



**BAY-WIDE REGIONAL HUMAN
HEALTH RISK ASSESSMENT TOOL
FOR DIESEL EXHAUST
PARTICULATE MATTER (DPM)**

Prepared for:
**Port of Los Angeles and
the Port of Long Beach
Los Angeles, California
and Long Beach, California**

Prepared by:
**ENVIRON International Corporation
Emeryville, California**

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ACRONYMS and ABBREVIATIONS

AERMAP	AERMOD's Terrain Preprocessor
AERMET	AERMOD Meteorological Preprocessor
AERMOD	American Meteorological Society/Environmental Protection Agency Regulatory Model
ARB	Air Resources Board
Basin	South Coast Air Basin
BWHRA	Bay-Wide Health Risk Assessment
CAAP	Clean Air Action Plan
Cal/EPA	California Environmental Protection Agency
CEQA	California Environmental Quality Act
CHE	Cargo Handling Equipment
COPC	Chemicals of Potential Concern
CSF	Cancer Slope Factor
DEM	Digital Elevation Maps
DPM	Diesel Exhaust Particulate Matter
HDV	Heavy-duty Vehicle
HRA	Health Risk Assessment
IARC	International Agency for Research on Cancer
ISCST3	Industrial Source Complex Short Term (Version 3) Air Dispersion Model
kg	Kilogram
km	Kilometer
L	Liter
m ³	Cubic Meter
mg	Milligram
µg	Microgram
NEPA	National Environmental Policy Act
NLCD	National Land Cover Dataset
NRC	National Research Council
NWS	National Weather Service
OEHHA	Office of Environmental Health Hazard Assessment
OGV	Ocean-going Vessels
POLA	Port of Los Angeles
POLB	Port of Long Beach
Ports	Port of Los Angeles and Port of Long Beach
PM	Particulate Matter
REL	Reference Exposure Level
SCAQMD	South Coast Air Quality Management District
SPPS	St. Peter and Paul School
Starcrest	Starcrest Consulting, LLC
TAC	Toxic Air Contaminants

TITP	Terminal Island Treatment Plant
TWG	Technical Working Group
USEPA	US Environmental Protection Agency
USGS	United States Geological Survey
WHO	World Health Organization

Executive Summary

In the San Pedro Bay Ports Clean Air Action Plan (CAAP 2006), the Port of Los Angeles and the Port of Long Beach (Ports) committed to develop goals and implement strategies that would substantially and constantly reduce emissions and public health risks from Ports-related mobile sources. These commitments were made in recognition of the Air Resources Board (ARB) statewide goal to reduce diesel-related health risks 85% by 2020 (ARB 2006a). As a means of characterizing reductions in public health impacts that could be achieved by implementation of CAAP commitments, and to understand the Ports progress towards meeting the CAAP Health Risk Reduction Standard, the Ports developed the Bay-Wide Health Risk Assessment (BWHRA) Tool. A key component in the development of the BWHRA Tool was preparation of a Bay-wide health risk assessment protocol (Protocol, Appendix A), developed in collaboration with the Technical Working Group (TWG) comprised of representatives from the Ports, United States Environmental Protection Agency (USEPA), ARB, and South Coast Air Quality Management District (SCAQMD). The Protocol identified cancer risk from diesel exhaust particulate matter (DPM) as the metric for characterizing cancer risk reductions achieved by implementation of Ports emission control strategies and current regulations, recognizing that cancer risk reductions are also a surrogate for reductions in other health effects. The ARB's exposure assessment of the Ports (ARB 2006b) served as the basis for the air dispersion modeling components of the Protocol. The Protocol also identified the methodologies to be followed in calculating exposure concentrations and cancer risk which are consistent with the guidance of the SCAQMD and California's Office of Environmental Health Hazard Assessment (OEHHA).

The selection of DPM-attributable cancer risk as the BWHRA Tool metric reflects the fact that DPM has been identified as the dominant contributor to state-wide cancer risks from airborne pollutants (ARB 2000). The ARB's exposure assessment of the Ports (ARB 2006b) also focused solely on DPM because of its potential to cause cancer and other health effects, and because cancer risks from DPM tend to be highest in areas with concentrated emissions, such as in areas impacted by the Ports. Notwithstanding the emphasis of the BWHRA Tool on DPM cancer risk, it is important to note that DPM emission control strategies that achieve cancer risk reductions will provide benefits towards reducing non-cancer health effects of DPM as well. Because diesel exhaust contributes particulate matter and other components to ambient air, DPM emission reduction strategies are also expected to reduce health impacts associated with small particulates (particulate matter with a diameter of 2.5 microns or less or PM_{2.5}) and to further attainment of the federal PM_{2.5} standard in the South Coast Air Basin (Basin).

Methods

The BWHRA Tool consists of three major components: (1) the DPM emission inventory of the mobile equipment operating at the Ports, (2) air dispersion modeling, and (3) an assessment of cancer risks from exposure to airborne DPM. The DPM emission inventory provides an estimate

of how much DPM is generated from different emission sources, while air dispersion modeling incorporates the emission inventory and meteorological data inputs into a computer model to predict concentrations of DPM in ambient air. Potential health risks from DPM were estimated for residential populations based on these modeled concentrations of DPM.

The BWHRA Tool utilized the Ports' DPM emission inventories for the baseline year of 2005 (Starcrest Consulting, LLC [Starcrest] 2007a,b) and forecast DPM emissions for 2020 (Starcrest 2008). The 2020 forecast emissions account for pre-recession Ports growth estimates, implementation of CAAP emission reduction strategies, and adopted regulations. DPM emission rates were developed for each of five source categories; heavy duty vehicles (HDV); railroad locomotives; harbor craft; ocean going vessels (OGV); and cargo handling equipment (CHE). The BWHRA Tool addressed emissions from these mobile sources within the Ports boundaries as well as over-water emissions from activities that occurred approximately 40 nautical miles from the coast. DPM emissions from HDVs on Interstates 110 and 710 and Highways 47 and 103 north to Interstate 405, as well as locomotives on the Alameda Corridor north to Interstate 405 were also included.

Air dispersion modeling was performed to estimate exposure concentrations from the environmental transport and distribution of DPM emissions from mobile sources at the Ports into the atmosphere. This modeling was performed in a manner consistent with ARB (2006b) with a few key modifications. First, AERMOD, the current USEPA approved state-of-the-art regulatory model was used instead of the older model used in ARB's study, ISCST3. Second, Port-specific meteorological data were used. Third, off-Port sources such as trucks and locomotives were modeled on major transportation corridors to I-405, which is farther than considered in the ARB assessment. The air dispersion modeling provided estimated ambient air concentrations of DPM within the same 20 by 20 mile modeling domain used by ARB. These concentrations were used along with standard exposure parameters and California's DPM cancer slope factor (CSF) to develop estimates of individual lifetime cancer risks above background, and population-weighted average lifetime cancer risks attributable to inhalation of DPM for residential populations in 2005 and 2020.

Results

Implementation of the CAAP and existing regulations are predicted to achieve widespread and significant reductions in individual cancer risk by 2020 throughout the BWHRA Tool modeling domain.

Between 2005 and 2020, residential cancer risks above 500×10^{-6} (500 in a million) are virtually eliminated from the zone around the Ports, with only small areas near Interstate 710 that still exceed this level. In 2005, estimated cancer risks between 251 and 500×10^{-6} (two hundred fifty one and five hundred in a million) impacted an extensive area around the Ports and major transportation corridors; by 2020, the zone that is affected by this level of risk is predicted to

shrink dramatically, and is largely restricted to areas directly adjacent to transportation corridors and the Ports boundaries.

By 2020, these risk reductions exceed 75% in many areas, with risk reductions between 70 and 75% expected for the majority of the domain. For residents in communities within 2 kilometer (km) of the Ports boundaries, most individuals are expected to experience risk reductions of 70% or more by the year 2020. Approximately 10% of individuals are predicted to have risk reductions between 60 to 70%, and a small area is expected to have risk reductions between 50 and 60%. The areas with the lowest predicted cancer risk reductions, less than 50%, occur in commercially or industrially-zoned areas between the Ports that are not currently occupied by residents.

As a means of characterizing the population-based reduction in risk within both the BWHRA Tool modeling domain and highly impacted communities, population-weighted average cancer risks attributable to Ports DPM sources were also calculated. For the modeling domain overall, population-weighted average cancer risks for 2005 of 249×10^{-6} (249 in a million) are predicted to be reduced significantly by 2020 to 66×10^{-6} (66 in a million). This 74% decrease in risk is consistent with the domain-wide risk reductions calculated for individuals. For communities within 2 km of the Port boundaries, population-weighted average cancer risks for 2005 of 519×10^{-6} (519 in a million) are predicted to be reduced by 2020 to 143×10^{-6} (143 in a million), a 72% decrease in risk.

These predicted risk reductions for 2020 are directly attributable to the Ports' CAAP (2006) emission reduction strategies, implemented in combination with USEPA's and ARB's adopted regulations. Further, the Ports are committed to reviewing the CAAP on a regular basis, and to examine progress towards achieving the CAAP goals during these reviews. The CAAP reviews will focus on the need to adjust implementation strategies by incorporating newly-developed technologies or other available measures to ensure that the CAAP goals and Health Risk Standard¹ are achieved. By following this framework, the Ports expect to achieve significant reductions in risk, and to attain more than their 'fair share' of DPM emission reductions on a statewide basis (CAAP 2009).

¹ The Health Risk Reduction Standard for reducing overall port-related health risk impacts, relative to 2005 conditions is: By 2020, reduce the population-weighted cancer risk of ports-related DPM emissions by 85% in highly-impacted communities located proximate to port sources and throughout the residential areas in the port region (CAAP 2009).

1 Introduction

In the San Pedro Bay Ports Clean Air Action Plan (CAAP 2006), the Ports articulated diesel exhaust particulate matter (DPM) emissions and health risk reduction goals whose specific targets would be incorporated into the San Pedro Bay-wide Standards. The focus of the Health Risk Reduction Standard (Standard) was to identify a criterion to use for understanding and monitoring progress towards achieving the Ports commitment to expeditiously and constantly reduce public health risk associated with Ports-related mobile sources. To inform development of that Standard, the Ports developed the Bay-wide health risk assessment (BWHRA) Tool, whose methodologies and results are described in this report and supporting appendices. A key component in the development of the BWHRA Tool was preparation of a BWHRA protocol (Protocol, Appendix A). The Protocol was developed in collaboration with the Technical Working Group (TWG), comprised of representatives from the Ports, the California Air Resources Board (ARB), the United States Environmental Protection Agency (USEPA) and the South Coast Air Quality Management District (SCAQMD). The Protocol identified cancer risk from DPM as the metric for characterizing cancer risk reductions achieved by implementation of Ports emission control strategies and current regulations, recognizing that cancer risk reductions are a surrogate for reductions in DPM non-cancer health effects as well. The ARB's exposure assessment of the Ports (ARB 2006b) provided the basis for the air dispersion modeling components of the Protocol. The Protocol also identified methodologies to be followed in calculating exposure concentrations and cancer risk which are consistent with the guidance of the SCAQMD and California's Office of Environmental Health Hazard Assessment (OEHHA).

The focus of the BWHRA Tool on DPM reflects the fact that long-term exposure to air pollution in the South Coast Air Basin (Basin) has been linked to a number of serious health effects including impaired lung function and an increased incidence of asthma (ARB 2004a) and impaired lung development in children (Gauderman et al. 2007). Diesel exhaust contributes particulate matter (PM) and other components to air pollution, and ARB determined that DPM accounts for approximately 70% of California's estimated potential cancer risk from toxic air contaminants (TACs) based on its monitoring data (ARB 2000). The ARB's Exposure Assessment for the Ports focused solely on DPM because of its potential to cause cancer and other health effects, and because cancer risks from diesel exhaust tend to be highest in areas with concentrated emissions (ARB 2006a). Consistent with those facts, ARB's analysis identified elevated regional cancer risks associated with ports-related DPM emissions (ARB 2006a). These results, supplemented by recently-completed project analyses at the Ports (e.g., Port of Los Angeles [POLA] 2007, 2008; and Port of Long Beach [POLB], 2009) indicate that DPM sources at the ports may be the most significant single contributor of any TAC to regional health effects. The ambient DPM concentrations in the vicinity of the Ports are below the State of California's current non-cancer reference exposure level (REL) (OEHHA & ARB 2009), and thus are lower than the level at which significant adverse non-cancer health effects would be anticipated. Therefore, the BWHRA Tool focuses solely on cancer risk estimation.

1.1 Objective

The objective of the BWHRA Tool was to prepare an exposure and risk assessment for Ports-related DPM sources in the baseline year 2005 relative to those estimated for forecasted DPM emissions from the Ports in 2020. These analyses were conducted to characterize the effectiveness of implementing current CAAP measures and adopted regulations, while providing an understanding of the overall progress of the Ports towards achieving the Standard. The year 2020 assessment includes assumptions of a 7.1% annual increase in growth of the Ports (*i.e.*, pre-recession rates of growth) in the years between 2005 and 2020 (Starcrest 2008), implementation of adopted regulations, and implementation of additional select control measures (CAAP 2006; Starcrest 2007a,b, 2008). These scenarios, the underlying assumptions, and emissions estimation methodologies were developed by Starcrest (2008) with the participation of staff of the Ports, the ARB, and the SCAQMD.

For diesel exhaust from goods movement in particular, the ARB has prepared a series of risk assessments, including human health risk assessments (HRAs) for a number of railyards (*e.g.*, ARB 2004b, 2007a,b), a human HRA for diesel emissions associated with the statewide goods movement system (ARB 2006b), and an evaluation of regional health risks posed by diesel emissions from the Ports (ARB 2006a). While the risk assessments prepared for the individual rail yards focused on local impacts, the risk assessments prepared as part of the Emission Reduction Plan for Ports and Goods Movement (ARB 2006b) and for the Ports (ARB 2006a) focused on sub-regional impacts. This BWHRA Tool also focuses on sub-regional, rather than local, impacts. Local impacts are addressed in the facility-specific risk assessments prepared with project-specific protocols by the Ports under the California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA) as part of the Ports' environmental programs. Since the BWHRA Tool is a sub-regional assessment that was specifically developed to support the CAAP health risk standard development, the methodologies of the BWHRA Tool have certain differences from specific guidance of state and local programs whose focus is on regulating single emission sources. In addition, due to the nature of the assessment, the BWHRA Tool utilized several technical approaches *e.g.*, analysis only of ports-related emission sources, use of fleet-average parameters to represent emission sources, and the generalization (grouping) of emission sources, that prevent the use of this tool to quantitatively assess project-specific cumulative risk under CEQA and NEPA.

Consistent with the Ports emissions inventories, and for comparability to ARB (2006a), the BWHRA Tool addresses mobile sources within the Ports' boundaries as well as over-water emissions. In addition, DPM emissions from trucks on major roadways (*i.e.*, Interstates 110 and 710 and Highways 47 and 103) and locomotives on the major rail line (*i.e.*, the Alameda Corridor) associated with Port operations - but outside the Ports' boundaries - were included. Based on an evaluation of meteorological data collected from stations in the vicinity of the Ports,

the BWHRA Tool included out-of-port truck and locomotive DPM emissions over an area extending approximately to Interstate 405 (see Appendix A).²

1.2 Project Scope

The Port of Los Angeles and the Port of Long Beach are owned by the cities of Los Angeles and Long Beach, respectively, and are operated and managed under a State Tidelands Trust that grants local municipalities jurisdiction over ports. Collectively, the two Ports encompass approximately 10,700 acres and more than 50 miles of waterfront. The Ports build and lease the terminals, but do not operate the ships, CHE, trucks, harbor craft, and locomotives that support activities of the Ports tenants. The BWHRA Tool evaluates on-port mobile source emissions from the Port of Los Angeles and the Port of Long Beach, and their respective cargo terminals, passenger terminals, inter-modal rail facilities, and maritime support services. Port-related truck emissions on major freeways (*i.e.*, Interstates 110 and 710 and Highways 47 and 103) and locomotive emissions on the major rail line (*i.e.*, the Alameda Corridor) in the vicinity of the Ports and north to Interstate 405 were also considered in the BWHRA Tool. Over-water emissions from OGVs are also included for activities within 40 nautical miles off the coast of Los Angeles and Orange counties. The mobile source categories evaluated in this assessment include OGVs, harbor craft (*e.g.*, tugboats, ferries, commercial fishing vessels, etc.), off-road CHE, railroad locomotives, and on-road HDVs (see Section 3).

To facilitate comparisons with ARB's Exposure Assessment of the Ports (ARB 2006a), the BWHRA Tool assesses sub-regional impacts of DPM, and uses the same geographic area (domain) of air dispersion modeling for estimation of DPM exposure point concentrations as that used by ARB.

1.3 Methodology

This report provides the background to the analysis, and also describes the methodologies followed for the air dispersion modeling and human health risk assessment elements of the BWHRA Tool. These approaches were established in a health risk assessment Protocol reviewed by the TWG (Appendix A). Emissions estimation methodologies are described in separate documents prepared by Starcrest (2007 a,b, 2008) and reviewed by the TWG.

Like any risk assessment for chemicals emitted to air, the BWHRA includes estimation of air emissions, dispersion modeling to estimate exposure concentrations, and calculation of potential health risks associated with modeled exposure concentrations. The risk assessment methods used in the BWHRA Tool are based on the fundamental principles of human health risk assessment described by the National Research Council ([NRC] 1983, 1994). The risk assessment methods of the BWHRA Tool are also consistent with guidance of the California

² The section of Interstate 110 between 223rd Street and Interstate 405 in northern Long Beach is not included in the analysis, as discussed in Appendix A.

Environmental Protection Agency (Cal/EPA), OEHHA (2003), the USEPA (2005a) and the SCAQMD (2003, 2005). These regulatory guidelines were developed to conform to the fundamental human HRA principles of the NRC (1983, 1994).

To foster comparability of the cancer risk estimates developed in this assessment with risk estimates from other analyses prepared for goods movement in California, the methods used in this BWHRA Tool are generally consistent with the risk assessment guidelines cited above - in particular with the ARB Hot Spots Guidance (OEHHA 2003). However, because those guidance documents were developed as part of specific regulatory programs that are not addressed by the BWHRA Tool, the detailed guidance in those documents is not necessarily consistent with the methodology and objectives of the BWHRA Tool sub-regional assessment.

For air dispersion modeling, the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) was used to estimate DPM exposure concentrations at off-site receptor locations. Air dispersion modeling with AERMOD follows a similar approach to that used by the ARB (2006b). Additional details of how the air modeling was performed are provided in Section 3 and in Appendices A and B.

The BWHRA Tool utilizes default exposure assumptions that are consistent with those recommended by OEHHA for screening-level (*i.e.*, Tier 1) assessments under the AB2588 Hot Spots program (OEHHA 2003). Cancer risk was calculated using a CSF for DPM that was derived by OEHHA to represent the toxicity of the diesel exhaust mixture (OEHHA 1998, 2000). The BWHRA Tool evaluates risks to residential receptor populations, with exposure quantified for the inhalation exposure pathway. Details of the exposure and risk calculations are given in Section 4 and Appendix C, and the results are presented in Section 5.

1.4 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 – Emission Inventory Summary: summarizes the DPM emission inventory results prepared by Starcrest.

Section 3.0 – Air Dispersion Modeling: describes the air dispersion modeling methods used to estimate DPM concentrations.

Section 4.0 – Risk Characterization: describes the methods used to estimate cancer risk from DPM exposure.

Section 5.0 – Results: provides the results of applying the BWHRA Tool, and discusses uncertainties in risk assessment.

Section 6.0 – References: provides citations for all references given in this report.

The appendices include supporting information as follows:

Appendix A: provides the Protocol developed for the BWHRA Tool.

Appendix B: provides additional details of the air dispersion modeling.

Appendix C: provides additional details of the risk characterization.

2 Air Emission Inventory Methodology

Starcrest was commissioned by each of the Ports to conduct a comprehensive, activity-based baseline emissions inventory of off-road CHE, railroad locomotives, on-road HDVs, OGVs, and harbor craft associated with the Ports activities in 2005 (Starcrest 2007a,b).

The Starcrest inventory addresses emissions that occur within the Ports boundaries from the five mobile sources categories noted above (OGVs, harbor craft [*e.g.*, tugboats, ferries, commercial fishing vessels, etc.], CHE, railroad locomotives, and HDVs). In addition, out-of-port Port-related truck emissions on major freeways (*i.e.*, Interstates 110 and 710 and Highways 47 and 103) and locomotive emissions on the major rail line (*i.e.*, the Alameda Corridor) in the vicinity of the Ports are also included in the BWHRA Tool. For consistency with ARB (2006a), Port-related over-water emissions from OGVs have also been included. The Starcrest inventories do not include mobile emissions from activities or facilities within the Ports' boundaries that are either on private land or that are unrelated to Ports operations. As noted in the Introduction, only those emission sources under Ports control are evaluated in the BWHRA Tool.

The baseline inventory encompasses emissions from a single calendar year (2005), and relies on methodologies described in Starcrest (2007a,b). Although Starcrest developed emissions data for a number of compounds, the BWHRA Tool only utilizes data for DPM emissions (see discussion in Introduction). Starcrest also developed an emission forecast for 2020 (Starcrest, 2008). That emission forecast incorporated growth projections for mobile sources at the Ports and reflects adopted regulations as well as implementation of the CAAP (2006). Table 2-1 summarizes the 2005 and 2020 DPM emissions by source category, and also provides the total mass and percentage reductions in DPM emissions for each Port.

3 Air Dispersion Modeling Methodology

Air dispersion modeling is performed to estimate exposure concentrations from the environmental transport and distribution of DPM emissions into the atmosphere from mobile sources at the Ports and from over-water Port-related vessel and harbor craft emissions and out-of-port Port-related truck emissions on major freeways as well as locomotive emissions on the major rail line in the vicinity of the Ports. 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 the air dispersion modeling in a manner consistent with the BWHRA Tool Protocol reviewed by the TWG (Appendix A). Air dispersion methodologies from other studies are used, where appropriate. These included ARB's Exposure Assessment study of the Ports (ARB 2006a) and/or guidance documents related to intermodal and railyard facilities prepared by ARB (2004b, 2005a, 2005b, 2006c) and SCAQMD (2003).

Air dispersion modeling is performed to estimate DPM exposure concentrations at off-Port locations within the modeling domain ("receptor locations") for two emissions scenarios:

- Baseline (year 2005) emissions inventory and
- Year 2020 emissions forecast inventory including projected growth of the Ports, emissions reductions due to adopted regulations, and implementation of the CAAP measures.

These scenarios, the underlying assumptions, and emissions estimation methodologies were developed by Starcrest (2007a,b, 2008) with the participation of staff of the Ports, the ARB, and the SCAQMD. The type of air dispersion model and modeling inputs that were used (i.e., pollutants modeled, pollutant averaging times, source characterization and parameters, meteorological data, terrain, land use, and receptor locations) are summarized below with further details in Appendix B.

3.1 Model Selection and Option

The air dispersion modeling conducted for the BWHRA tool uses the USEPA's state-of-the-art regulatory model AERMOD (version 07026) to estimate DPM exposure concentrations at off-Port receptor locations (USEPA 2005b). AERMOD is a near-field, steady-state Gaussian plume model, and uses 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 sources) for distances of up to 50 kilometers. The use of AERMOD represents an update to the approach taken in ARB's Exposure Assessment of the Ports (ARB 2006a) in which an older USEPA model, Industrial Source Complex Short Term version 3 (ISCST3), was used to estimate exposure concentrations of DPM.

Because the BWHRA tool focuses solely on DPM-associated cancer risk, ENVIRON calculated the annual average DPM concentration for both the 2005 and 2020 emission scenarios consistent with regulatory guidance for the averaging time used for cancer risk assessments.

3.2 Source Characterizations and Parameters

Source characterization, location, and model-specific parameter information is necessary to model the dispersion of air emissions. As the BWHRA tool is developed to evaluate sub-regional impacts, ENVIRON performed the air dispersion modeling analyses using a simplified source treatment similar to the methods applied by ARB in their assessment of the Ports (ARB 2006a), which includes the identification of major source categories (e.g., OGVs, harbor craft, locomotives, CHEs, on-terminal and on-road HDVs), the approximation of locations for major source categories, and the use of fleet-average source parameter.

Details of emission source model parameters and locations are described further in Appendix B. Sources are assumed to have identical spatial allocation for both the 2005 and 2020 scenarios except for a few specific changes associated with approved or anticipated projects at the Ports. See Appendix B for a list of projects and spatial allocation changes that are either approved or anticipated to occur by 2020. ENVIRON used temporal data to represent the daily time variation of emissions for the major source types consistent with ARB's study (ARB 2006a).

3.3 Meteorological Data

AERMOD requires meteorological data from both near the surface and higher up in the atmosphere ("upper air data") to characterize the transport and dispersion of pollutants in the atmosphere. Details of the meteorological selection and processing are provided in Appendices A (which includes the BWHRA Tool Protocol prepared for this project) and B.

Given the large extent of the modeling domain for this assessment and the influence of geographic features on prevailing wind patterns, several surface meteorological stations were needed to fully characterize the varying conditions found in different areas of the Ports' operations. In order to determine the area(s) over which individual surface meteorological stations would be applicable, ENVIRON divided the Ports' operational areas into four zones: Inner Harbor, Middle Harbor, Outer Harbor and Beyond the Breakwater. The geographical areas comprising the operational zones are shown in Figure 3-1 and are defined in Appendix B. In the BWHRA tool Protocol and Sphere of Influence Report (Appendix A), the following stations, located on or near Port operational areas and operated by the Port of Los Angeles, were identified as the most representative of meteorological conditions within or near the Ports:

- St. Peter and Paul School (SPPS): Inner Harbor and Land-side Out of Port Emissions
- Terminal Island Treatment Plant (TITP): Middle Harbor
- Berth 47: Outer Harbor and Beyond Breakwater

As recommended by the National Climatic Data Center, Upper air data from the San Diego Miramar Naval Air Station is used in AERMET (USEPA's meteorological data processor for AERMOD) processing for the Ports. The cloud cover data from Long Beach Daugherty Field, as recommended by ARB, is also used in AERMET processing for the Ports.

Prior to running AERMET, surface characteristics for the meteorological monitoring site and/or the selected Port facilities must be specified. The surface parameters include surface roughness, albedo, and Bowen ratio, which are used to compute fluxes and stability of the atmosphere (USEPA 2004). The evaluation and selection of surface parameters, including the selection of surface parameter values and land use sectors is described in the BWHRA Tool Protocol found in Appendix A and utilizes USEPA methods applicable at the time that the BWHRA tool was developed.³

3.4 Land Use and Terrain

AERMOD can evaluate the effects of urban heat island effects on atmospheric transport and dispersion using an urban boundary layer option. ENVIRON selected the urban boundary layer option for this study based on the highly urbanized areas present in the modeling domain. Appendix B provides additional details on the model inputs used for this option.

To ensure the modeling reflected the geographic features found in the modeling domain, ENVIRON used United States Geological Survey (USGS) 7.5 minute digital elevation maps (DEMs) for the entire modeling domain, similar to ARB's Ports study (ARB 2006a). Appendix B lists the specific terrain files used and any exceptions to the incorporation of elevation data into AERMOD.

3.5 Receptor Locations and Estimation of Exposure Concentrations

As described in the Protocol (Appendix A), two Cartesian grids representing off-site receptor locations around the Ports were included in the dispersion modeling to estimate DPM exposure concentrations for use in the estimation of DPM cancer risks. ENVIRON uses a receptor grid with 200-meter spacing, similar to ARB's Ports study (ARB 2006a), out to a distance of two kilometers (km) from the Ports' boundaries. A second Cartesian receptor grid with 500-meter spacing covering a total area of approximately 20 miles by 20 miles is also included. The extent of this grid is similar to the Cartesian receptor grid in ARB's Ports study (ARB 2006a) and extends south of the Ports over the San Pedro Bay, north to approximately Lynwood, west to approximately Torrance, and east to approximately Buena Park, as shown in Figure 3-1.

³ In January 2008, USEPA released updated guidance for surface parameters analysis with the release of AERSURFACE, a model preprocessor to assist in determining surface parameters consistent with the new guidance (USEPA 2008a,b). The guidance recommends different methods than those used in the BWHRA tool for calculating the surface parameters. However, the impact of using these different methods relative to the methods used in the BWHRA Tool is insignificant, as discussed in more detail in Appendix B.

DPM exposure concentrations from all modeled sources were summed to estimate the total DPM exposure concentration at each receptor location for both the 2005 baseline and 2020 future forecast scenarios.

4 Health Risk Assessment Methodology

This section describes the methodology used in evaluating potential human health risk from exposure to DPM emitted during operations of the Ports, and Section 5 presents the principal results of that assessment. Supplemental material is provided in Appendix C, including a discussion of the derivation of the DPM CSF. Quantification of potential health effects from DPM exposure incorporates the four elements of risk assessment identified by the NRC (1983): (1) hazard identification (including identification of chemicals of potential concern); (2) exposure assessment; (3) dose-response assessment; and (4) risk characterization. Each of these components is addressed in the following sections.

The risk assessment regulations and guidance documents that were considered in developing the methodology used in this assessment include:

- Air Toxics Hot Spots Program Risk Assessment Guidelines (OEHHA 2003),
- Air Resources Board Recommended Interim Risk Management Policy for Inhalation-Based Residential Cancer Risk (ARB 2003b)
- Supplemental Guidelines for Preparing Risk Assessments for the Air Toxics “Hot Spots” Information and Assessment Act (SCAQMD 2005)

The BWHRA Tool utilized screening-level (Tier 1) assumptions and parameters in accordance with the guidance cited above. The focus of the BWHRA Tool on sub-regional effects distinguishes it from project-specific CEQA or NEPA evaluations at the Ports, which are designed to address questions of local impacts and health effects associated with a project or facility. Using air dispersion modeling of contaminants to near-source receptors, project-specific analyses examine impacts at maximum impact points, sensitive receptors locations, and other receptor populations that are not consistent with the source characterization methods and air dispersion modeling of the BWHRA Tool. In contrast, the BWHRA Tool estimates overall sub-regional cancer risks attributable to DPM emissions from the Ports consistent with the ARB (2006a) Exposure Assessment of the Ports. The BWHRA Tool methodology is further distinguished from that used in project analyses by the manner in which emission rates are averaged. The BWHRA Tool uses discrete DPM emission rates estimated for 2005 and 2020 and held constant over the subsequent respective 70-year averaging periods, whereas project analyses utilize emission rates calculated for each year of the project life. Because of these significant technical differences, the BWHRA Tool results are appropriate for informing development of the Standard as well as emission reduction strategies in general, but are not applicable for evaluating the impacts of an individual project or facility on the bay-wide scale.

4.1 Hazard Identification (Identification of Chemicals of Potential Concern)

Hazard identification is defined by the NRC (1983) as the determination of whether a particular chemical is or is not causally linked to particular health effects. In practice, this component of a

risk assessment identifies chemicals associated with a site or activity that are also linked to adverse health effects, and determines whether they should be carried through the risk assessment as chemicals of potential concern (COPCs).

As discussed in the Introduction, this BWHRA Tool focuses on DPM as the sole COPC. Under California regulatory guidelines (OEHHA 1998, 2007), DPM is used as a surrogate for the chemical mixture that is diesel exhaust, and the unit risk factor (URF) that OEHHA developed for DPM reflects that approach (OEHHA 1998). Diesel exhaust is a complex mixture of hydrocarbons, particulates, gases, water, and other compounds. The precise composition of the mixture depends on several factors including the fuel source, engine type, engine age, and operating condition. Diesel exhaust is classified by OEHHA and the USEPA as a carcinogen, and both agencies also recognize that diesel exhaust causes non-cancer effects as well (OEHHA 1998, 2007; USEPA 2007). DPM is a component of PM, and recent scientific data have linked prolonged exposure to PM to premature mortality, respiratory effects, and cardiovascular disease (see discussion in the Introduction and in Section 5.3).

4.2 Exposure Assessment

This component of a human health risk assessment is used to determine the extent of human exposure before or after application of regulatory controls (NRC 1983). As implemented here, the exposure assessment identifies the scenarios and receptor populations, and selects exposure pathways and exposure parameters appropriate to quantification of intake and potential cancer health effects associated with DPM emissions from the Ports. Theoretical chemical intakes for each potentially exposed human population and exposure pathway are estimated using equations consistent with or recommended by OEHHA (2003) and ARB (2003b).

4.2.1 Potentially Exposed Populations

The BWHRA Tool quantifies health effects to residential populations. In accordance with the sub-regional focus of the BWHRA Tool, impacts on sensitive receptors are not addressed in this assessment, but are considered in project HRAs that address local impacts.

Exposure of residential receptors was estimated based on DPM concentrations in all areas outside of the Ports boundaries, excluding over water areas, within the modeling domain. Actual land use zoning was not considered in the evaluation of residential receptor exposure.

4.2.2 Exposure Pathways

At the Ports, DPM is released to ambient air as exhaust from internal combustion engines. Because air is the principal environmental medium affected by DPM emissions, inhalation is the dominant route of exposure, and is the only exposure pathway evaluated by the BWHRA Tool.

4.2.3 Exposure Parameters

The parameters used to calculate exposure are based on a series of reported and assumed factors regarding human activity in the vicinity of the Ports *e.g.*, exposure time, exposure frequency, and exposure duration. The exposure parameters listed below for residential populations are consistent with a screening level, Tier 1 risk assessment when applied pursuant to OEHHA guidelines (OEHHA 2003).

Exposure estimates for residential receptors were based on the assumption that exposure to DPM occurs outdoors 24 hours per day, 350 days per year for 70 years (*i.e.*, that residents are present in their home seven days a week for 50 weeks a year [or about 96 percent of the time] with approximately two weeks [15 days] spent away from home) (OEHHA 2003). Uptake of DPM by inhalation was calculated using the 80th percentile breathing rate of 302 liters per kilogram of body weight per day (L/kg BW-day) (ARB 2003a). A default value for averaging time of 70 years, or 25,550 days was used.

The equation used to calculate exposure to a modeled concentration of DPM is provided in Appendix C.

4.3 Dose-Response Assessment

Because of the decision to focus on DPM-attributable cancer risk as the sole assessment metric (see Introduction), cancer risk was the only health effect end point evaluated in this BWHRA Tool. Both OEHHA (2008) and the USEPA have classified diesel exhaust as a carcinogen (USEPA 2008c). Consistent with OEHHA and the USEPA, other health agencies, including the International Agency for Research on Cancer ([IARC] 1998), and the World Health Organization ([WHO] 1996) have also concluded that diesel exhaust is a probable human carcinogen.

For DPM, the value used to estimate cancer risk from exposure is the CSF. The CSF is defined by OEHHA (2003) as the “theoretical upper bound probability of excess cancer cases occurring in an exposed population assuming a lifetime exposure to the chemical when the chemical dose is expressed in exposure units of milligrams/kilogram-day (mg/kg-d).” OEHHA’s CSF for DPM is $1.1 \text{ (mg/kg-d)}^{-1}$; derivation of the CSF for diesel exhaust is discussed in Appendix C.

5 Results

This section presents the results of the risk calculations for Ports-related DPM emissions in 2005 and 2020. Details of how cancer risks were calculated are provided in Appendix C.

5.1 Individual Cancer Risks

Implementation of CAAP emission reduction measures and adopted regulations are predicted to achieve widespread and significant reductions in individual cancer risk.

Between 2005 and 2020, residential cancer risks above 500×10^{-6} (500 in a million) are virtually eliminated from the zone around the Ports, with only small areas near Interstate 710 that still exceed this level (Figures 5-1 and 5-2). In 2005, estimated residential cancer risks between 251 and 500×10^{-6} (two hundred fifty one and five hundred in a million) impacted an extensive area around the Ports and major transportation corridors; by 2020, the zone that is affected by this level of risk is predicted to shrink dramatically, and is largely limited to areas directly adjacent to transportation corridors and the Ports boundaries.

Figure 5-3 shows the percentage reduction in individual cancer risk between 2005 and 2020 across the BWHRA Tool modeling domain. This method of presenting cancer risk provides important perspective on the scale of the risk reductions; by the year 2020, risk reductions exceed 75% in many areas of the domain, with risk reductions between 70 and 75% expected for the majority of the domain.

The Ports recognize that individuals who reside in communities within 2 km of the Ports boundaries and nearby transportation corridors may be more highly impacted by Ports-related emissions than for individuals in the domain as a whole. Evaluation of this near-Port area (Figure 5-4), showed that while significant risk reductions of 70% or more are predicted for the majority of this 2 km zone by 2020, approximately 10 % of individuals are predicted to have risk reductions between 60 to 70% and a small area is expected to have risk reductions between 50 and 60%. The areas with the lowest predicted cancer risk reductions, less than 50%, occur in commercially or industrially-zoned areas between the Ports that are not currently occupied by residents.

DPM emissions and risks from all sources decrease by the year 2020, with the relative importance to cancer risk of different source categories such as HDVs, locomotives, or OGVs varying throughout the domain (Figure 5-5). For the communities closest to the Ports and transportation corridors, ports-related truck and locomotive emissions are important contributors to risk in both 2005 and 2020. Although risks attributable to HDV remain for these communities in 2020, overall HDV emissions are expected to have decreased 84%, resulting in substantial decreases in risk from this source by 2020 relative to 2005 levels. CHE-associated risks are also important contributors to 2005 risks near intermodal operations, but by 2020 the importance of this source decreases markedly due to significant reductions in emissions from

this source. For the year 2020, the planned increased reliance on on-port rail as a means of decreasing HDV emissions results in only modest reductions in rail-related emissions and risk for locations near the Ports. OGV emissions, while reduced significantly by 2020, continue to be a major contributor to risk levels throughout the domain. OGV emissions are the focus of ARB and international regulatory efforts targeting reductions in fuel sulfur content. When implemented, along with ARB's regulation for the use of shorepower, these regulations should yield public health benefits throughout the Basin.

5.2 Population-Weighted Average Cancer Risks

Population-weighted average cancer risks attributable to Ports DPM sources were calculated to characterize the population-based reduction in risk within the BWHRA Tool domain between 2005 and 2020. For the modeling domain overall, population-weighted average cancer risks for 2005 of 249×10^{-6} (249 in a million) are predicted to be reduced significantly by 2020 to 66×10^{-6} (66 in a million), a decrease of 74% (Table 5-1). For highly impacted communities, population-weighted average cancer risks for 2005 of 519×10^{-6} (519 in a million) are predicted to be reduced by 2020 to 143×10^{-6} (143 in a million), a 72% decrease in risk (Table 5-2). These decreases in risk are consistent with the risk reductions calculated for individual residential receptors (see preceding discussion), and confirm the magnitude of the risk reductions expected from the Ports current DPM emission reduction strategies.

5.3 Discussion and Conclusions

The BWHRA Tool was used to predict reductions in both individual and population-weighted average cancer risk in 2020 from implementing CAAP (2006) DPM emission reduction strategies in combination with regulations adopted by the USEPA and ARB. The cancer risks calculated for 2005 and 2020 represent the predicted risks, above background levels, attributable to Ports-related DPM sources. These analyses indicate that widespread public health benefits will result from the reduction in DPM emissions from Ports-related mobile sources, yielding risk reductions of 70% or more for the majority of the modeling domain in 2020.

For the entire Basin in the year 2000, individual cancer risk from all TACs combined has been estimated at 1000×10^{-6} (1000 in a million); risks of approximately 720×10^{-6} (720 in a million) have been attributed to DPM alone (ARB 2006d). These values represent risk to individuals from all sources, and they indicate that Ports DPM sources represent only a portion of the air quality and public health risk concerns facing the Basin.

As discussed in the CAAP (2009) update, the Ports cannot singlehandedly resolve the Basin's air quality issues, the results from application of the BWHRA Tool demonstrate that the Ports' CAAP commitments, actions, and policies to reduce DPM levels can have significant beneficial effects on public health. The reduction in DPM emissions will also reduce $PM_{2.5}$, producing

additional health benefits while supporting Basin-wide efforts to attain the federal PM_{2.5} standard. The Ports have committed to reviewing the CAAP on a regular basis, and during these reviews, to examine progress towards achieving the CAAP goals. The CAAP reviews will focus on the need to adjust implementation strategies by incorporating newly-developed technologies or other available measures to ensure that the CAAP goals and Health Risk Standard are achieved. By following this framework, the Ports expect to attain the significant reductions in cancer risk noted above, and to identify and apply technologies not yet available to ultimately reach the Health Risk Reduction Standard (CAAP 2009).

5.4 Uncertainties Associated with Health Risk Analysis

There is inherent uncertainty in all risk assessments, with the source(s) of that uncertainty dependent on the specific assumptions and models used to estimate risk (Council on Environmental Quality 1989). Understanding the degree of uncertainty associated with each component of a risk assessment is critical to interpreting the results of that assessment. As recommended by the NRC (1994), [a risk assessment should include] “a full and open discussion of uncertainties in the body of each ... risk assessment, including prominent display of critical uncertainties in the risk characterization.” In accordance with these recommendations, the key uncertainties and critical assumptions associated with the air dispersion modeling and health risk estimation are provided in Appendices B and C. The uncertainties associated with the emission estimations used in this BWHRA Tool are provided in Starcrest (2007a,b and 2008).

The risks calculated by application of the BWHRA Tool were estimated using a series of conservative assumptions regarding exposure concentrations, the magnitude and duration of exposure, and carcinogenic potency of DPM. These assumptions, applied in a manner consistent with current guidance (OEHHA 2003; ARB 2003b), tend to produce upper-bound estimates of risk, ensuring that these values do not underestimate the actual risks posed by DPM emissions from the ports. It is important to note that the risks calculated in the BWHRA Tool do not necessarily represent the actual risks experienced by populations in the modeling domain. By using standardized conservative assumptions in a risk assessment, the USEPA (1989) has noted that:

“These values [risk estimates] are upper-bound estimates of excess cancer risk potentially arising from lifetime exposure to the chemical in question. A number of assumptions have been made in the derivation of these values, many of which are likely to overestimate exposure and toxicity. The actual incidence of cancer is likely to be lower than these estimates and may be zero.”

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