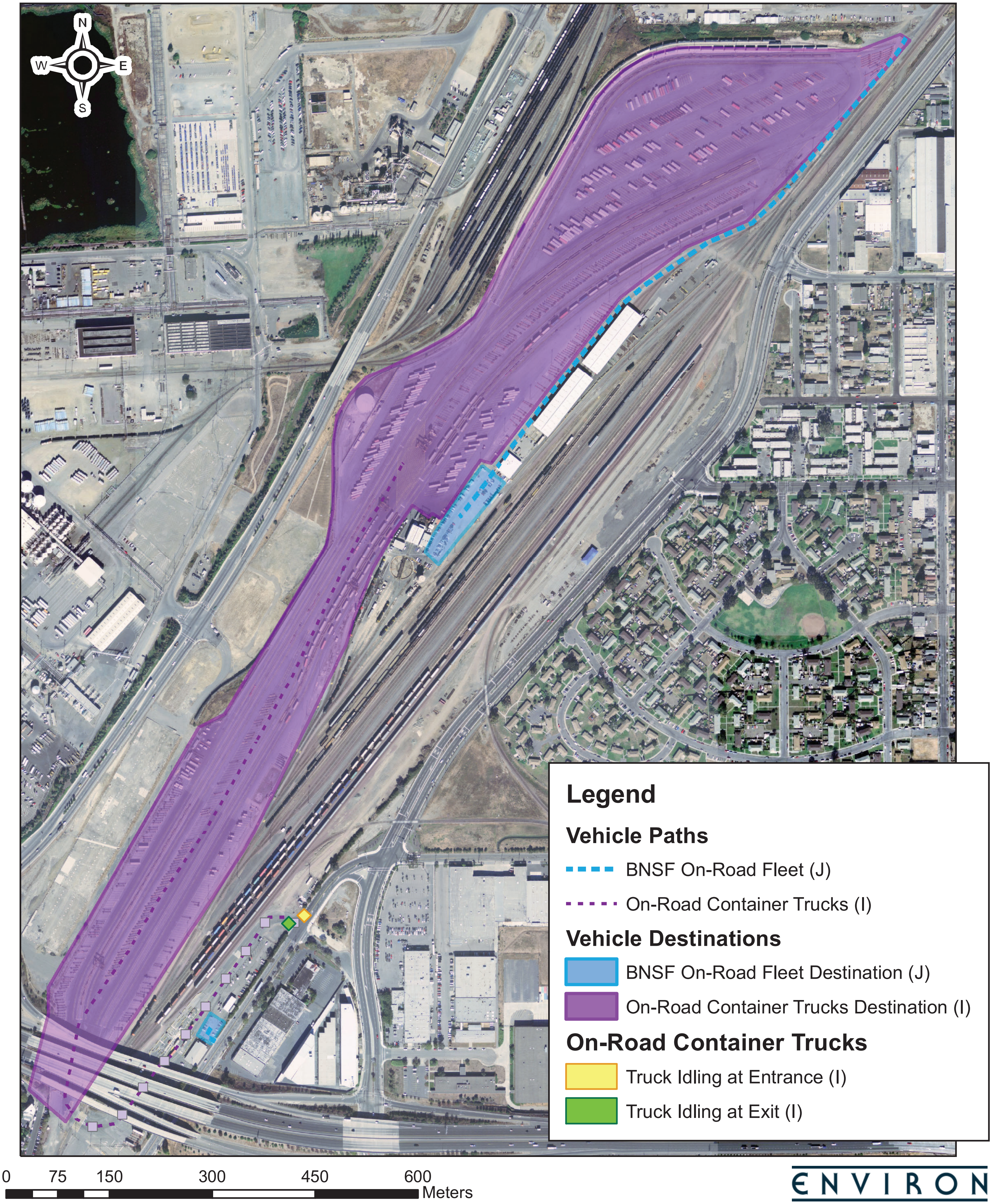

Figure 4-1a: Locations of Modeled Stationary Locomotive Sources - Maintenance Activities
BNSF Richmond Rail Yard
Richmond, California

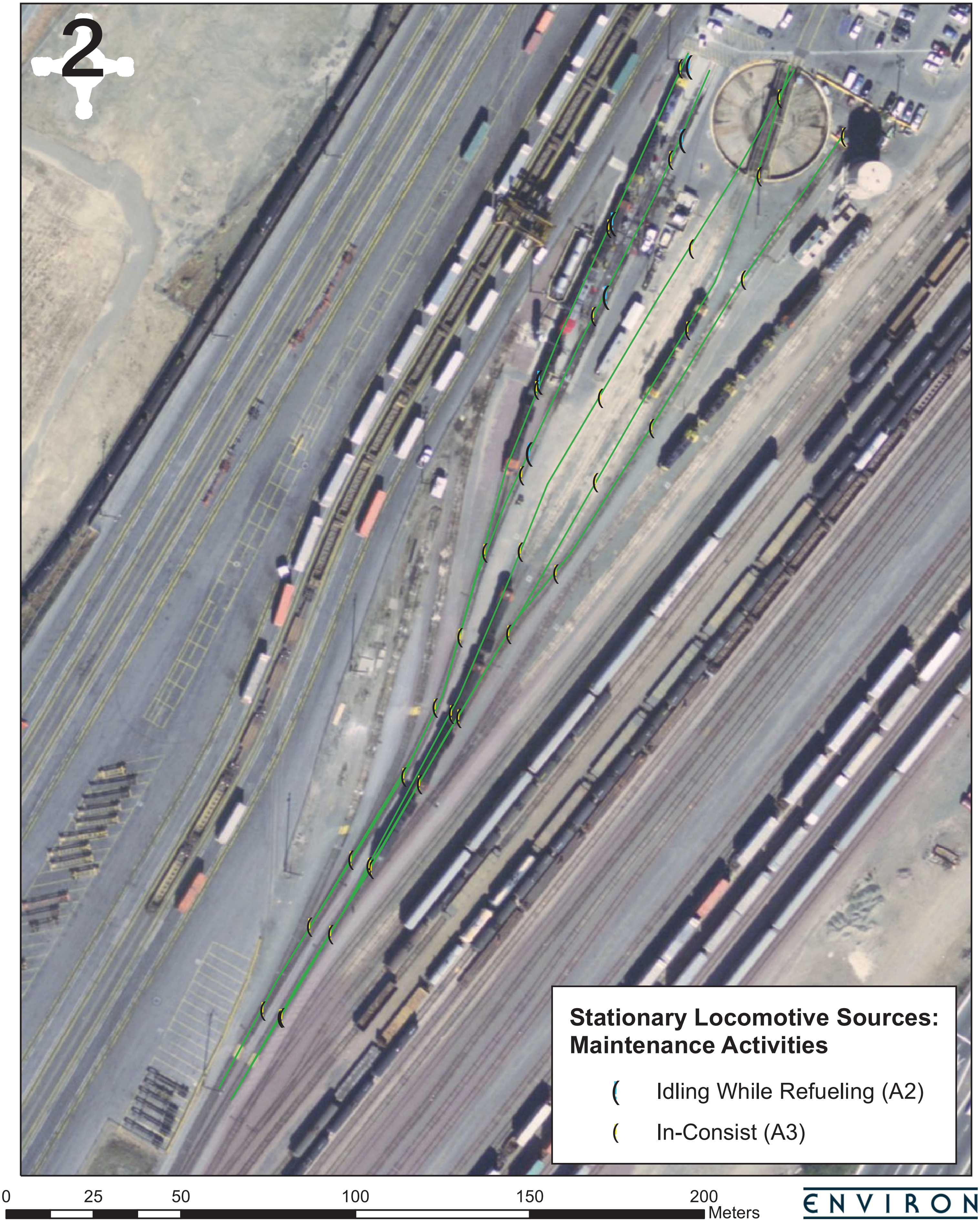

Figure 4-1b: Locations of Modeled Stationary Locomotive Sources - Switching and Line Haul BNSF Richmond Rail Yard Richmond, California

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Figure 4-2a: Locations of Modeled Movement Locomotive Source - Maintenance Activities
BNSF Richmond Rail Yard
Richmond, California

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Figure 4-2b: Locations of Locomotive Movement Sources - Line Haul
BNSF Richmond Rail Yard
Richmond, California

Figure 4-2c: Locations of Modeled Movement Locomotive Sources - Switching
BNSF Richmond Rail Yard
Richmond, California

Figure 4-3: Locations of Modeled Cargo Handling and Off-Road Equipment Sources
BNSF Richmond Rail Yard
Richmond, California

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Figure 4-4: Locations of Modeled On-Road Container Truck and On-Road Fleet Sources
BNSF Richmond Rail Yard
Richmond, California

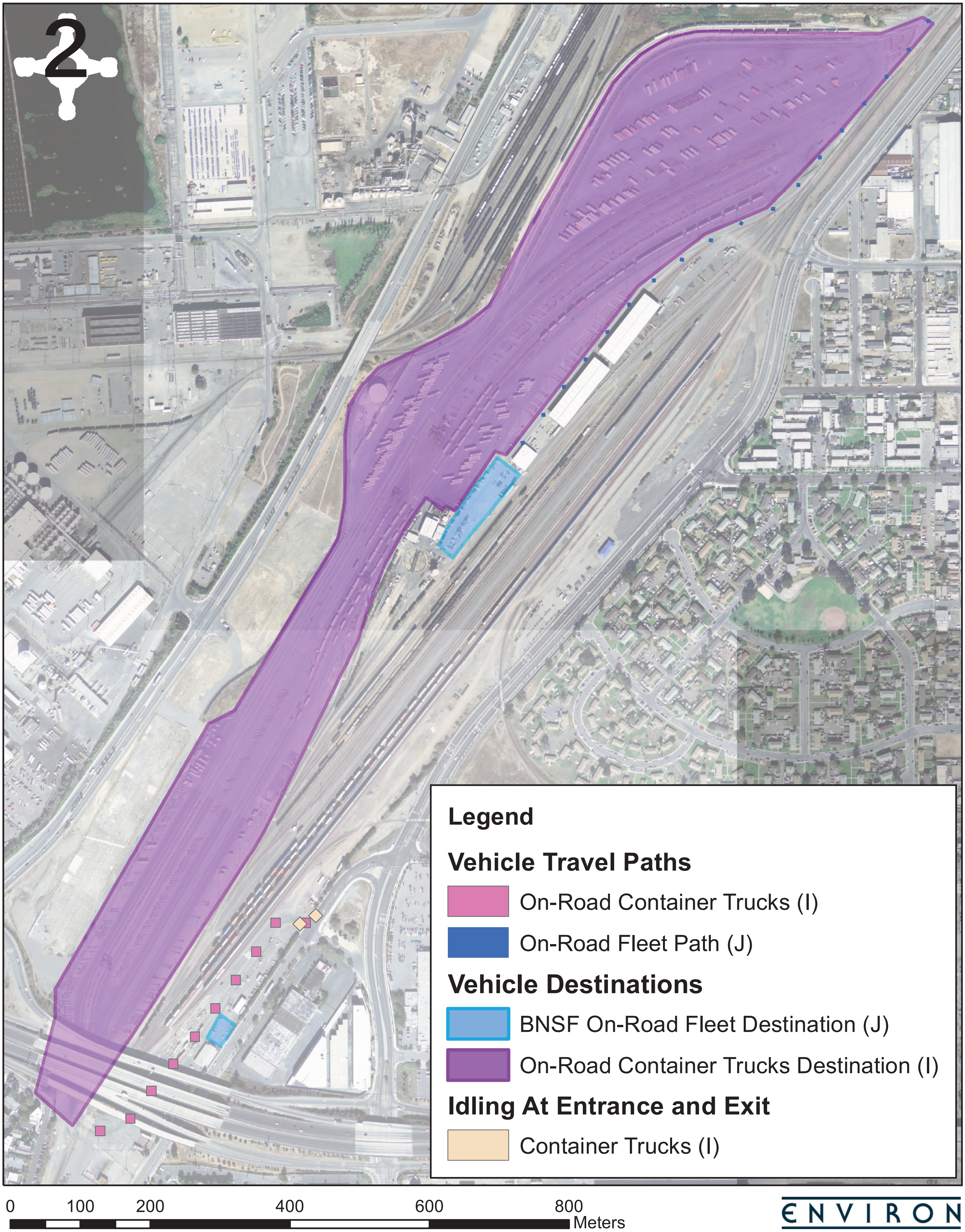

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Figure 4-5: Locations of Modeled Permitted Stationary Sources
BNSF Richmond Rail Yard
Richmond, California

0 60 120 240 360 480 Meters

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Figure 4-6: Selection of Sectors for Surface Parameter Analysis
BNSF Richmond Rail Yard
Richmond, California

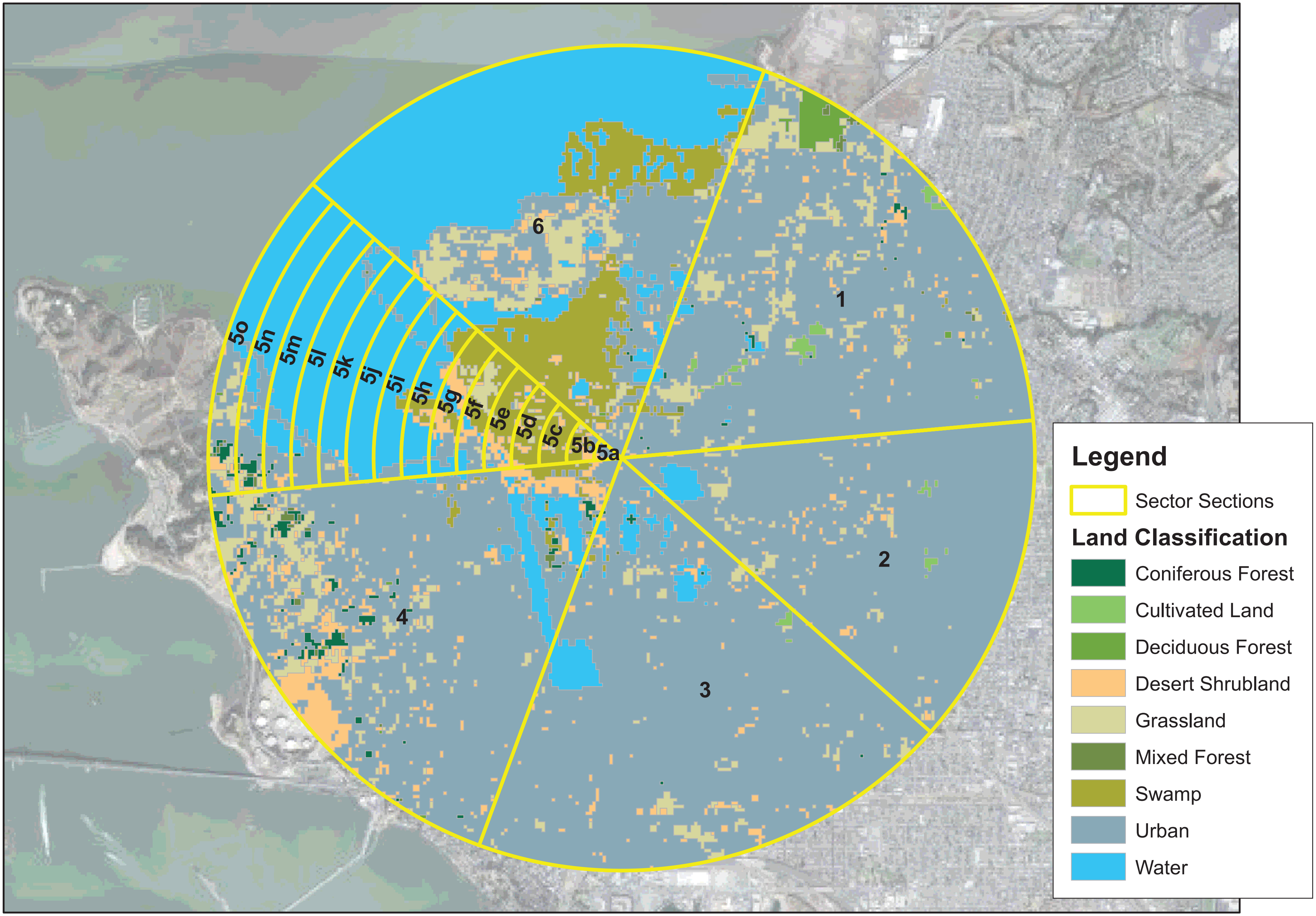

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Figure 4-7: Location of Buildings and Structures at the Facility
BNSF Richmond Rail Yard
Richmond, California

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Figure 4-8: Land Use Within Three Kilometers of Facility
BNSF Richmond Yard
Richmond, California

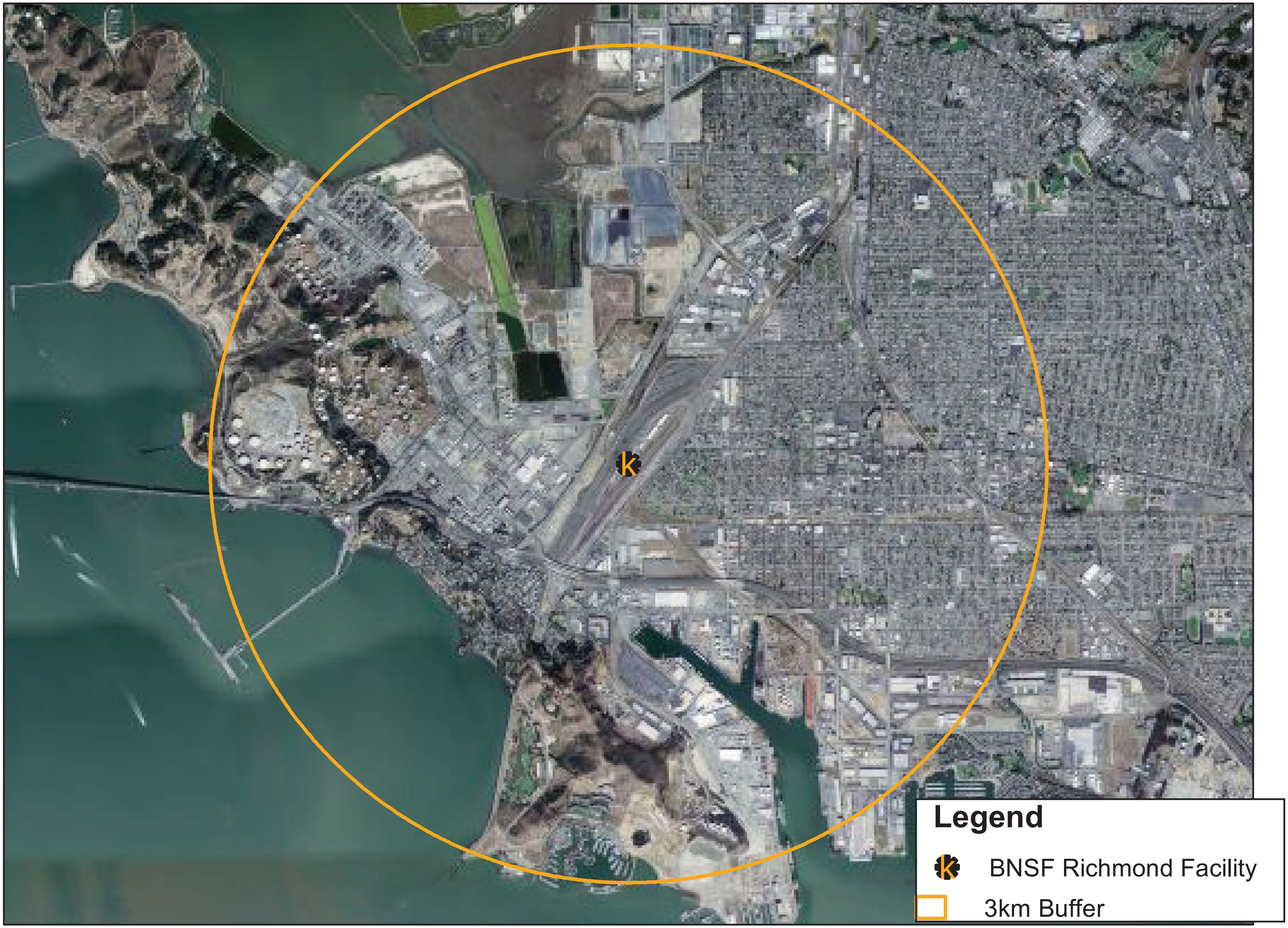

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Figure 4-9a: Location of Discrete Receptors in Fine Grid
BNSF Richmond Rail Yard
Richmond, California

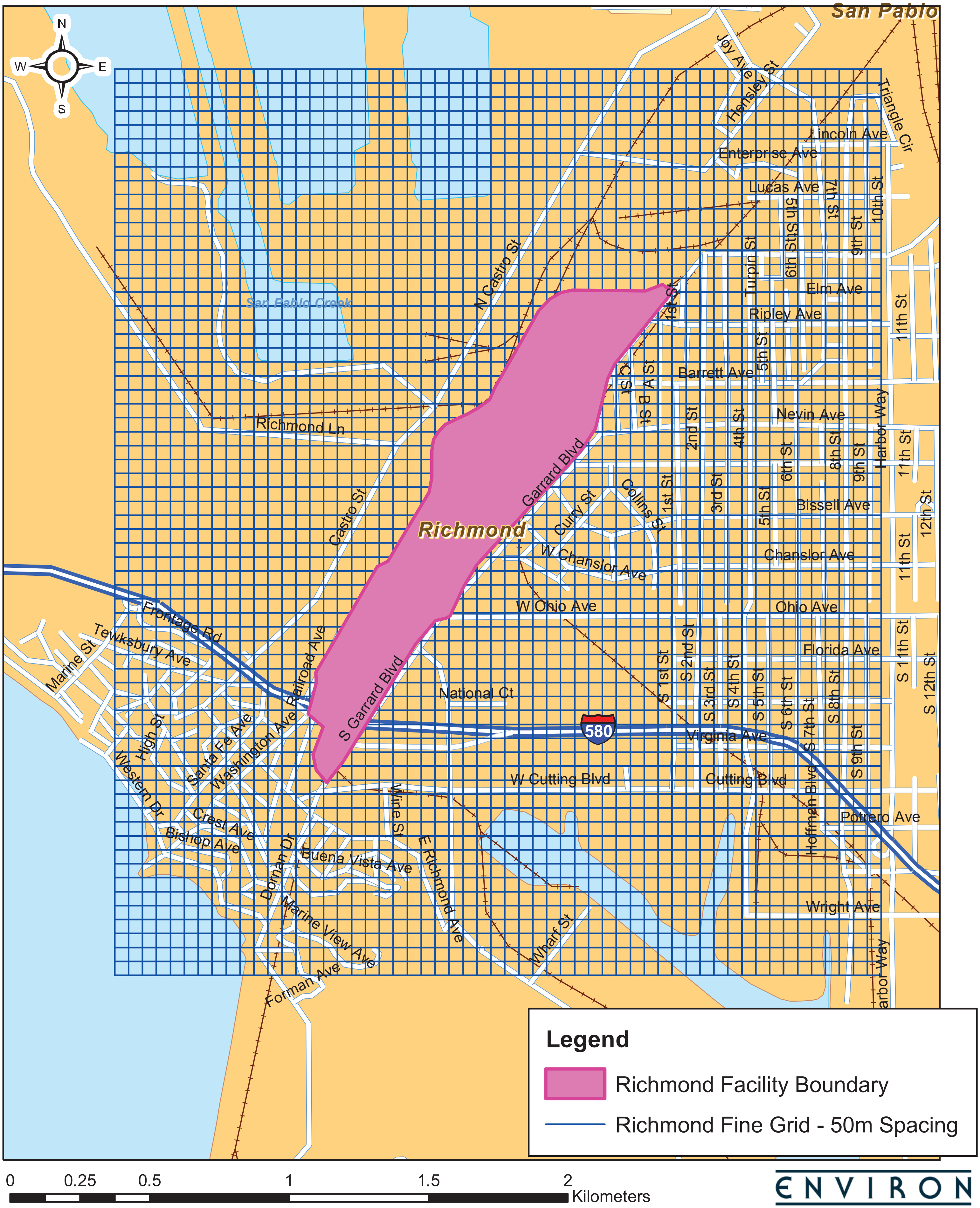

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Figure 4-9b: Location of Discrete Receptors in Medium Grid
BNSF Richmond Rail Yard
Richmond, California

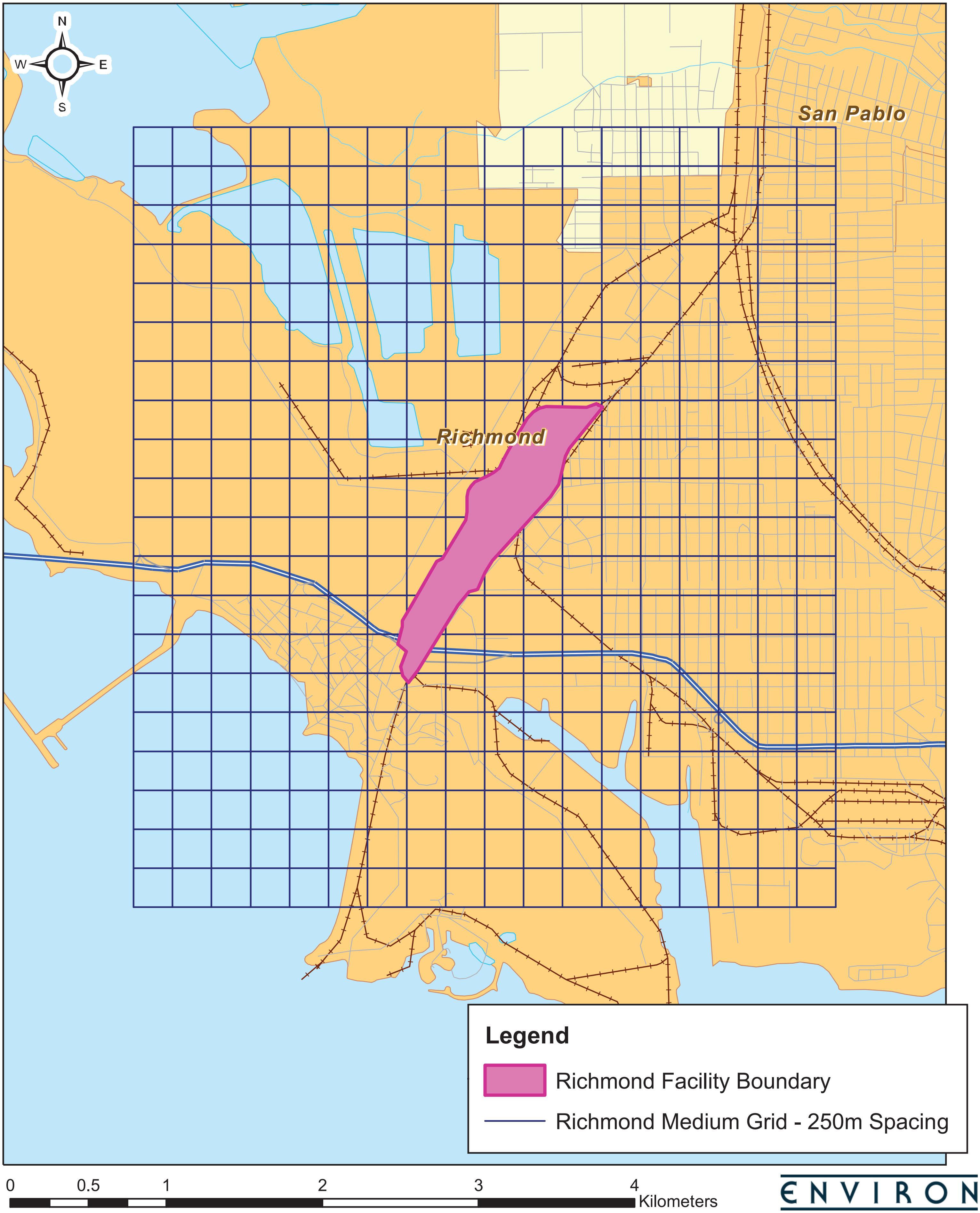
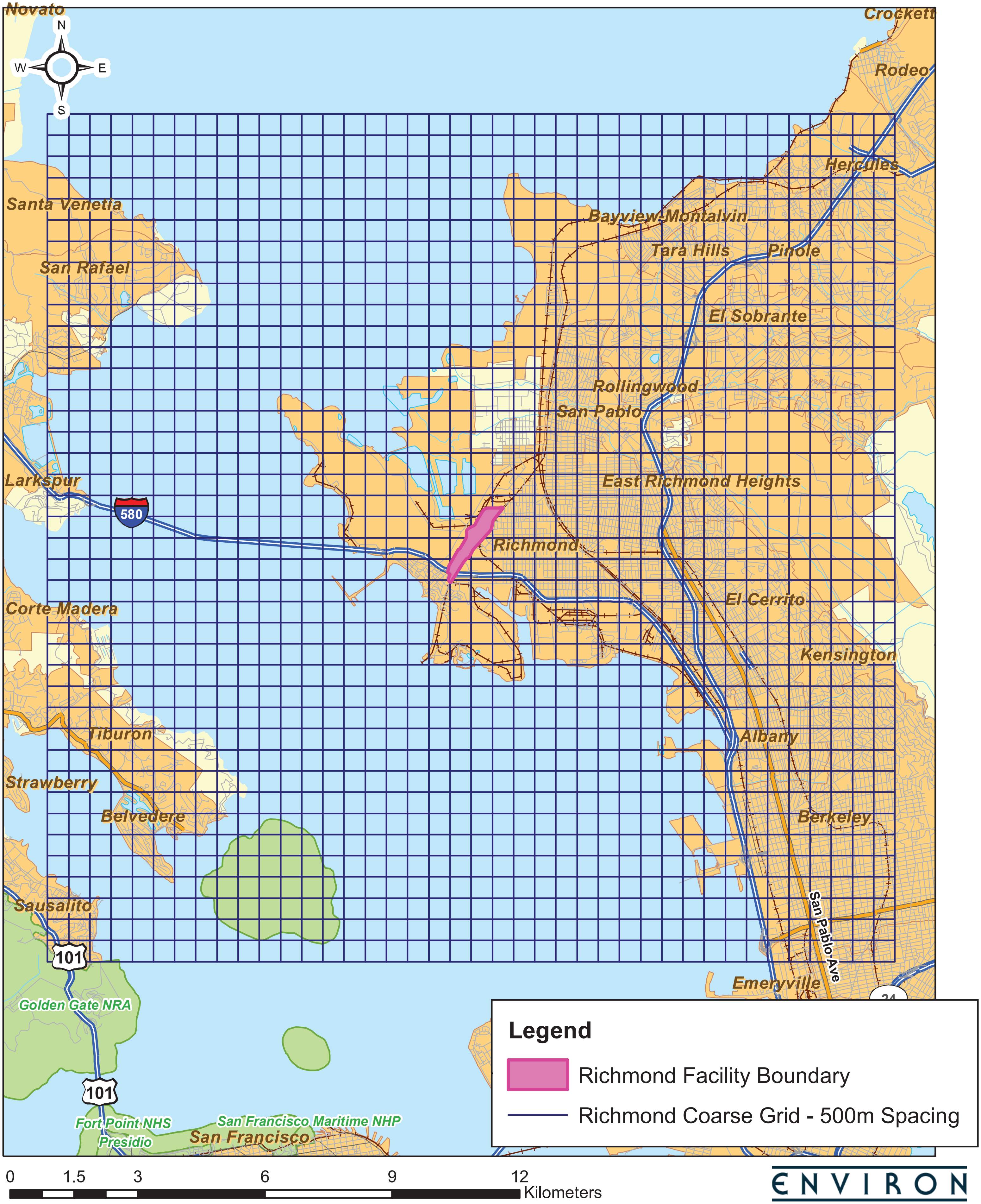


Figure 4-9c: Location of Discrete Receptors in Coarse Grid
BNSF Richmond Rail Yard
Richmond, California



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