Draft Environmental Impact Report

CANDLESTICK POINT–HUNTERS POINT SHIPYARD PHASE II

Volume V: Draft EIR Appendix H3 to Appendix P2

SAN FRANCISCO REDEVELOPMENT AGENCY
File No. ER06.05.07

CITY AND COUNTY OF SAN FRANCISCO PLANNING DEPARTMENT
File No. 2007.0946E

State Clearinghouse No. 2007082168

DEIR Publication Date: November 12, 2009
San Francisco Redevelopment Agency Commission Public Hearing Date: December 15, 2009
San Francisco Planning Commission Public Hearing Date: December 17, 2009
DEIR Public Review Period: November 12, 2009–December 28, 2009

Written comments should be sent to:
Environmental Review Officer—San Francisco Redevelopment Agency
One South Van Ness Avenue, Fifth Floor, San Francisco, CA 94103
or
Environmental Review Officer—San Francisco Planning Department
1650 Mission Street, Suite 400, San Francisco, CA 94103

CANDLESTICK POINT–HUNTERS POINT SHIPYARD PHASE II DEVELOPMENT PLAN PROJECT

Draft Environmental Impact Report

Volume V: Draft EIR Appendix H3 to Appendix P2

San Francisco Redevelopment Agency File No. ER06.05.07
City and County of San Francisco Planning Department File No. 2007.0946E
State Clearinghouse No. 2007082168

San Francisco Redevelopment Agency
One South Van Ness Avenue, Fifth Floor, San Francisco, California 94103, *and*
City and County of San Francisco Planning Department
1650 Mission Street, Suite 400, San Francisco, California 94103

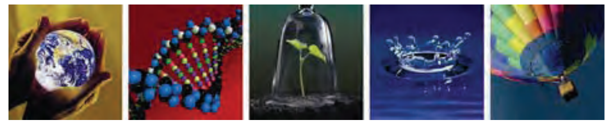
DEIR Publication Date: November 12, 2009
San Francisco Redevelopment Agency Commission Public Hearing Date: December 15, 2009
San Francisco Planning Commission Public Hearing Date: December 17, 2009
DEIR Public Review Period: November 12, 2009–December 28, 2009

Written comments should be sent to:
Environmental Review Officer—San Francisco Redevelopment Agency
One South Van Ness Avenue, San Francisco, California 94103
or
Environmental Review Officer—San Francisco Planning Department
1650 Mission Street, Suite 400, San Francisco, California 94103

Contents

Volume VI: Draft EIR Appendix Q1 to Appendix V2

Appendix H3 ENVIRON Ambient Air Quality and Human Health Risk Assessment, October 30, 2009



Appendix H1: Ambient Air Quality Human Health Risk Assessment

Candlestick Point – Hunters Point Shipyard Phase II Development Plan San Francisco, California

Prepared for:
PBS&J
San Francisco, California

Prepared by:
ENVIRON International Corporation
San Francisco and Emeryville, California

Date:
October 30, 2009

Project Number:
03-20816A

Contents

List of Attachments

List of Acronyms

AAQ	Ambient Air Quality
AERMOD	American Meteorological Society/Environmental Protection Agency Regulatory Model
ARB	California Air Resources Board
BAAQMD	Bay Area Air Quality Management District
Cal/EPA	California Environmental Protection Agency
CEQA	California Environmental Quality Act
CP	Candlestick Point
DPM	Diesel Particulate Matter
EIR	Environmental Impact Report
EMFAC	EMission FACtor model
HHRA	Human Health Risk Assessment
HI	Hazard Index
HPS	Hunters Point Shipyard
MEI	Maximally Exposed Individual
NFL	National Football League
PBS&J	Post, Buckley, Schuh & Jernigan, Inc.
PM	Particulate Matter
$PM_{2.5}$	Particulate Matter Less than 2.5 Microns in Aerodynamic Diameter
PM_{10}	Particulate Matter Less than 10 Microns in Aerodynamic Diameter
R&D	Research and Development
SFDPH	San Francisco Department of Public Health
TAC	Toxic Air Contaminants
USEPA	United States Environmental Protection Agency

List of Units

gsf	gross square footage
m^3	cubic meter
μg	microgram

1 Introduction

At the request of Post, Buckley, Schuh & Jernigan, Inc. (PBS&J), ENVIRON International Corporation (ENVIRON) has performed four ambient air quality (AAQ) human health risk assessments (HHRA) as part of the Environmental Impact Report (EIR) for the proposed Candlestick Point – Hunters Point Shipyard Phase II Development Plan ("Project"). The EIR for the Project is being prepared by PBS&J on behalf of the San Francisco Redevelopment Agency and the San Francisco Planning Department.

The Project will consist of the development of approximately 702-acre area east of U.S. 101 in the southeast area of the City and County of San Francisco and will occupy the waterfront area from south of India Basin to Candlestick Cove. The Project is comprised of two major sub-components: Candlestick Point (CP) and Hunters Point Shipyard (HPS) Phase II.

Details of the Project are described in Chapter II of the EIR. The Project proposed by Lennar Urban includes a mixed-use community with a range of residential, retail, office, research and development, civic and community uses, and parks and recreational open space. In addition, a major component would be a new stadium for the San Francisco 49ers, a National Football League (NFL) team. Necessary infrastructure improvements (including several roadway modifications) are also proposed in support of the Project development plan.

The EIR also examines variants to the Project:

- Variant 1 would include an additional 2.5 million gross square footage (gsf) of research and development space on the proposed stadium site. All other elements of the Project would remain the same.
- Variant 2 would redistribute 1,350 residential units to the proposed stadium site from Candlestick Point. All other elements of the Project would remain the same.
- A third variant (Variant 3) would include the same land use program and overall description as the Project, with different locations for the residential towers.
- Variant 4 is the same overall development plan as the Project, but with minor shifts in building locations to accommodate 570,000 gsf for the proposed utility systems (with 330,000 gsf located below ground).
- Variant 5 assumes that a new stadium would be constructed and shared between the San Francisco 49ers and the Oakland Raiders football teams. The land use program would remain the same as the proposed Project.

Chapter IV of the EIR analyzes these Variants. Evaluation of the variants in the EIR allows for consideration and approval of these variants without further environmental review.

ENVIRON conducted four AAQ HHRAs in support of the EIR for the Project, as follows:

1. **Human Health Risk Assessment of Construction-Related Diesel Particulate Matter:** This HHRA included evaluation of the potential health effects associated with exposure to diesel particulate matter (DPM) that may be emitted during Project-related construction activities.

2. **Human Health Risk Assessment of Chemicals Bound to Airborne PM_{10}:** This HHRA included an evaluation of the potential health effects associated with potential exposures to chemicals bound to particulate matter (PM) with a mean diameter of 10 microns or less (PM_{10}) released from soils during Project-related construction activities. Those chemicals present in soil dusts at concentrations above the residential cleanup goal are evaluated.

3. **Analysis of Toxic Air Contaminant Emissions from Stationary Sources in Research and Development Areas:** This HHRA involved a screening-level prospective analysis to evaluate potential health impacts from future stationary sources of toxic air contaminant (TAC) emissions in the areas designated for research and development (R&D) within the proposed Project.

4. **$PM_{2.5}$ Analysis of Traffic/Vehicular Emissions**: This HHRA included an evaluation of the potential health impacts associated with concentrations of particulate matter (PM) with a mean diameter of 2.5 microns or less ($PM_{2.5}$) along major thoroughfares in the vicinity of the Project due to Project-related traffic.

The HHRAs performed by ENVIRON have been conducted in accordance with the California Environmental Quality Act (CEQA) and were prepared using information obtained from PBS&J and Lennar Urban.

The HHRAs are presented in four separate attachments to this main report, as identified below. Attachment V presents documentation of the meteorological data used in the air dispersion modeling component of the four AAQ HHRAs. The methods used in each HHRA as well as the findings from each analysis are summarized below.

Since the HHRAs were completed, changes were made to the Project Description including the addition of roadway improvements on Ingerson and Jamestown Avenues, compaction of Candlestick Point construction schedule (completion in 2026), and slight changes to the Candlestick Point phasing boundaries. These changes to the Project Description were found not to change the HRA conclusions significantly, as documented in a technical memorandum included in Attachment VI. In addition to the above changes, Variant 4 (a new stadium constructed and shared between the San Francisco 49ers and the Oakland Raiders football teams) has been renumbered Variant 5; with a new Variant 4 (the Utilities Variant) which proposes centralized wastewater facilities, heating and cooling plants, and a transvac system for trash (tubes). This new Variant 4 includes 527,000 gsf of new development most of which is underground.

2 Analysis of Construction Equipment Emissions

ENVIRON performed an HHRA to evaluate the potential human health effects associated with potential exposure to DPM that may be emitted during construction activities related to the Project. The full HHRA is included as Attachment I.

2.1 Methodology

The methods used in the analysis of DPM emissions from Project-related construction emissions are consistent with CEQA guidelines and Bay Area Air Quality Management District (BAAQMD), California Environmental Protection (Ca/EPA) and United States Environmental Protection Agency (USEPA) risk assessment guidance. The HHRA incorporates conservative (i.e., health-protective) methodologies for the following: 1) the estimation of DPM emissions, 2) the calculation of airborne DPM concentrations at receptor locations, and 3) the estimation of excess lifetime cancer risks and noncancer health effects or hazard indices (HIs).

ENVIRON estimated DPM emissions for construction equipment associated with the Project construction activities. Construction activities considered in this evaluation include abatement, demolition, grading, excavation, and foundation and structure construction. Specifically, construction sources of DPM evaluated in this HHRA included off-road construction equipment such as lifts, loaders, excavators, dozers, and graders. ENVIRON also evaluated three types of vehicle traffic in this DPM construction HHRA:

- Equipment and material delivery,
- Spoils and debris hauling, and
- Construction employee commute.

Airborne DPM concentrations were then estimated at receptor locations using the DPM emissions estimates and the USEPA recommended air dispersion model American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) version 07026.

Offsite receptors evaluated in this HHRA included residents (child and adult), workers and sensitive receptors (school children) located in the surrounding community and along the expected travel routes of on-road delivery and haul trucks. Onsite receptors evaluated in this HHRA included residents at the Alice Griffith Housing area. As stated in the Chapter II of the EIR, the proposed Project includes rebuilding Alice Griffith Housing to provide one-for-one replacement units and ensuring that eligible Alice Griffith Housing residents have the opportunity to move to the new, upgraded units directly from their existing Alice Griffith Housing units without having to relocate to any other area. Based on the proposed plan outlined in the EIR, it is anticipated that construction activities within the Alice Griffith Housing area will be phased by parcel. While construction occurs at one parcel, residents will continue to reside at the remaining parcels. These residents were identified as onsite receptors for the Project.

Based on the results of the exposure evaluation and air dispersion modeling, ENVIRON developed quantitative estimates of excess lifetime cancer risks and noncancer HIs associated with potential exposure to DPM that may be emitted during construction activities related to the Project. The methods used to estimate excess lifetime cancer risks and noncancer HIs are consistent with risk assessment guidance from BAAQMD, Cal/EPA and USEPA.

In accordance with CEQA, the cancer risks and chronic noncancer HIs estimated in this HHRA were then compared to the BAAQMD CEQA thresholds of significance. Pursuant to BAAQMD *CEQA Guidelines* (BAAQMD 1999), projects that expose the public to TACs in excess of the following thresholds would be considered to have a significant air quality impact:

- Probability of contracting cancer for the maximally exposed individual (MEI) exceeds 1×10^{-5} (10 in a million);
- Ground level concentrations of noncarcinogenic TACs resulting in a Hazard Index greater than 1 for the MEI.

2.2 Findings

The results of this HHRA indicate that potential excess lifetime cancer risks to offsite residents, workers and sensitive receptors in areas surrounding the Project are below 10 in a million for DPM emitted from construction activity, assuming that certain mitigation measures are implemented as discussed in Attachment I. Further, estimated cancer risks for onsite residents at the Alice Griffith Housing area are also below 10 in a million. The estimated chronic noncancer hazard indices are below one for all receptors evaluated in this HHRA. Thus, based on the results of this HHRA, DPM emission related to Project construction activities should not have a significant air quality impact according to BAAQMD CEQA Guidelines (BAAQMD 1999).

The many conservative assumptions that have been used in this assessment regarding the estimation of emissions, ambient air concentrations, exposure assumptions, and carcinogenic potency lead to an overestimate of potential risks, the magnitude of which could be substantial.

A screening-level analysis was conducted to evaluate the potential impacts of changes to the Project Description on the HHRA conclusions. This screening-level analysis is described in Attachment VI: Technical Memorandum, Updated Project Description. Using this screening approach, the estimated excess lifetime cancer risks and chronic noncancer HIs for all receptors are below the BAAQMD CEQA thresholds of significance, and therefore, the impact from these emissions remains less than significant.

3 Analysis of Airborne Soils

ENVIRON performed a HHRA to evaluate the potential human health risks due to potential exposure to chemicals that may be present in airborne soils (dusts) emitted during Project-related construction activities. The full HHRA is included as Attachment II.

3.1 Methodology

The methods used in the analysis of soil dust emissions from Project-related construction activities are consistent with CEQA guidelines and BAAQMD, Ca/EPA, and USEPA risk assessment guidance. The dusts evaluated are referred to as PM_{10}, that is, PM with a mean aerodynamic diameter of 10 microns or less. PM_{10} corresponds to particles of a size that could be inhaled and retained in the lungs.

Conservative (i.e., health-protective) methodologies were applied for the following: 1) the estimation of PM_{10} emissions from soils, 2) the calculation of airborne PM_{10} and associated chemical concentrations at receptor locations, and 3) the estimation of excess lifetime cancer risks and noncancer health effects or HIs.

The sources of PM_{10} emissions evaluated were demolition and soil grading activities associated with Project construction activities. Those Project areas where PM_{10} emissions were from soils with chemicals present at concentrations above residential cleanup goals were included in the evaluation. Airborne PM_{10} concentrations were estimated at receptor locations using the PM_{10} emissions estimates and the USEPA recommended air dispersion model AERMOD version 07026. Chemical concentrations associated with the airborne PM_{10} were estimated based on the chemical concentrations in soils, referred to as the soil source terms.

Offsite receptors evaluated in the HHRA included residents (child and adult), workers, and sensitive receptors (school children) located in the surrounding community. Onsite receptors evaluated included residents at the Alice Griffith Housing area. As discussed in Section 2.1, it is anticipated that construction activities within the Alice Griffith Housing area will be phased by parcel. While construction occurs at one parcel, residents will continue to reside at the remaining parcels.

Inhalation exposures were quantitatively evaluated for all receptors. In addition, a sensitivity analysis – referred to as a multipath analysis – was conducted for specific chemicals to evaluate the potential contribution of other (noninhalation) exposure pathways. Specifically, airborne dusts released during construction activities could deposit on soils such that exposures could also occur through other pathways (i.e., incidental ingestion of and dermal contact with soil for all receptors, and for residents, ingestion of produce grown in residential gardens).

Based on the results of the exposure evaluation and air dispersion modeling, ENVIRON developed quantitative estimates of excess lifetime cancer risks and noncancer HIs associated with potential exposures to chemicals bound to PM_{10} emitted during construction activities. The methods used to estimate excess lifetime cancer risks and noncancer HIs are consistent with risk assessment guidance from BAAQMD, Cal/EPA, and USEPA. The estimated cancer risks and chronic noncancer HIs were then compared to the BAAQMD CEQA thresholds of significance presented in Section 2.1.

3.2 Findings

The results of this HHRA indicate that potential excess lifetime cancer risks to offsite residents, workers, and sensitive receptors surrounding the Project are below 10 in a million for inhalation exposures to chemicals bound to PM_{10} emitted during construction activities. Further, estimated cancer risks for onsite residents at the Alice Griffith Housing area are below 10 in a million. The estimated chronic noncancer HIs are below one for all receptors evaluated. Thus, based on the results of this HHRA, PM_{10} emissions related to Project construction activities should not have a significant air quality impact according to current BAAQMD CEQA Guidelines (BAAQMD 1999).

The results of the sensitivity analysis for cumulative exposures from inhalation and noninhalation (i.e., incidental ingestion of and dermal contact with soil for all receptors, and for residents, ingestion of produce grown in residential gardens) exposure pathways indicate that the estimated cancer risks and noncancer HIs are below BAAQMD thresholds for all populations evaluated.

A screening-level analysis was conducted to evaluate the potential impacts of changes to the Project Description on the HHRA conclusions. This screening-level analysis is described in Attachment VI: Technical Memorandum, Updated Project Description, which indicates that at the MEI worker, resident adult and resident child the estimated excess lifetime cancer risks continue to be below the threshold of 10 in a million (1.0×10^{-5}) and the noncancer chronic HIs and acute HIs are below the threshold of 1.0. The estimated excess lifetime cancer risks and chronic and acute noncancer HIs for all receptors are below the BAAQMD CEQA thresholds of significance, and therefore, the impact from these emissions remains less than significant.

4 Analysis of Operational Sources

ENVIRON performed a prospective screening-level analysis to evaluate potential health impacts from operational sources of TACs which may locate in the areas designated for R&D within the Project. The full analysis included as Attachment III.

4.1 Methodology

For this prospective screening-level analysis, ENVIRON made a series of assumptions:

- A wide range of stationary sources could operate in the R&D area; thus, the identity and amounts of the TACs emitted from these sources can not be determined at this time.
- The area designated for proposed R&D development would be divided into one-acre plots, which is consistent with the minimum size of a parcel based on the expected land uses within the R&D parcels.
- A single R& D facility (or stationary source) would be constructed on the one-acre plot.
- The cancer risk at the boundary of each one-acre plot was set not to exceed a designated cancer risk level or chronic noncancer HI threshold.
- It was conservatively assumed that all receptor locations surrounding the R&D area were residential.

Evaluation of the impacts associated with stationary sources consisted of two (2) steps:

1.) TAC emissions for each stationary source within a one-acre plot were estimated assuming that the cancer risk and HI at the plot boundary corresponded to 5 in a million and 0.5, respectively.

2.) TAC emissions from each stationary R&D source were summed to assess the cumulative impact of all potential stationary sources within the area designated for R&D development on the surrounding community.

Pursuant current BAAQMD *CEQA Guidelines* (BAAQMD 1999), projects that expose the public to TACs in excess of the following thresholds would be considered to have a significant air quality impact:

- Probability of contracting cancer for the MEI exceeds 1×10^{-5} (10 in a million);
- Ground level concentrations of noncarcinogenic TACs resulting in a HI greater than 1 for the MEI.

4.2 Findings

This analysis presents a conservative assessment of the cumulative excess lifetime cancer risk and chronic noncancer HI due to TAC emissions from the R&D areas at any surrounding receptor location. All receptors were initially evaluated as residential receptors. It assumes that each allowable location for TAC emissions will emit chemicals at the maximum allowable rate. In fact, the TAC emissions at some of these locations will be below the maximum rate (for example office building emissions for TAC would be zero or close to zero), and the resultant cumulative risks will also be lower.

Under this conservative evaluation, there are limited areas outside of the R&D areas that would exceed the proposed BAAQMD thresholds if they were residential locations. However, none of these areas are designated for residential land use in the proposed Project. If these areas were used for commercial or recreational land use, the frequency and duration of potential exposures would be less than that for a resident. Thus, the estimated risks and HIs would decrease below the proposed thresholds.

Further evaluation may be warranted if land use in the vicinity of the Project is modified or if the placement of the stationary sources does not conform to the assumptions made in this screening-level analysis.

5 Analysis of $PM_{2.5}$ Concentrations

ENVIRON performed an evaluation of $PM_{2.5}$ concentrations due to Project-associated traffic. The evaluation of potential health impacts from $PM_{2.5}$ is not required under current CEQA guidelines, but was performed in response to guidance developed by the San Francisco Department of Public Health (SFDPH). The complete evaluation is included as Attachment IV.

5.1 Methodology

The methods used in the analysis of $PM_{2.5}$ emissions from Project-related traffic are consistent with guidance of the SFDPH. The SFDPH is concerned that individuals who live in the proximity of heavily-travelled roads or freeways will incur adverse health effects as a result of exposure to vehicle emissions. To minimize contributions to health impacts associated with locating new residential projects near roadway “hot spots”, the SFDPH developed a strategy to assess and mitigate air pollution at these locations. Their strategy is based on the use of an annual average threshold concentration of $PM_{2.5}$ (0.2 microgram per cubic meter [$\mu g/m^3$]) within a 150 meter zone of a new project as a means of assessing the potential for concern. The threshold concentration of $PM_{2.5}$ is meant to serve as a health-protective “proxy” or surrogate for pollutant exposures from vehicles i.e., $PM_{2.5}$ is not the only pollutant of concern. Instead, the $PM_{2.5}$ threshold serves as a concentration meant to protect the health of residents from all vehicle-associated emissions from a project.

Emissions from vehicle exhaust, tire wear, and brake wear were estimated using emission factors generated using the most recent version of the EMission FACtor model (EMFAC), developed by the California Air Resources Board (ARB). Vehicle volumes were estimated from the traffic report, prepared by the CHS Consulting Group.

The concentration of $PM_{2.5}$ from vehicular emissions was characterized by developing exposure point concentrations at residential receptors surrounding the thoroughfares and roadways evaluated: Third Street; Innes Avenue/Hunters Point Boulevard /Evans Avenue; Palou Avenue; Gilman Avenue/Paul Avenue; and Harney Way. Those thoroughfares were identified in the traffic report as primary or secondary roads which connect the proposed Project site and major arterials to U.S. 101. In addition, Evans Avenue/Hunters Point Boulevard /Evans Avenue, and Harney Way were selected since they were identified as streets with significant truck traffic and thus are expected to yield more $PM_{2.5}$ compared to other roads. Furthermore, Palou Avenue, Gilman Avenue/Paul Avenue were selected since there are residences in the vicinity of these roads where individuals may incur exposure to $PM_{2.5.}$

Annual average airborne concentrations of $PM_{2.5}$ attributable to Project-related traffic emissions were estimated by applying a Gaussian air dispersion model, approved by the USEPA and ARB for use in the environmental documentation of transportation projects. Both free flowing traffic and queuing at intersections were evaluated.

The potential health impacts from Project-associated $PM_{2.5}$ were evaluated by comparing predicted concentrations of $PM_{2.5}$ to the SFDPH $PM_{2.5}$ threshold of 0.2 μg/m^3. The evaluation of potential health impacts from $PM_{2.5}$ is not required under current CEQA guidelines, but was conducted to comply with SFDPH guidance.

5.2 Findings

Modeled concentrations of $PM_{2.5}$ attributable to Project traffic do not exceed the SFDPH threshold concentration of 0.2 μg/m^3. The maximum $PM_{2.5}$ concentration in residential areas is 0.2 μg/m^3, indicating that by comparison to the SFDPH threshold, residents in the areas impacted by Project traffic are not expected to experience adverse health effects.

This evaluation utilized a number of conservative assumptions in modeling $PM_{2.5}$ concentrations which provide support for the determination that adverse effects of exposure to $PM_{2.5}$ are not likely.

A screening-level analysis was conducted to evaluate the potential impacts of changes to the Project Description on the HHRA conclusions. As described in Attachment VI: Technical Memorandum, Updated Project Description, $PM_{2.5}$ concentrations in the area surrounding Gilman, Ingerson, Jamestown, and Third Street are not expected to exceed 0.2 micrograms per cubic meter (μg/m^3), the SFDPH threshold (SFDPH 2008). The maximum estimated concentration is 0.15 μg/m^3, which occurs on the northern side of Gilman, near its easternmost end. As the impact from traffic PM2.5 remains below the SFDPH threshold, the impact from these emissions remains less than significant.

6 References

Bay Area Air Quality Management District (BAAQMD). 1999. *BAAQMD CEQA Guidelines: Assessing the Air Quality Impacts of Projects and Plans*. December.

San Francisco Department of Public Health (SFDPH). 2008. *Assessment and Mitigation of Air Pollutant Health Effects from Intra-urban Roadways: Guidance for Land Use Planning and Environmental Review.* May 6.

Attachment I:
Human Health Risk Assessment of Construction-Related Diesel Particulate Matter

Candlestick Point – Hunters Point Shipyard Phase II Development Plan San Francisco, California

Contents

List of Tables

List of Figures

List of Acronyms

AERMOD	American Meteorological Society/Environmental Protection Agency Regulatory Model
ARB	Air Resources Board
BAAQMD	Bay Area Air Quality Management District
Cal/EPA	California Environmental Protection Agency
Cal/OSHA	California Occupational Safety and Health Administration
CEQA	California Environmental Quality Act
CP	Candlestick Point
CPF	Cancer Potency Factor
DPM	Diesel Particulate Matter
EIR	Environmental Impact Report
EMFAC	EMission FACtor model
HHRA	Human Health Risk Assessment
HI	Hazard Index
HPS	Hunters Point Shipyard
HRSA	Health Risk Screening Analysis
HQ	Hazard Quotient
IARC	International Agency for Research on Cancer
ISC	Industrial Source Complex
ISCST3	Industrial Source Complex Short Term Model
LST	Localized Significance Thresholds
MEI	Maximally Exposed Individual
MEIR	Maximally Exposed Individual Resident
MEIW	Maximally Exposed Individual Worker
MHDT	Medium-Heavy-Duty-Trucks
NED	National Elevation Dataset
NFL	National Football League
NRC	National Research Council
NSR	New Source Review
OEHHA	Office of Environmental Health Hazard Assessment
PBS&J	Post, Buckley, Schuh & Jernigan, Inc.
PM_{10}	Particulate Matter Less than 10 Microns in Aerodynamic Diameter
RAAC	Risk Assessment Advisory Committee
R&D	Research and Development
REL	Reference Exposure Level
RH	Relative Humidity
SCAQMD	South Coast Air Quality Management District
SFPD	San Francisco Police Department
SRA	State Recreation Area
TAC	Toxic Air Contaminants
URBEMIS	URBan EMISsions Model
USEPA	United States Environmental Protection Agency

USGS	United States Geological Survey
WHO	World Health Organization

List of Units

°F	degrees Fahrenheit
g	gram
gsf	gross square footage
kg	kilogram
L	liters
m^3	cubic meter
mph	miles per hour
mg	milligram
μg	microgram
μm	micrometer or micron
s	second

1 Introduction

At the request of Post, Buckley, Schuh & Jernigan, Inc. (PBS&J), ENVIRON International Corporation (ENVIRON) performed a human health risk assessment (HHRA) to evaluate the potential health effects associated with diesel particulate matter (DPM) emissions from construction activities associated with the proposed Candlestick Point – Hunters Point Shipyard Phase II Development Plan ("Project"). This HHRA has been conducted as part of an Environmental Impact Report (EIR) for the Project which is being prepared by PBS&J on behalf of the San Francisco Redevelopment Agency and the San Francisco Planning Department. This HHRA estimates excess lifetime cancer risks and chronic noncancer hazard indices (HIs) and compares them to the Bay Area Air Quality Management District ("BAAQMD" or "District") California Environmental Quality Act (CEQA) thresholds of significance.

1.1 Objective and Methodology

The purpose of this HHRA is to evaluate potential human health effects due to exposure to DPM from heavy equipment exhaust that may be emitted during Project-related construction activities including abatement, demolition, grading, excavation, and foundation and structure construction. Specifically, construction sources of DPM evaluated in this HHRA include off-road construction equipment such as lifts, loaders, excavators, dozers, and graders.

Potential exposures to DPM from on-road diesel trucks that transport construction materials and debris from the Project to the nearest freeways have also been evaluated in this HHRA. On-road sources of DPM evaluated in this HHRA include on-road equipment such as haul trucks, and on-road support vehicles (e.g., pick-ups). In addition, potential exposures to DPM resulting from workers commuting to the Project site during construction activities have also been evaluated.

The methodology used in this HHRA is consistent with the following California Environmental Protection Agency (Cal/EPA), BAAQMD and United States Environmental Protection Agency (USEPA) risk assessment guidance:

- Air Toxics Hot Spots Program Risk Assessment Guidelines: Part IV Technical Support Document for Exposure Assessment and Stochastic Analysis (Cal/EPA 2000),
- Air Toxics Hot Spots Program Risk Assessment Guidelines (Cal/EPA 2003),
- BAAQMD CEQA Guidelines: Assessing the Air Quality Impacts of Projects and Plans (BAAQMD 1999),
- BAAQMD Air Toxics Risk Evaluation Procedure and Risk Management Policy (BAAQMD 2000),
- BAAQMD Bay Area Air Quality Management District Staff Report (BAAQMD 2005a),
- BAAQMD Air Toxics New Source Review (NSR) Program Health Risk Screening Analysis (HRSA) Guidelines (BAAQMD 2005b),

- USEPA *Risk Assessment Guidance for Superfund: Volume 1- Human Health Evaluation Manual (Part A)*. Interim Final. (USEPA 1989a), and
- USEPA *Exposure Factors Handbook* (USEPA 1997).

Potential exposures to DPM from proposed Project construction activities were evaluated for offsite receptors in the vicinity of the Project and the expected travel routes of on-road diesel haul trucks. Potential exposures to DPM by potential onsite residents within the Alice Griffith Housing area were also evaluated.

Based on the results of the exposure evaluation and air dispersion modeling, ENVIRON developed quantitative estimates of excess lifetime cancer risks and chronic noncancer HIs associated with potential exposure to DPM that may be emitted during Project construction activities. The estimated risks are then compared to the thresholds for significance identified in the BAAQMD CEQA Guidelines.

1.2 Report Organization

The remainder of this HHRA report is divided into eight sections as follows:

Section 2.0 – Background: presents a description of the Project and regulatory background.

Section 3.0 – Chemical Selection: describes the selection of chemicals to be evaluated in the HHRA.

Section 4.0 – Exposure Assessment: discusses the populations that may be potentially exposed to DPM, exposure pathways, exposure assumptions, methodology used to estimate DPM air concentrations, and calculation of dose.

Section 5.0 – Toxicity Assessment: describes the toxicity values used to quantify excess lifetime cancer risks and noncancer HIs in this HHRA.

Section 6.0 – Risk Characterizations: presents the methods used to estimate excess lifetime cancer risks and chronic noncancer HIs related to DPM emissions from the Project. The risk characterization results are also presented and discussed in this section.

Section 7.0 – Uncertainties: summarizes uncertainties associated with the methodology used in the HHRA.

Section 8.0 – Conclusions: summarizes the results and conclusions of this HHRA.

Section 9.0 – References: includes all references cited in this report.

2 Background

2.1 Projection Description

Details of the Project have been provided in the Project Description included in Chapter II of the EIR prepared by PBS&J. Based on information provided in this source, the Project will consist of the development of two areas collectively referred to as the Candlestick Point-Hunters Point Shipyard Phase II Development Plan (the "Project"). The description of the Project is organized under two major sub-components: Candlestick Point (CP) and Hunters Point Shipyard Phase II (HPS Phase II). The Project comprises an approximately 702-acre area shown on Figure 2-1 and Figure 2-2.

The Project proposed by Lennar Urban includes a mixed-use community with a range of residential, retail, office, research and development, civic and community uses, and parks and recreational open space. In addition, a major component would be a new stadium for the San Francisco 49ers, a National Football League (NFL) team. Necessary infrastructure improvements (including several roadway modifications) are also proposed in support of the Project development plan, as shown on Figure 2-2.

A summary of the Project for the CP and HPS Phase II development are summarized separately below. A more detailed discussion of the Project is included in Chapter II of the EIR.

Candlestick Point: This area is approximately 281 acres in size. Current land use in the CP area includes Candlestick Park stadium, and associated parking lots and access roadways. The area also includes several vacant privately owned parcels that are used primarily for stadium parking. Acquisition of these parcels is anticipated as part of the Project. The CP area also includes the Alice Griffith Housing area (Figure 2-2). Approximately 120 acres of the 154-acre Candlestick Point State Recreation Area (SRA) is also included within the Project and forms the south and east shoreline boundary.

The proposed Project for CP includes site preparation activities, including abatement, demolition of existing structures, and grading, and construction of residential units, parks and open space, retail space, community services, office space, hotel accommodations, and a performance arena. The development plan also includes a rebuild of Alice Griffith Housing which will provide upgraded units to existing residents.

Hunters Point Shipyard Phase II: The HPS Phase II area comprises 421 acres (dry-land) on the former Navy Parcels B, C, D and E. Navy Parcel F comprises approximately 440 acres of submerged lands in San Francisco Bay surrounding the central portion of the HPS Phase II area to the north, east and south. The entire HPS Phase II area is currently under the jurisdiction of the Navy. The HPS Phase II area includes many structures associated with ship repair, piers, dry-docks, storage, administrative, and other former Navy uses, largely from the World War II era. Most structures are vacant, although several former Navy buildings are currently leased and occupied. Current tenants at the HPS Phase II area include an estimated

252 artists located in studios on Parcels A and B, and a San Francisco Police Department (SFPD) facility on Parcel D-1 in Building 606. The proposed Project plan for this area includes new residential units, parks and open space, research and development (R&D), community services, artist studios and centers, neighborhood retail, and a new stadium for the San Francisco 49ers, a NFL team. The stadium parking plan will accommodate parking for stadium events and will serve public recreational uses.

The EIR also examines variants to the Project:

- Variant 1 would include an additional 2.5 million gross square footage (gsf) of research and development space on the proposed stadium site. All other elements of the Project would remain the same.
- Variant 2 would redistribute 1,350 residential units to the proposed stadium site from Candlestick Point. All other elements of the Project would remain the same.
- A third variant (Variant 3) would include the same land use program and overall description as the Project, with different locations for the residential towers.
- Variant 4 assumes that a new stadium would be constructed and shared between the San Francisco 49ers and the Oakland Raiders football teams. The land use program would remain the same as the proposed Project.

Chapter IV of the EIR analyzes these Variants. Evaluation of the Variants in the EIR allows for consideration and approval of these variants without further environmental review.

However, a single variant (Variant 4) was selected for evaluation in the assessment of potential exposures to DPM resulting from Project-related construction activities. Construction of the new stadium (Variant 4) is projected to take longer and involve more construction equipment than the other Variants, resulting in the greatest potential for DPM exposures relative to the other Variants. Consequently, it may be assumed that if DPM exposures and associated risk estimates for Variant 4 are below BAAQMD significance levels then the risks associated with Variants 1 through 3 would also be lower than the CEQA significance thresholds.

The Project construction activities are anticipated to occur over a 19 year period, beginning in 2010 and concluding in 2028. However, the schedules vary by area as follows: CP (18 years, 2011-2028) and HPS Phase II (nine years, 2010-2018).

2.2 Surrounding Area

The Project comprises an approximately 702-acre area east of U.S. 101 in the southeast area of the City and County of San Francisco and occupies the waterfront area from south of India Basin to Candlestick Cove (Figure 2-1 and Figure 2-2).

The CP area is immediately east of Executive Park, with the Bayview neighborhood to the north, the HPS Phase II to the northeast, and Candlestick Point SRA along the Bay frontage generally to the east (Figure 2-1). The CP area is generally bounded by Hawes Street to the northwest and Jamestown Avenue to the southwest, the Candlestick Cove and South Basin areas of the Bay are to the south and east, respectively.

The HPS Phase II area is to the southeast of the Bayview Hunters Point neighborhood. As shown in Figure 2-1, the HPS Phase II area is generally bounded by San Francisco Bay to the north, east, and south. The south end of the western boundary extends from Yosemite Slough along Arelious Walker Drive to approximately Crisp Road, excluding the University of California San Francisco (UCSF) property. The northern boundary generally extends along Crisp Road and Spear Avenue. The northernmost end of the HPS Phase II area is contiguous with Earl Street.

Figure 2-3 shows the zoning information, obtained from the City of San Francisco, for areas in the immediate vicinity of the Project. To the west of the Project, the city areas are zoned mixed-use residential and industrial. The area to the south is zoned for commercial or industrial use. The Project Area is bordered by the San Francisco Bay to the north and east.

2.3 Regulatory Background

This HHRA is prepared in compliance with CEQA. In accordance with CEQA, the excess lifetime cancer risks and chronic noncancer HIs estimated in this HHRA are compared to the BAAQMD CEQA thresholds of significance. Pursuant to BAAQMD *CEQA Guidelines* (BAAQMD 1999), projects that expose the public to toxic air contaminants (TACs) in excess of the following thresholds would be considered to have a significant air quality impact:

- Probability of contracting cancer for the maximally exposed individual (MEI) exceeds 1×10^{-5} (10 in a million);
- Ground level concentrations of non-carcinogenic TACs resulting in a Hazard Index greater than 1 for the MEI.

3 Chemical Selection

Diesel exhaust, as DPM, is the only chemical identified for inclusion in this HHRA. DPM emissions from heavy equipment exhaust during construction activities (such as abatement and demolition, grading and infrastructure development, foundation/structure construction, interior/exterior finishing and offsite roadway improvements), are the focus of this HHRA. This includes exhaust from both onsite construction equipment and on-road diesel trucks that serve the construction site (bringing materials to the site and removing debris and soils), as well as workers' personal vehicles.

DPM is generated when an engine burns diesel fuel and consists of a mixture of gases and fine particles (also known as soot) that can penetrate deeply into the lungs, where they can contribute to a range of health problems. In 1998, Cal/EPA listed DPM as a TAC based on its potential to cause cancer and other adverse health effects (Cal/EPA 1998).

Diesel exhaust is a complex mixture that includes hundreds of individual constituents (Air Resources Board [ARB] 1998). Diesel exhaust, as a mixture, is identified by the State of California as a known carcinogen (Cal/EPA 1998, 2009a). However, under California regulatory guidelines (Cal/EPA 1998, 2009a), DPM is used as a surrogate measure of exposure for the mixture of chemicals that make up diesel exhaust as a whole. Cal/EPA and other proponents of using the surrogate approach to quantifying cancer risks associated with the diesel mixture indicate that this method is preferable to use of a component-based approach. A component-based approach involves estimating risks for each of the individual components of a mixture. Critics of the component-based approach believe it will underestimate the risks associated with diesel as a whole mixture because the identity of all chemicals in the mixture may not be known and/or exposure and health effects information for all chemicals identified within the mixture may not be available. Further, Cal/EPA (2003) has concluded that "potential cancer risk from inhalation exposure to whole diesel exhaust will outweigh the multipathway cancer risk from the speciated components."

4 Exposure Assessment

The USEPA (1989a) defines exposure as “contact of an organism with a chemical or physical agent” and defines the magnitude of exposure as “the amount of the agent available at the exchange boundaries of the organism (e.g., skin, lungs, gut) and available for absorption.” Exposure assessments are designed to determine the degree of contact a person has with a chemical. The components of the exposure assessment include the identification of potentially exposed populations, the identification of exposure pathways, estimation of DPM exposure concentrations, and the selection of exposure assumptions to quantify chemical intakes.

4.1 Potentially Exposed Populations

To evaluate the potential human health risks posed by a site or project, it is necessary to identify the populations that may be exposed to the chemicals present and to determine the pathways by which exposures may occur. Identification of potentially exposed populations requires evaluating the human activity and land-use patterns at and in the vicinity of the Project. The populations considered in this HHRA are offsite receptors in areas surrounding the Project and onsite receptors within the Alice Griffith Housing area.

Land use in the area surrounding the Project is generally zoned for residential, commercial, industrial or a variety of mixed-uses. Consequently, offsite residents (child and adult residents) and offsite workers were identified for evaluation in this HHRA. Offsite receptor locations evaluated in the HHRA are shown in Figure 4-1a. Consistent with current BAAQMD CEQA guidelines (1999), risks and HIs are also reported for the location of the maximally exposed individual resident (MEIR) and the maximally exposed individual worker (MEIW). The MEIR and MEIW are defined as the receptor locations where individuals may reside or work with the maximum estimated excess lifetime cancer risk or chronic noncancer HI (Cal/EPA 2003).

Potential offsite sensitive populations were also identified for evaluation in this HHRA based on guidance from the District (BAAQMD 2005a) and Cal/EPA (2003). Offsite sensitive receptors identified for the HHRA included K-12 schools within one kilometer of the Project. The offsite sensitive receptor locations identified for the Project are also shown on Figure 4-1a.

As discussed in Section 1, this HHRA evaluates human health impacts to offsite receptors associated with DPM emissions from Project construction activities in each of the CP and HPS Phase II areas. In addition, the total Project emissions are evaluated that include the aggregate emissions associated with the development of these two areas. Therefore, risks are estimated for offsite receptors, including the MEIR and MEIW and sensitive receptor locations, for each of the three Project components: (1) CP, (2) HPS Phase II, and (3) the total Project.

Onsite residents within the Alice Griffith Housing area were also identified for evaluation in this HHRA (Figure 4-1b). Thus, risks are estimated for onsite receptors at the Alice Griffith Housing area assuming potential exposure to DPM related to the construction of the total Project (both CP and HPS Phase II). In addition, onsite receptors at the Alice Griffith Housing area are assumed to reside at the housing area during rebuild of Alice Griffith. As stated in the Chapter II of the EIR, the proposed Project includes rebuilding Alice Griffith Housing to provide one-for-one replacement units ensuring that eligible Alice Griffith Housing residents have the opportunity to move to the new, upgraded units directly from their existing Alice Griffith Housing units without having to relocate to any other area. Based on the proposed plan outlined in the EIR, it is anticipated that construction activities within the Alice Griffith Housing area will be phased by parcel (CP01 through CP06 as shown on Figure 2-2). While construction occurs at one parcel, residents will continue to reside at the remaining parcels. These residents have been identified as onsite receptors for the Project and are shown on Figure 4-1b. For this evaluation, as a conservative screening, residential receptors in parcels CP01, CP02 and CP04 were evaluated as those parcels are central to the Alice Griffith Housing area and will be surrounded by construction activity at various points during the Project. Additionally, these are the Alice Griffith Housing parcels which are located most downwind from construction activity in Alice Griffith (as shown by the wind rose in Figure 4-2). Parcels CP03, CP05 and CP06 will not have construction activity associated with the Project to their west; however, emissions from construction activities on these parcels will impact parcels CP01, CP02 and CP04.

Onsite workers are not evaluated, as it is ENVIRON's understanding that onsite workers are protected by the California Occupational Safety and Health Administration (Cal/OSHA) in accordance with State health and safety requirements (8 CCR § 5194).

4.2 Exposure Pathways

Once potentially exposed populations are identified, the complete exposure pathways by which individuals in each of these populations may be exposed to DPM from the Project are determined. An exposure pathway is defined as "the course a chemical or physical agent takes from a source to an exposed organism (USEPA 1989a)." A complete exposure pathway requires the following four key elements:

- Chemical source,
- Migration route (i.e., environmental transport),
- An exposure point for contact (e.g., air), and
- Human exposure route (e.g., inhalation).

An exposure pathway is not complete unless all four elements are present.

Only the inhalation exposure pathway was considered in the evaluation of DPM. Selection of additional pathways for a multipathway analysis is specific to the chemical and land use designations in the area potentially impacted by the Project. Cal/EPA (2003) has identified chemicals that must be evaluated in a multipathway analysis and DPM is not listed by Cal/EPA as a multipathway chemical. Thus, for this HHRA, ENVIRON only conducted an evaluation of inhalation exposures.

4.3 Exposure Assumptions

The exposure parameters listed below and used for estimating excess lifetime cancer risks for offsite resident, onsite resident, offsite worker, and offsite sensitive receptor populations were obtained using site-specific information and risk assessment guidelines from BAAQMD, Cal/EPA, and USEPA, with the exception of project-specific exposure durations. Project construction is anticipated to occur over a 19 year period beginning in 2010 and ending in 2028, with activities in the CP and HPS Phase II areas spanning various periods during this interval. As such, the exposure duration assumed for each receptor was limited by the planned construction periods for each area and the Project as a whole as follows:

- CP – Planned construction from 2011 – 2028 (18 years)
- HPS Phase II – Planned construction from 2010 – 2018 (9 years)
- Total Project – Planned construction from 2010 – 2028 (19 years)

The population-specific exposure parameters are discussed below and are summarized in Table 4-1. The Project-specific exposure durations are also summarized in Table 4-2.

4.3.1 Offsite and Onsite Residents

For this HHRA, as a conservative (i.e., health-protective) approach, ENVIRON assumed that residents are present at their residence for 24 hours per day, 350 days per year (USEPA 1989a, 1991; Cal/EPA 2003). However, adults spend only 68 to 73% of their total daily time at home (USEPA 1997), rather than the 100% assumed in this HHRA. Accordingly, the actual risks to residents in the vicinity of the Project are likely to be significantly lower than those estimated in this HHRA.

The Office of Environmental Health Hazard Assessment (OEHHA) risk assessment guidelines provides guidance for estimating risks based on "average" and "high-end" exposure conditions (Cal/EPA 2003). Consistent with this guidance, the HHRA includes an evaluation of average and high-end exposure conditions. Average exposure conditions represent an exposure scenario based on 50^{th} percentile or average exposure parameters. According to OEHHA, a high-end value should be chosen so that the potential incremental cancer risk will not be underestimated.

For adult residents, the high-end and average inhalation rates are 19 cubic meters per day (m^3/day) [302 L/kg-day] (BAAQMD 2005b, Cal/EPA 2003) and 17 m^3/day [271 L/kg/day] (Cal/EPA 2003), respectively.[1] The high-end estimate is representative of the 80th percentile

---

[1] For the purposes of this analysis, each breathing rate is presented in units of cubic meters per day (m^3/day) and liters per kilogram day (L/kg-day). The breathing rates are mathematically equivalent but are presented in both units to reflect differences in the units presented in the reference guidance. The daily breathing rate was calculated by multiplying the default breathing rate by the default body weight and a conversion factor of 1000 L/m^3, as shown in Table 4-1.

breathing rate of recommended by BAAQMD (2005b) and Cal/EPA (2003) for risk management decisions. The default body weight for an adult resident is 63 kg (Cal/EPA 2003).

For child residents, the high-end and average inhalation rates are 10 m^3/day [581 L/kg-day] (BAAQMD 2005b, Cal/EPA 2003) and 8 m^3/day [452 L/kg/day] (Cal/EPA 2003), respectively.[2] The default body weight for a child resident is 18 kg (Cal/EPA 2003). Child residents are assumed to be exposed for a duration of nine years, as recommended by BAAQMD (2005b) and Cal/EPA (2003). To be conservative (i.e., health-protective), a nine year rolling average DPM concentration was used to estimate potential risks for a child. The nine year rolling average reflects the highest concentrations that may occur within the 19 year Project period. Emissions for each year of construction activity were estimated and modeled to determine annual air concentrations. These annual air concentrations were used to determine the maximum 9-year rolling average over the construction period. These rolling averages were calculated for each of the three Project components: (1) CP, (2) HPS Phase II, and (3) the total Project.

The default inhalation absorption factor of one was used for both adult and child offsite residents (Cal/EPA 2003).

4.3.2 Offsite Workers

Offsite workers are assumed to be exposed to DPM emissions eight hours per day for 245 days per year (BAAQMD 2005b, Cal/EPA 2003). The breathing rate for a worker is 1.3 cubic meters per hour (m^3/hour) over an eight hour work-day, which corresponds to a daily breathing rate of 10 m^3/day [149 L/kg-day]. The default body weight for the offsite worker is 70 kg (Cal/EPA 2003).

The default inhalation absorption factor of one was used for the offsite worker (Cal/EPA 2003).

4.3.3 Offsite Sensitive Receptors

As discussed in Section 4.1, potential offsite sensitive populations were identified for evaluation in this HHRA based on guidance from the District (BAAQMD 2005a) and Cal/EPA (2003). As discussed in Section 4.1, offsite sensitive receptors identified for the HHRA include K-12 schools within a one kilometer radius surrounding the Project. For this reason, a school child was identified as the sensitive receptor for evaluation in this HHRA.

As recommended by the BAAQMD, the exposure time for a school child is assumed to be 10 hours per day and is representative of a school day (BAAQMD 2005b). The exposure frequency and duration were assumed to be 180 days per year for nine years (BAAQMD 2005b). The high-end breathing rate of 10 m^3/day [581 L/kg-day] recommended for a child

[2] *Ibid.*

population was used (BAAQMD 2005b, Cal/EPA 2003).[3] The default body weight for a school child is 18 kg (Cal/EPA 2003).

The default inhalation absorption factor of one was used for the offsite sensitive receptors (Cal/EPA 2003).

4.4 Emissions Estimation

This section describes the estimation of DPM emissions associated with construction activities at the Project, including the estimation of emission factors and assumptions for truck counts and equipment inventory. These emissions estimates are used to develop exposure point air concentrations of DPM using air dispersion modeling techniques.

An inventory of diesel-fueled equipment used for the construction of the Project (e.g., drills, haul trucks, loaders), including their location of use, years of operation and schedule during those years was provided by MACTEC on behalf of Lennar Urban. Additionally, MACTEC indicated that construction equipment used for the Project will utilize emission control technology in advance of a regulatory requirement such that 50% of the fleet will meet USEPA Tier 4 engine standards for construction activities during 2010 and 2011, increasing to 75% of the fleet in 2012 and 100% of the fleet starting in 2013 and for the duration of the Project.[4] As discussed below, the accelerated emission control measure was incorporated into this analysis. Additionally, in order to minimize the potential impacts to residents living in Alice Griffith from the construction activities in that area, it was assumed that construction activities in the Alice Griffith parcels (CP01 though CP06) would always utilize Tier 4 equivalent equipment.[5]

4.4.1 Offroad Equipment

For each type of off-road equipment, the engine size and average load factor was based on defaults utilized in the URBan EMISsions Model (URBEMIS 2007) version 9.2.4.[6] ENVIRON used OFFROAD2007[7] (ARB 2006b) modified with the ARB's In-Use Off-Road Diesel Vehicle Rule[8], to estimate emissions from this equipment for each year of the Project. For each year,

---

[3] *Ibid.*
[4] E-mail from D. Nanstad, MACTEC, to M. Keinath, ENVIRON, on August 24, 2009.
[5] When construction activities begin in the Alice Griffith parcels in 2011, 50% of the equipment used sitewide will have Tier 4 equivalent engines. However,100% of the equipment used in the Alice Griffith parcels (CP01 – CP06) will have Tier 4 equivalent engines such that the Tier 4 engines will preferentially be slated for use in Alice Griffith over other areas of the Project which are located further away from existing residential receptors.
[6] URBEMIS is a computer program which integrates ARB emissions models EMFAC2007 and OFFROAD2007 that can be used to estimate emissions associated with land development projects in California such as residential neighborhoods, shopping centers, and office buildings; area sources such as gas appliances, wood stoves, fireplaces, and landscape maintenance equipment; and construction projects (http://www.arb.ca.gov/planning/urbemis/urbemis2007/urbemis2007.htm).
[7] OFFROAD2007 is an emissions model distributed by ARB to calculate emission rates from major categories of engines and vehicles used in the agricultural, construction, lawn and garden and off-road recreation areas in California (http://www.arb.ca.gov/msei/offroad/offroad.htm)
[8] ARB's In-Use Off-Road Diesel Vehicle Rule was approved on July 26, 2007 and will come into effect in 2010. The

the emission factor developed from OFFROAD2007 for each piece of equipment was compared with the limitation set forth in the In-Use Off-Road Diesel Vehicle Rule and the lower value was used. As OFFROAD2007 assumes fleet attrition will result in replacement by new, lower emission equipment, often the emission rate reported in OFFROAD2007 is lower than that required by the ARB In-Use Regulation, which is intended to be a fleet wide average. In all cases, the lower OFFROAD2007 or In-Use Regulation emissions rate was used for this analysis as this was expected to represent the most likely scenario for equipment emissions over the Project duration.

Additionally, as discussed above, the Project will implement an accelerated emission control measure making sure that 50% of the equipment used will be Tier 4 or equivalent in 2010 and 2011, 75% of the fleet in 2012 and 100% of the fleet starting in 2013 for the duration of the Project. To implement these accelerated control measures, a composite emission factor was developed for each category of equipment by apportioning emission rates from the Tier 4 equivalent or the OFFROAD2007/ARB Regulation (discussed earlier) by the percentage of use. For example, in 2010 the composite emission rate for each category of equipment was calculate based on 50% Tier 4 equivalent engines and 50% OFFROAD2007/ARB Regulation compliant engines.

4.4.2 Onroad vehicles

DPM emissions from haul trucks, worker commute and Project management vehicles (e.g., pick-up trucks) were calculated using the estimated vehicle trips based on URBEMIS. The emission factors for particulate matter less than 10 micrometers (μm) in aerodynamic diameter (PM_{10}) were generated with the current version of the EMission FACtor model (ARB 2006) developed by ARB [9] and modified to account for the On-Road Heavy-Duty Diesel Vehicles (In-Use) Regulation that was approved by ARB on December 11, 2008. Emissions reductions resulting from the On-Road Heavy-Duty Diesel Vehicles (In-Use) Regulation approved by the ARB on December 11, 2008 were estimated from ARB's Private Fleet Database,[10] which lists statewide emissions with and without the approved truck rule.

For this analysis, annual average particulate matter less than 10 microns (PM_{10}) emission factors (in gram/vehicle-mile) for medium-heavy-duty trucks (MHDT) were generated by running EMFAC 2007 in "Emfac Mode" for San Francisco County, California. Emfac Mode, also called "Area Fleet Average Emissions", generates emission factors in terms of grams of pollutant emitted per vehicle activity and can calculate a matrix of emission factors at specific values of temperature, relative humidity, and vehicle speed. The model was run for vehicle speeds between 0 miles per hour (mph), for idling, and 35 mph, the posted speed limit on Harney Road.

---

rule sets increasingly stringent fleet-average emission rates year-by-year through 2021.

[9] The EMission FACtors (EMFAC) model is distributed by ARB to calculate emission rates from all motor vehicles, (such as passenger cars and heavy-duty trucks) operating on highways, freeways and local roads in California (http://www.arb.ca.gov/msei/onroad/latest_version.htm)

[10] http://www.arb.ca.gov/regact/2008/truckbus08/emissinv.xls

In addition, the model was run using a temperature of 58 degrees Fahrenheit (^{o}F) and a relative humidity (RH) of 76% (the average of the last calendar quarter of 2002 and first three calendar quarters of 2003 at Hunters Point Shipyard[11]). EMFAC 2007 was run for each year of the Project, between 2010 and 2028, inclusive.

4.5 Estimated DPM Air Concentrations

This section describes the estimation of DPM air concentrations at receptor locations potentially exposed to diesel emissions from construction of the Project. Section 4.5.2 details the air dispersion modeling, including model selection, source configuration, use of site-specific meteorological data and identification of receptor locations. The modeled concentrations were then used to estimate potential exposures and health risks, as described in Section 6.

ENVIRON conducted air dispersion modeling to estimate the DPM concentrations associated with construction emissions from the Project as characterized in Section 4.4. The air dispersion analysis was performed in accordance with USEPA, ARB and BAAQMD modeling guidelines (USEPA 2005a, Cal/EPA 2003, BAAQMD 2005b). The air dispersion analysis requires the following: 1) selection of the dispersion model, 2) selection of appropriate dispersion coefficients based on land use, 3) preparation of meteorological data, 4) evaluation of potential terrain considerations, 5) selection of receptor locations, and 6) identification of the source specific release parameters, operational schedule, and averaging time periods. The following sections describe each of these steps.

4.5.1 Air Dispersion Model Selection

ENVIRON used the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) version 07026, the USEPA recommended air dispersion model (USEPA 2004). AERMOD was developed as a replacement for USEPA's Industrial Source Complex Short Term (ISCST3) air dispersion model to improve the accuracy of air dispersion model results for routine regulatory applications and to incorporate the progress of scientific knowledge in atmospheric turbulence and dispersion. This change was made in November 2005 (USEPA 2005a).

Air modeling dispersion factors (i.e., concentration per unit emission rate), sometimes called "chi-over-Q" ("χ/Q"), were estimated for the simulated dispersion sources (i.e., construction equipment, emergency generators, and delivery truck/vehicles) using AERMOD in conjunction with information about the locations of the sources and receptors, as well as assumptions about the nearby land use.

The following equation was used to estimate annual average concentration from the modeled dispersion factor:

[11] Onsite meteorological data for Hunters Point Shipyard was obtained from BAAQMD.

$$\text{Annual Average Concentration} = \left(Q_{annual} \times \left(\frac{\chi}{Q} \right)_{annual} \right)_i$$

Where:

Q = emission rate of DPM (grams [g]/second [s])

$\left(\frac{\chi}{Q}\right)$ = dispersion factor ($\mu g/m^3$)/(g/s)

i = stack source

The results of the air dispersion analysis were used in conjunction with the chemical-specific emissions rates discussed in Section 4.4.

4.5.2 Urban Heat Island Effect

As determined in the land use analysis discussed in Attachment V, the sources are not located in an urban area and therefore the urban boundary layer option was not selected in AERMOD.

4.5.3 Meteorological Data

As discussed in Attachment V, ENVIRON used meteorological data collected from a meteorological station installed at the Hunter's Point Shipyard for a period from October 1, 2002 through September 30, 2003. This location was determined to be the most representative meteorological data available for air dispersion modeling for the Project, as it was onsite. Meteorological data for use in AERMOD were processed in accordance with the AERMOD Implementation Guidance released in January 2008. A description of meteorological data processing and processed meteorological data ready for use in AERMOD can be found in Attachment V. Construction equipment is assumed to operate eight hours per day (from 7 am to 3 pm) and the wind rose for this period is shown in Figure 4-2.

4.5.4 Terrain

An 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). Complex terrain can affect the results of a dispersion analysis involving point and volume sources, but does not affect the predicted results for area sources (USEPA 2005b). Terrain elevations were obtained from United States Geological Survey (USGS) National Elevation Dataset (NED) for the San Francisco area and imported to sources and receptors using AERMAP, a data preprocessing module associated with AERMOD.

4.5.5 Source Configuration

For the HPS and CP projects, MACTEC, on behalf of Lennar Urban, provided a detailed map of construction parcels ranging in size from 2 acres to 75 acres.

Since the BAAQMD has not developed specific methodologies for modeling construction emissions, construction activity was modeled using the Localized Significance Thresholds (LST) methodology developed by the South Coast Air Quality Management District (SCAQMD). The general construction areas were represented by a series of adjacent volume sources. For parcels less than five acres, each source was 10 meters by 10 meters, with a release height of five meters. For parcels larger than or equal to five acres, each source was 20 meters by 20 meters, also with a release height of five meters. ENVIRON conducted the modeling analysis on a year-by-year basis to account for the relocation of construction activities as the Project progresses.

The location of proposed construction presented with adjacent volume sources is shown in Figure 4-3. The construction source parameters used in the air dispersion model are summarized in Table 4-3. Emissions associated with haul trucks transporting construction materials and worker commute vehicles were modeled as line sources represented by separated volume sources with a spacing of twice of the road width as shown in Figure 4-4. The width of these volume sources was set to be equal to the maximum width of the road segment. This approach is consistent with the line source set up recommended by Industrial Source Complex (ISC) User's Guide (USEPA 1995). The offsite traffic source parameters used in the air dispersion model are summarized in Table 4-3.

4.5.6 Receptors

A grid receptor spacing of 50 meters was used up to approximately one kilometer from the Project boundaries to evaluate offsite receptors, both worker and resident (as shown in Figure 4-1a). Figure 4-1a also shows the offsite sensitive receptors (e.g., K-12 schools) which were evaluated at their location. Onsite resident receptors in the Alice Griffith Housing area were evaluated using a 20 meter grid spacing (as shown in Figure 4-1b).

4.5.7 Adjustment Factors

Cal/EPA recommends that "annual average concentrations for the worker inhalation pathway will need to be adjusted" so that the "average concentration that a worker breathes over his or her working day may be used" for the exposure analysis (Cal/EPA 2003). Since the DPM air concentrations were modeled assuming a continuous averaging time (i.e., 24 hours, 7 days per week), an adjustment factor, recommended by Cal/EPA, was applied to estimate an exposure point concentration that reflects the exposures that occur for less than 24 hours and are concurrent with construction activities occurring at the Project. The modeling adjustment factors for offsite residents, offsite workers, and offsite sensitive receptors are discussed below.

4.5.7.1 Offsite Residents

Offsite residents are assumed to be present at their residence 24 hours per day, seven days per week. This assumption is consistent with the modeled annual average air concentration (24-hours, seven days per week). Thus, the annual average concentration need not be adjusted.

4.5.7.2 Offsite Worker

As recommended by *Air Toxics Hot Spots Risk Assessment Guidelines* (Cal/EPA 2003), an adjustment factor of 4.2 was applied to the annual average concentration prediction (based on 24 hours per day) for offsite workers to account for a construction schedule of approximately eight hours per day and five days per week ([24/8] * [7/5] = 4.2). This concentration represents the theoretical maximum 8-hour concentration over the five day operating period to which the offsite workers might be exposed.

4.5.7.3 Offsite Sensitive Receptors

An adjustment factor of 3.36 was applied to the annual average concentration (24 hours concentration) predicted for the school child to account for a construction schedule of approximately 10 hours per day and five days per week ([24/10] * [7/5] = 3.36). This concentration represents the theoretical maximum 10-hour concentration over the five day operating period to which the school child might be exposed.

4.5.8 Exposure Point Concentrations

The exposure point concentrations were calculated using the following equation:

$$Ca = \text{Annual Average Concentration} \times T$$

Where:

Ca = Exposure point concentration in air (μg/m^3)

T = Modeling-adjustment factor (unitless)

The ambient air concentrations estimated for all modeled offsite receptors, including the MEIR (adult and child), MEIW, and sensitive receptors assuming exposure to DPM related to construction activities at CP, HPS – Phase II, and total Project are shown in Table 4-4. DPM concentrations estimated for onsite residents at the Alice Griffith Housing area are shown on Table 4-5.

4.6 Calculation of Dose

For determining exposure to a carcinogenic chemical, the dose estimated for the inhalation pathway is a function of the concentration of a chemical in the air, C_i, and the intake of that chemical. The dose for inhalation, $Dose_{inh}$, can be calculated as follows:

$$Dose_{inh} = \frac{Ca \times IR \times EF \times ED \times F \times A \times CF}{BW \times AT}$$

Where:

$Dose_{inh}$ = Dose of a chemical (milligrams [mg] chemical/kilogram [kg] body weight-day),

Ca = Exposure point concentration of chemical in air (µg/m^3)

IR = Inhalation Rate (m^3/day)

EF = Exposure Frequency (days/year)

ED = Exposure Duration (years)

F = Fraction of day exposed (hours/24 hours)

A = Inhalation Absorption Factor (unitless)

CF = Conversion Factor (mg/µg)

BW = Body Weight (kg)

AT = Averaging Time (days)

The estimated doses for the MEIR (adult and child), MEIW, and sensitive receptors assuming exposure to DPM related to construction activities at CP, HPS – Phase II, and total Project are shown in Table 4-6. Doses estimated for residents at the Alice Griffith Housing area are shown on Table 4-7.

5 Toxicity Assessment

The toxicity assessment characterizes the relationship between the magnitude of exposure and the nature and magnitude of adverse health effects that may result from such exposure. For purposes of calculating exposure criteria to be used in risk assessments, adverse health effects are classified into two broad categories – cancer and noncancer endpoints. Toxicity values used to estimate the likelihood of adverse effects occurring in humans at different exposure levels are identified as part of the toxicity assessment component of a risk assessment.

Consistent with Cal/EPA risk assessment guidance, ENVIRON used the Cal/EPA cancer potency factor (CPF) for DPM to estimate cancer risks associated with exposure to diesel emissions resulting from the Project (Cal/EPA 2009b). As discussed in Section 3, DPM is used as a surrogate measure of exposure for the mixture of chemicals that make up diesel exhaust. The chronic reference exposure level (REL) for DPM, presented in Table 5-1, represents the average daily exposure concentrations at (or below) which no adverse health effects are anticipated (Cal/EPA 2008). The toxicity values for DPM used in this HHRA are summarized in Table 5-1.

6 Risk Characterization

Risk characterization involves the description of the nature and magnitude of human risk, including the associated uncertainty (NRC 1983). The risk characterization integrates the results of the exposure and effects analyses to evaluate the likelihood of adverse effects associated with exposure to estimated DPM emissions for Project activities. An important step of the risk characterization process is the evaluation of uncertainty associated with the risk estimates (USEPA 1989a). Cancer risks and noncancer HIs were estimated for the populations identified in Section 4.1. The exposure parameters (Section 4.3), representative concentrations (Section 4.5), and agency-approved toxicity values (Section 5.0) are used to estimate the cancer risks and noncancer HI for DPM.

The results of this HHRA are presented as estimated excess lifetime cancer risks and noncancer HIs. Cancer risk estimates represent the probability of cancer (presented as a probability per million people) related to potential exposures to DPM emissions quantified in this HHRA. Noncancer HIs are represented as the ratio between the estimated DPM exposure-point concentrations and REL for DPM identified as part of the toxicity assessment. The excess lifetime cancer risks and noncancer HIs estimated in this HHRA are then compared to CEQA thresholds identified by the BAAQMD (1999) to determine if any significant impacts can be associated with Project DPM emissions.

As outlined in Section 1, separate estimates of the excess lifetime cancer risks and noncancer HIs were derived for DPM emissions from the construction and development of CP and HPS Phase II. In addition, human health effects attributed to DPM emissions from total Project impacts are also quantified.

This section presents the methods used to estimate excess lifetime cancer risks and noncancer HIs, the results of this HHRA, and the associated uncertainties.

6.1 Risk Characterization Methodology

6.1.1 Estimation of Cancer Risks

Excess lifetime cancer risks are estimated as the upper-bound incremental probability that an individual will develop cancer over a lifetime as a result of exposure to potential carcinogens. The estimated excess lifetime risk is expressed as a unitless probability. The cancer risk attributed to a chemical is calculated by multiplying the chemical intake or dose by the chemical-specific CPF. The equation used to calculate the potential excess lifetime cancer risk for DPM is as follows:

$$Risk = Dose_{inh} \times CPF$$

Where:

Risk	=	Cancer Risk; the probability of an individual developing cancer as a result of exposure to a particular cumulative dose of a potential carcinogen (unitless)
$Dose_{inh}$	=	Dose of a chemical (mg chemical/kg body weight-day)
CPF	=	Cancer Potency Factor (mg chemical/kg body weight-day)$^{-1}$

6.1.2 Estimation of Chronic Noncancer Hazard Quotients

The potential for exposure to result in chronic noncancer effects is evaluated by comparing the estimated annual average air concentration (which is equivalent to the average daily air concentration) to the noncancer chronic REL for DPM. When calculated for a single chemical, the comparison yields a ratio termed a hazard quotient (HQ). To evaluate the potential for adverse chronic noncancer health effects from simultaneous exposure to multiple chemicals, the hazard quotients (HQs) for all chemicals are summed, yielding a HI. As DPM is the only compound evaluated in this HHRA, the HI is equal to the HQ for DPM and is used as a point of comparison to the BAAQMD CEQA thresholds of significance.

The equations used to calculate the chemical-specific HQs and the overall HI are:

$$HQ_i = C_i / REL_i$$

Where:

HQ_i	=	Hazard Quotient for $Chemical_i$
C_i	=	Average Daily Air Concentration for $Chemical_i$ (µg/m^3)
REL_i	=	Noncancer Reference Exposure Level for $Chemical_i$ (µg/m^3)

6.2 Risk Characterization Results

The estimated cancer risks and noncancer HIs are discussed relative to significance thresholds for TACs identified by the BAAQMD for the MEI (BAAQMD 1999). According to the BAAQMD *CEQA Guidelines* (1999), the significance threshold is a cancer risk greater than 10 in one million (1×10^{-5}) and a noncancer HI of greater than one for the MEI. Planned projects that do not have the potential to expose the public to TACs in excess of these thresholds would not be considered to have a significant air quality impact.

This section compares the estimated excess lifetime cancer risks and noncancer HIs for each population in relation to significance thresholds under CEQA. The cancer risks and noncancer HQs outlined below are also summarized in Tables 6-1 through 6-4.

6.2.1 Offsite Residents

All estimated excess lifetime cancer risks and noncancer HIs for offsite residents associated with construction emissions attributable to the CP, HPS Phase II, and the total Project are well below the current BAAQMD significance thresholds of 10 in a million and one, respectively.

As summarized in Table 6-1, the estimated cancer risks for the offsite MEIR–adult are 1.7 in a million (1.7×10^{-6}), 1.6 in a million (1.6×10^{-6}) and 1.8 in a million (1.8×10^{-6}) assuming high-end exposure assumptions for the CP, HPS Phase II, and total project, respectively. The estimated cancer risks for the offsite MEIR–adult assuming average exposures are slightly lower than those estimated using high-end exposure assumptions.

The estimated excess lifetime cancer risks for the offsite MEIR–child are 2.8 in a million (2.8×10^{-6}), 3.1 in a million (3.1×10^{-6}) and 3.2 in a million (3.2×10^{-6}) assuming high-end exposure assumptions for the CP, HPS Phase II, and total project, respectively. The estimated cancer risks for the MEIR–child resident assuming average exposures are slightly lower than those estimated using high-end exposure assumptions.

As shown on Table 6-2, the estimated noncancer HIs for all offsite residents are 0.008 or below.

6.2.2 Onsite Residents at the Alice Griffith Housing Area

All estimated excess lifetime cancer risks and noncancer HIs for onsite residents at the Alice Griffith Housing area are well below the current BAAQMD significance thresholds of 10 in a million and 1, respectively.

As summarized in Table 6-3, the estimated cancer risk for the onsite MEIR–adult resident at the Alice Griffith Housing area assuming high-end exposure assumptions is 2.6 in a million (2.6×10^{-6}). The estimated cancer risk for the onsite MEIR–adult assuming average exposures is slightly lower than that estimated using high-end exposure assumptions.

The estimated total cancer risk for the onsite MEIR–child resident at the Alice Griffith Housing area assuming high-end exposure assumptions is 4.5 in a million (4.5×10^{-6}). The estimated cancer risks for the onsite MEIR–child resident assuming average exposures are slightly lower than those estimated using high-end exposure assumptions.

As shown on Table 6-4, the estimated noncancer HIs for all onsite residents at the Alice Griffith Housing area is 0.02 or below.

6.2.3 Offsite Workers

All estimated excess lifetime cancer risks and noncancer HIs for offsite workers associated with construction emissions attributable to the CP, HPS Phase II, and the total Project are well below the current BAAQMD significance thresholds of 10 in a million and one, respectively.

The estimated risks for the MEIW for the CP, HPS Phase II, and total Project are 3.3 in a million (3.3×10^{-6}), 3.8 in a million (3.8×10^{-6}) and 4.5 in a million (4.5×10^{-6}), respectively. The estimated noncancer HIs for all offsite worker populations is 0.01 or below.

6.2.4 Offsite Sensitive Receptors

All estimated excess lifetime cancer risks and noncancer HIs for sensitive receptors associated with construction emissions attributable to the CP, HPS Phase II, and the total Project are well below the current BAAQMD significance thresholds.

The estimated risks for the maximum offsite sensitive receptor for the CP, HPS Phase II, and the total Project are 1.5 in a million (1.5×10^{-6}), 0.23 in a million (2.3×10^{-7}) and 1.6 in a million (1.6×10^{-6}), respectively. The estimated noncancer HIs for all sensitive receptors is 0.006 or below.

7 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 Cal/EPA 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, ENVIRON has evaluated the uncertainties associated with this HHRA, including emissions estimation, air dispersion modeling, and risk estimation. The following sections summarize the critical uncertainties associated with the emissions estimation, air dispersion modeling and risk estimation components of the risk assessment.

7.1 Estimation of Emissions

There are a number of uncertainties associated with the estimation of emissions from the Project that may affect the subsequent estimation of exposure concentrations and risk characterization. Emission models (e.g., EMFAC2007 and OFFROAD2007) and regulatory requirements (e.g., Tier 4 or ARB Regulation) were used to estimate overall emissions from construction activity at the Project. Emissions models make assumptions about the age of a fleet and attrition based on statewide averages which were assumed to approximate the fleet used for the Project. Additionally, regulatory requirements reflect the maximum allowable emission rate from a certified engine; however, actual emission rates tend to be lower than that limit. As such, using the maximum allowable emission rate will likely overestimate emissions from that source.

7.2 Estimation of Exposure Concentrations

As discussed in Section 4, the USEPA-recommended dispersion model AERMOD was used to estimate average offsite DPM exposure concentrations at the various offsite 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 2005a). Therefore, offsite exposure concentrations used in this assessment represent approximate offsite exposure concentrations.

7.3 Source Representation

The source parameters (*i.e.*, release velocity and release temperature) used to model emission points are sources of uncertainty. For all emission sources, source parameters were based on methods developed by regulatory agencies for use in their own analyses (e.g., SCAQMD LST or ARB). The BAAQMD has not yet developed a District-specific methodology for evaluating emissions from construction emissions sources. As there might be discrepancies in actual emissions characteristics of a source and its representation used in the Agency methodologies used, offsite exposure concentrations used in this assessment represent approximate offsite exposure concentrations.

7.4 Risk Characterization

7.4.1 Exposure Assumptions

Numerous assumptions must be made in order to estimate human exposure to chemicals. These assumptions include parameters such as breathing rates, exposure time and frequency, exposure duration, and human activity patterns. While a mean value derived from scientifically defensible studies is the best estimate of central tendency, most of the exposure variables used in this HHRA are high-end estimates. For example, it is assumed that residential receptor exposure to DPM occurs 24 hours per day for 350 days per year, a highly conservative assumption since most residents do not remain in their homes for this period of time. The combination of several high-end estimates used as exposure parameters may substantially overestimate chemical intake. The cancer risks calculated in this assessment are therefore likely to be higher than may be required to be protective of public health.

7.4.2 Toxicity Assessment

The Cal/EPA CPF for DPM was used to estimate cancer risks associated with exposure to DPM from Project emissions. However, the CPF derived by Cal/EPA for DPM is highly uncertain in both the estimation of response and dose. Public health and regulatory organizations such as the International Agency for Research on Cancer (IARC), World Health Organization, and USEPA agree that diesel exhaust may cause cancer in humans. However, after thorough evaluation of the animal test data and epidemiology data on diesel exhaust, and in contrast to the approach used in California, the USEPA concluded that the existing data did not provide an adequate basis for quantitative risk assessment (USEPA 2002).

7.4.3 Risk Calculation

The USEPA (1989b) notes that the conservative assumptions used in a risk assessment are intended to assure that the estimated risks do not underestimate the actual risks posed by a site and that the estimated risks do not necessarily represent actual risks experienced by populations at or near a site. By using standardized conservative assumptions in a risk assessment, USEPA (1989b) further states 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."*

The estimated risks in this HHRA are based primarily on a series of conservative assumptions related to predicted environmental concentrations, exposure, and chemical toxicity. The use of conservative assumptions tends to produce upper-bound estimates of risk. Although it is difficult to quantify the uncertainties associated with all the assumptions made in this risk assessment, the use of conservative assumptions is likely to result in substantial overestimates of exposure, and hence, risk. BAAQMD acknowledges this uncertainty by stating: "the methods used [to estimate risk] are conservative, meaning that the real risks from the source may be lower than the calculations, but it is unlikely that they will be higher" (BAAQMD 2009).

8 Conclusions

In summary, the results of this HHRA indicate that potential excess cancer risks to offsite residents, workers and sensitive receptors surrounding the Candlestick Park – Hunters Point Shipyard Phase II Project are below 10 in a million for DPM emitted from construction activity, assuming that certain mitigation measures are implemented. Further, estimated cancer risks for onsite residents at the Alice Griffith Housing area are also below 10 in a million. The estimated chronic noncancer hazard indices are below 1 for all receptors evaluated in this HHRA. Pursuant to BAAQMD CEQA Guidelines (BAAQMD 1999), projects that expose the public to toxic air contaminants in excess of the following thresholds would be considered to have a significant air quality impact:

- Probability of contracting cancer for the MEI exceeds 1×10^{-5} (10 in a million);
- Ground level concentrations of non-carcinogenic toxic air contaminants would result in a HI greater than 1 for the MEI.

Thus, based on the results of this HRSA, the project should not have a significant impact on air quality according to BAAQMD CEQA Guidelines.

The many conservative assumptions that have been used in this assessment regarding the estimation of emissions, ambient air concentrations, exposure assumptions, and carcinogenic potency lead to an overestimate of potential risks, the magnitude of which could likely be substantial.

9 References

Air Resources Board (ARB). 1998. *Initial Statement of Reasons for Rulemaking. Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant*. June.

ARB. 2006a. Emission Factors (EMFAC2007) model (Version 2.3). November. Available at: http://www.arb.ca.gov/msei/onroad/latest_version.htm

ARB. 2006b. Off-Road Emissions Inventory (OFFROAD2007). Mobile Source Emissions Inventory Program. December. Available at: http://www.arb.ca.gov/msei/offroad/offroad.htm

Bay Area Air Quality Management District (BAAQMD). 1999. *BAAQMD CEQA Guidelines: Assessing the Air Quality Impacts of Projects and Plans*. December.

BAAQMD. 2000. *Bay Area Air Quality Management Air Toxic Risk Evaluation Procedure (REP) and Risk Management Policy (RMP).* February.

BAAQMD. 2005a. *Bay Area Air Quality Management District Staff Report.* Toxic Evaluation Section. June.

BAAQMD. 2005b. *Air Toxics NSR Program Health Risk Screening Analysis (HRSA) Guidelines*. June.

BAAQMD. 2009. *Frequently Asked Questions – Toxic Air Contaminants. Online: http://www.baaqmd.gov/Help/~/~/link.aspx?_id=C8992846AA0045ECABDB489211201B61&_z=z. Accessed August 5.*

California Environmental Protection Agency (Cal/EPA). 1998. Findings of the Scientific Review Panel on The Report on Diesel Exhaust, as adopted at the Panel's April 22, 1998, meeting. Office of Environmental Health Hazard Assessment. Available electronically at http://www.arb.a.gov.

Cal/EPA 2000. *Air Toxics Hot Spots Program Risk Assessment Guidelines: Part IV Technical Support Document for Exposure Assessment and Stochastic Analysis.* Office of Environmental Health Hazard Assessment. September.

Cal/EPA. 2003. *The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments*. Office of Environmental Health Hazard Assessment. August.

Cal/EPA. 2008. *All Chronic Reference Exposure Levels (cRELs)*. Office of Environmental Health Hazard Assessment. December 18.

Cal/EPA. 2009a. *Air Toxics Hot Spots Program Risk Assessment Guidelines: Part II Technical Support Document for Describing Available Cancer Potency Factors.* Office of Environmental Health Hazard Assessment. May.

Cal/EPA. 2009b. *California Cancer Potency Values*. Office of Environmental Health Hazard Assessment. October.

Risk Assessment Advisory Commmittee (RAAC). 1996. *A Review of the California Environmental Protection Agency's Risk Assessment Practices, Policies, and Guidelines.* October.

National Research Council (NRC). 1983. *Risk Assessment in the Federal Government: Managing the Process.* National Academy Press, Washington, DC.

NRC. 1994. *Science and Judgment in Risk Assessment.* National Academies Press. Washington D.C.

Urban Emissions Model (URBEMIS 2007) (Version 9.2.4 – 2008). Rimpo and Associates Inc. Available at: http://www.urbemis.com.

U.S. Environmental Protection Agency (USEPA). 1989a. *Risk Assessment Guidance for Superfund: Volume 1- Human Health Evaluation Manual (Part A).* Interim Final. Washington, D.C. December.

USEPA. 1989b*. Risk Assessment Guidance for Superfund Human Health Risk Assessment:* U.S. EPA Region IX Recommendations (Interim Final). San Francisco, CA. December 15.

USEPA. 1991. *Risk Assessment Guidance for Superfund. Volume 1: Human Health Evaluation Manual. Supplemental Guidance. Standard Default Exposure Factors.* Office of Emergency and Remedial Response. March 25.

USEPA. 1995. United States Environmental Protection Agency (USEPA). 1995. *User's Guide for the Industrial Source Complex (ISC3) Dispersion Models.* Research Triangle Park, North Carolina. EPA-454/B-95-003a. September.

USEPA. 1997. *Exposure Factors Handbook*. EPA/600/P-95/002Fa. August.

USEPA. 2002. *Health Assessment Document for Diesel Engine Exhaust.* National Center for Environmental Assessment, Office of Research and Development, Washington, DC. EPA/600/8-90/057F. May.

USEPA. 2004. United States Environmental Protection Agency (USEPA). 2004b. *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.

USEPA. 2005a. *Guideline on Air Quality Models (Revised). 40 Code of Federal Regulations, Part 51, Appendix W.* Office of Air Quality Planning and Standards. November.

USEPA. 2005b. United States Environmental Protection Agency (USEPA). 2005. *Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and*

Complex Terrain) Dispersion Model and Other Revisions; Final Rule. 40 CFR Part 51, Appendix W. 70 Federal Register 68218-61. November 9.

Tables

Table 4-1
Exposure Assumptions
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Parameter Symbol	Parameter Definition	Units	Receptor Population											
			School Child		Offsite Worker		Resident							
							Adult				Child			
							Average Exposure		High End Exposure		Average Exposure		High End Exposure	
IR	Inhalation Rate	L/kg-day	581	a	149	a	271	b	302	a	452	b	581	a
		m^3/day	10		10		17		19		8		10	
F	Fraction of Day Exposed	unitless	0.42	c	1	c	1	c	1	c	1	c	1	c
EF	Exposure frequency	days/year	180	a	245	a	350	a	350	a	350	a	350	a
T	Modeling Adjustment Factor	unitless	3.4	d	4.2	e	1	f	1	f	1	f	1	f
CF	Conversion Factor	mg/ug	1.E-03		1.E-03		1.E-03		1.E-03		1.E-03		1.E-03	
A	Inhalation Absorption Factor	unitless	1		1		1		1		1		1	
BW	Body Weight	kg	18	b	70	b	63	b	63	b	18	b	18	b
AT	Averaging time	days	25,550		25,550		25,550		25,550		25,550		25,550	

Notes:
L = Liter
kg = kilogram
m^3 = cubic meters
mg = milligram
µg = microgram

[a] BAAQMD 2005.

[b] Cal/EPA 2003.

[c] Fraction of day exposed for the school child calculated assuming a school day of 10 hours per day (BAAQMD 2005). The value was calculated as follows: 0.42 = 10 hours/24 hours. The fraction of the day adjustment is not necessary for offsite workers or residents.

[d] Since the annual average concentrations were estimated assuming continuous exposure (i.e., 24 hours per day, 7 days per week), an adjustment must be applied to the modeling to account for the time the receptor is actually present at school or work (Cal/EPA 2003). The school child is assumed to be present at a school location 10 hours per day, 5 days per week (BAAQMD 2005). Therefore, a factor of 3.4 (equal to [24 hours/10 hours]*[7 days/5 days]) was applied to account for the difference in exposure time.

[e] Since the annual average concentrations were estimated assuming continuous exposure (i.e., 24 hours per day, 7 days per week), an adjustment must be applied to the modeling to account for the time the receptor is actually present at school or work (Cal/EPA 2003). The off-site worker is assumed to be present at a work location 8 hours per day, 5 days per week (BAAQMD 2005). Therefore, a factor of 4.2 (equal to [24 hours/8 hours]*[7 days/5 days]) was applied to account for the difference in exposure time.

[f] Modeling adjustment not necessary for residential receptors.

Source:
Bay Area Air Quality Management District (BAAQMD). 2005. *BAAQMD Air Toxics NSR Program Health Risk Screening Analysis (HRSA) Guidelines.* June.
California Environmental Protection Agency (CalEPA). 2003. *Air Toxics Hot Spots Program Risk Assessment Guidelines: The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments* . Office of Environmental Health Hazard Assessment. August.

Table 4-2
Project-Specific Exposure Durations (in years)
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Project Area	Receptor Population							
	School Child		Offsite Worker		Off-site Resident			
					Adult		Child	
Candlestick Point	9	a,b	18	b	18	b	9	a,b
Hunters Point Shipyard	9	a,b	9	b	9	b	9	a,b
Candlestick Point - Hunters Point Shipyard Phase II Development Plan	9	a,b	19	b	19	b	9	a,b

Notes:

[a] BAAQMD 2005.
[b] Project specific estimate based on planned construction periods, as follows:
Candlestick Point = 2011-2028, Hunters Point Shipyard = 2010-2018,
and Candlestick Point - Hunters Point Shipyard Phase II Development Plan = 2010-2028.

Source:
Bay Area Air Quality Management District (BAAQMD). 2005. *BAAQMD Air Toxics NSR Program Health Risk Screening Analysis (HRSA) Guidelines.* June.

Table 4-3
Summary of Modeled Source Parameters
Bayview Waterfront
San Francisco, California

Source Category	Source Type	Release Height (m)	Length of Side or Center to Center Distance (m)	Initial Lateral Dimension[b] (m)	Initial Vertical Dimension[c] (m)
Construction Equipment	Volume	5[a]	10	2.33	1.2
			20	4.65	1.2
Haul Truck/Commute Vehicle					
Harney Way	Line	0.6[d]	40	18.6	0.1
Hunters Point Boulevard			40	18.6	0.1

Notes:
m = meters
[a] SCAQMD 2008.

[b] For elevated volume sources, initial vertical dimension was calculated as vertical dimension of source divided by 4.3 based on AERMOD user's guide.

[c] Initial lateral dimension was calculated as center to center distance divided by 2.15 for line source represented by separated volume sources and length of side divided by 4.3 for single volume source based on AERMOD user's guide.

[d] Based on information from a previous ARB study (ARB 2000) characterizing risk from a school bus, the release height of on-road commuting vehicles and medium-heavy-duty trucks, light-heavy-duty trucks, and light-duty automobiles transporting equipment and materials is taken as 0.6 meters.

Source:
South Coast Air Quality Management District (SCAQMD). 2008. *Final Localized Significance Threshold Methodology*. July.

United State Environmental Protection Agency (USEPA). 2004. *User's Guide for the AMS/EPA Regulatory Model - AERMOD*. September.

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 4-4
Annual Average DPM Concentrations at the Offsite Maximally Exposed Individuals (MEI)
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Project Area	Receptor Population			
	School Child	Offsite Worker	Resident	
			Adult	Child
Candlestick Point	2.7E-02	2.7E-02	2.1E-02	3.6E-02
Hunters Point Shipyard	4.1E-03	6.4E-02	4.0E-02	4.0E-02
Candlestick Point - Hunters Point Shipyard Phase II Development Plan	2.9E-02	3.6E-02	2.1E-02	4.0E-02

Note:
Units are microgram per cubic meter (ug/m^3).

Table 4-5
Annual Average DPM Concentrations at the Onsite Maximally Exposed Individuals (MEI) for the Alice Griffith Housing
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Year	Parcel			Maximum Concentration
	CP-01	CP-02	CP-04	
2010	NA	6.0E-04	6.5E-04	6.5E-04
2011	NA	NA	4.0E-02	4.0E-02
2012	NA	NA	4.6E-02	4.6E-02
2013	NA	NA	7.1E-02	7.1E-02
2014	5.2E-02	NA	NA	5.2E-02
2015	6.9E-02	7.1E-02	NA	7.1E-02
2016	6.5E-02	4.4E-02	NA	6.5E-02
2017	6.9E-02	8.3E-02	NA	8.3E-02
2018	3.8E-02	2.4E-02	4.2E-02	4.2E-02
2019	4.5E-02	4.6E-02	2.2E-02	4.6E-02
2020	2.8E-02	2.8E-02	1.2E-02	2.8E-02
2021	9.1E-03	8.1E-03	5.3E-03	9.1E-03
2022	5.7E-03	5.2E-03	3.6E-03	5.7E-03
2023	4.0E-03	4.5E-03	3.5E-03	4.5E-03
2024	3.6E-03	3.9E-03	2.8E-03	3.9E-03
2025	3.2E-03	3.2E-03	2.3E-03	3.2E-03
2026	2.9E-03	2.9E-03	2.2E-03	2.9E-03
2027	1.3E-03	1.3E-03	1.0E-03	1.3E-03
2028	4.3E-04	4.7E-04	3.8E-04	4.7E-04

Note:
NA = Not Applicable. Construction activity on parcel during year. Therefore, residents will not be present on the parcel during this period.
Units are microgram per cubic meter (ug/m^3)

Table 4-6
Dose Estimates at the Offsite Maximally Exposed Individuals (MEI)
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Project Area	Units	Receptor Population					
		School Child	Offsite Worker	Resident			
				Adult		Child	
				Average Exposure	High End Exposure	Average Exposure	High End Exposure
Candlestick Point	mg/kg-day	1.4E-06	3.0E-06	1.4E-06	1.6E-06	2.0E-06	2.6E-06
Hunters Point Shipyard		2.1E-07	3.5E-06	1.3E-06	1.5E-06	2.2E-06	2.9E-06
Candlestick Point - Hunters Point Shipyard Phase II Development Plan		1.5E-06	4.0E-06	1.5E-06	1.7E-06	2.2E-06	2.9E-06

Equation:
Dose = (Ca * T * IR * EF * ED * F * A * CF) / (BW * AT)
See Table 4-1 for the exposure assumptions IR, EF, T, A, F, CF, BW, and AT.
See Table 4-2 for the exposure durations (ED).
See Table 4-4 for the annual average air concentrations (Ca).

Note:
All doses presented in units of milligram per kilogram per day (mg/kg-day).

Table 4-7
Dose Estimates at the Onsite Maximally Exposed Individuals (MEI) for the Alice Griffith Housing
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Year	Receptor Population			
	Resident			
	Adult		Child	
	Average Exposure	High End Exposure	Average Exposure	High End Exposure
2010	2.4E-09	2.7E-09	4.0E-09	5.2E-09
2011	1.5E-07	1.7E-07	2.5E-07	3.2E-07
2012	1.7E-07	1.9E-07	2.9E-07	3.7E-07
2013	2.6E-07	2.9E-07	4.4E-07	5.6E-07
2014	1.9E-07	2.1E-07	3.2E-07	4.1E-07
2015	2.7E-07	3.0E-07	4.4E-07	5.7E-07
2016	2.4E-07	2.7E-07	4.0E-07	5.2E-07
2017	3.1E-07	3.4E-07	5.1E-07	6.6E-07
2018	1.5E-07	1.7E-07	2.6E-07	3.3E-07
2019	1.7E-07	1.9E-07	2.9E-07	3.7E-07
2020	1.1E-07	1.2E-07	1.8E-07	2.3E-07
2021	3.4E-08	3.7E-08	5.6E-08	7.2E-08
2022	2.1E-08	2.4E-08	3.5E-08	4.6E-08
2023	1.7E-08	1.8E-08	2.8E-08	3.5E-08
2024	1.5E-08	1.6E-08	2.4E-08	3.1E-08
2025	1.2E-08	1.3E-08	2.0E-08	2.5E-08
2026	1.1E-08	1.2E-08	1.8E-08	2.3E-08
2027	5.0E-09	5.5E-09	8.3E-09	1.1E-08
2028	1.7E-09	1.9E-09	2.9E-09	3.7E-09

Equation:
Dose = (Ca * T * IR * EF * ED * F * A * CF) / (BW * AT)
See Table 4-1 for the exposure assumptions IR, EF, T, A, F, CF, BW, and AT.
See Table 4-2 for the exposure durations (ED).
See Table 4-5 for the Maximum annual average air concentrations (Ca).

Note:
All doses presented in units of milligram per kilogram per day (mg/kg-day).

Table 5-1
Carcinogenic and Noncarcinogenic Toxicity Values
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Chemical	Cancer Potency Factor[a]	Chronic Reference Exposure Level[b]	Acute Reference Exposure Level
	([mg/kg-day]$^{-1}$)	ug/m^3	ug/m^3
Diesel PM	1.10E+00	5.00E+00	----

Notes:
---- = Value not available.
ug/m^3 = micrograms per cubic meter
[mg/kg-day]$^{-1}$ = per milligram per kilogram-day

[a] Cal/EPA 2009.
[b] Cal/EPA 2008.

Sources:
California Environmental Protection Agency (CalEPA). 2008. *OEHHA Acute, 8-hour and Chronic Reference Exposure Level (REL) Summary.* Office of Environmental Health Hazard Assessment. December 18.
California Environmental Protection Agency (Cal EPA). 2009. Toxicity *Criteria Database.* July 21.

Table 6-1
Summary of Cancer Risks at the Offsite Maximally Exposed Individuals (MEI)
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Project Area	Receptor Population					
	School Child	Offsite Worker	Resident			
			Adult		Child	
			Average Exposure	High End Exposure	Average Exposure	High End Exposure
Candlestick Point	1.5E-06	3.3E-06	1.5E-06	1.7E-06	2.2E-06	2.8E-06
Hunters Point Shipyard	2.3E-07	3.8E-06	1.5E-06	1.6E-06	2.4E-06	3.1E-06
Candlestick Point - Hunters Point Shipyard Phase II Development Plan	1.6E-06	4.5E-06	1.6E-06	1.8E-06	2.5E-06	3.2E-06

<u>Equation</u>
Cancer risk = Dose * CPF
See Table 4-6 for receptor population-specific doses.
CPF = Cancer potency factor (See table 5-1).

Table 6-2
Summary of Noncancer Hazard Indices (HIs) at the Offsite Maximally Exposed Individuals (MEI)
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Project Area	Receptor Population			
	School Child	Offsite Worker	Resident	
			Adult	Child
Candlestick Point	0.005	0.005	0.004	0.007
Hunters Point Shipyard	0.0008	0.01	0.008	0.008
Candlestick Point - Hunters Point Shipyard Phase II Development Plan	0.006	0.007	0.004	0.008

Equation
Hazard Index (HI) = Ca/REL
See Table 4-4 for receptor population-specific air concentrations (Ca).
REL = Reference exposure level (See table 5-1).

Table 6-3
Summary of Cancer Risks at the Onsite Maximally Exposed Individuals (MEI) for the Alice Griffith
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Year	Receptor Population			
	Resident			
	Adult		Child[a]	
	Average Exposure	High End Exposure	Average Exposure	High End Exposure
2010	2.7E-09	3.0E-09	4.4E-09	5.7E-09
2011	1.6E-07	1.8E-07	*2.7E-07*	*3.5E-07*
2012	1.9E-07	2.1E-07	*3.2E-07*	*4.1E-07*
2013	2.9E-07	3.2E-07	*4.8E-07*	*6.2E-07*
2014	2.1E-07	2.4E-07	*3.5E-07*	*4.5E-07*
2015	2.9E-07	3.2E-07	*4.9E-07*	*6.3E-07*
2016	2.6E-07	2.9E-07	*4.4E-07*	*5.7E-07*
2017	3.4E-07	3.8E-07	*5.6E-07*	*7.3E-07*
2018	1.7E-07	1.9E-07	*2.8E-07*	*3.6E-07*
2019	1.9E-07	2.1E-07	*3.1E-07*	*4.0E-07*
2020	1.2E-07	1.3E-07	1.9E-07	2.5E-07
2021	3.7E-08	4.1E-08	6.2E-08	7.9E-08
2022	2.3E-08	2.6E-08	3.9E-08	5.0E-08
2023	1.8E-08	2.0E-08	3.0E-08	3.9E-08
2024	1.6E-08	1.8E-08	2.7E-08	3.4E-08
2025	1.3E-08	1.4E-08	2.2E-08	2.8E-08
2026	1.2E-08	1.3E-08	2.0E-08	2.6E-08
2027	5.5E-09	6.1E-09	9.1E-09	1.2E-08
2028	1.9E-09	2.1E-09	3.2E-09	4.1E-09
Total Risk	2.4E-06	2.6E-06	3.5E-06	4.5E-06

Equations
Cancer risk = Dose * CPF
See Table 4-7 for receptor population-specific doses.
CPF = Cancer potency factor (See table 5-1).

Note:
[a] The maximum consecutive nine year period is reported for the child to reflect the default exposure duration assumed for a child receptor by the California Environmental Protection Agency (2003). The consecutive nine year period is shown in italics.

Table 6-3
Summary of Cancer Risks at the Onsite Maximally Exposed Individuals (MEI) for the Alice Griffith
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

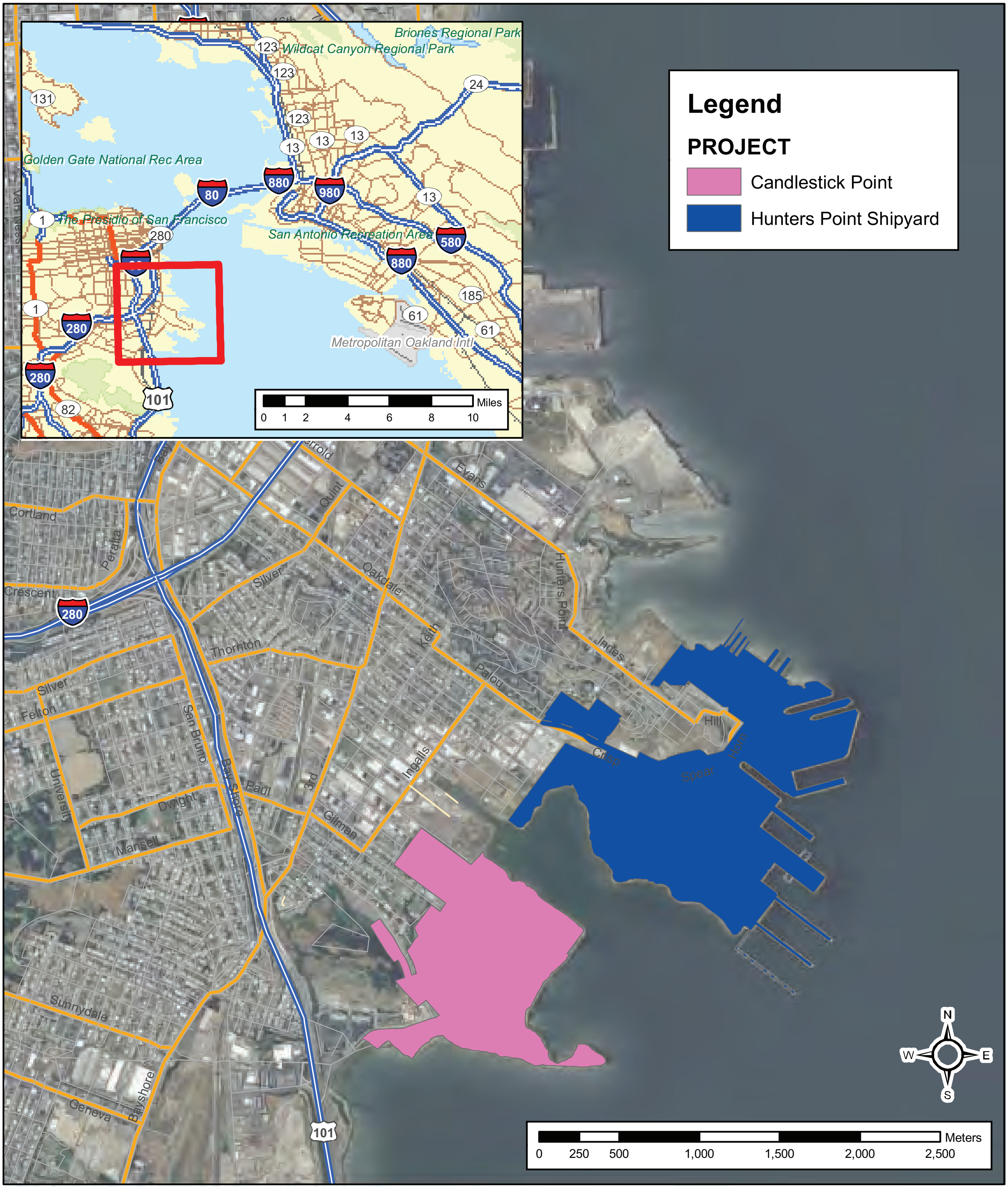
Reference:
California Environmental Protection Agency (CalEPA). 2003. *Air Toxics Hot Spots Program Risk Assessment Guidelines: The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments*. Office of Environmental Health Hazard Assessment. August.

Table 6-4
Summary of Noncancer Hazard Indices (HIs) at the Onsite Maximally Exposed Individuals (MEI) for the Alice Griffith Housing
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Year	Residents
	Hazard Index (HI)
2010	0.0001
2011	0.01
2012	0.01
2013	0.01
2014	0.01
2015	0.01
2016	0.01
2017	0.02
2018	0.008
2019	0.009
2020	0.006
2021	0.002
2022	0.001
2023	0.0009
2024	0.0008
2025	0.0006
2026	0.0006
2027	0.0003
2028	0.00009
Maximum HI	0.02

<u>Equation</u>
Hazard Index (HI) = Ca/REL
See Table 4-5 for receptor population-specific air concentrations (Ca).
REL = Reference exposure level (See table 5-1).

Figures



ENVIRON

6001 Shellmound St., Suite 700, Emeryville, CA 94608

Project Site Vicinity Map
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Figure **2-1**

Drafter: EH Date: 09/17/2009 Contract Number: 0320816A

Legend

Road Improvement Construction

- Carroll Ave
- Gilman Ave
- Harney Way
- Hunter's Point Blvd
- Ingall St
- Palou Ave
- Thomas Ave

PROJECT

- Candlestick Point
- Hunters Point Shipyard

Note:
1. CP, HP designations reflect proposed construction phases.
2. Alice Griffith Housing area is represented by CP-01 through CP-06.

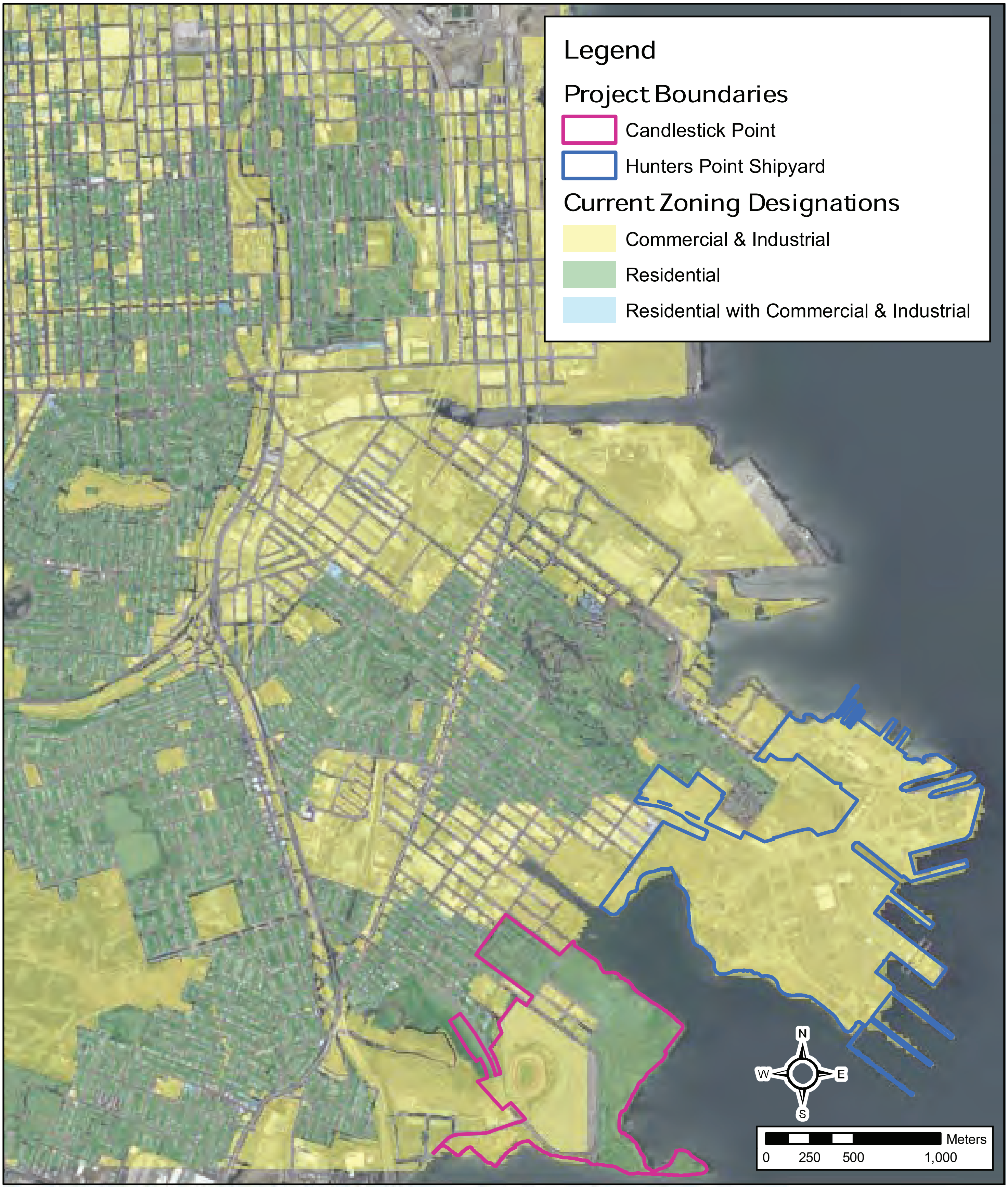
ENVIRON

6001 Shellmound St., Suite 700, Emeryville, CA 94608

Project Overview
Candlestick Point - Hunters Point Shipyard Phase II
Development Plan
San Francisco, California

Drafter: EH Date: 09/21/2009 Contract Number: 0320816A Approved: Revised:

Figure
2-2



ENVIRON

6001 Shellmound St., Suite 700, Emeryville, CA 94608

Surrounding Land Use
Candlestick Point - Hunters Point Shipyard Phase II
Development Plan
San Francisco, California

Figure 2-3

Drafter: EH Date: 09/17/2009

Contract Number: 0320816A

ENVIRON

6001 Shellmound St., Suite 700, Emeryville, CA 94608

Offsite Receptor Locations
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Figure 4-1a

Drafter: EH | Date: 09/17/2009 | Contract Number: 0320816A | Approved: | Revised:

ENVIRON

6001 Shellmound St., Suite 700, Emeryville, CA 94608

Onsite Receptor Locations
Candlestick Point - Hunters Point Shipyard Phase II
Development Plan
San Francisco, California

Figure

4-1b

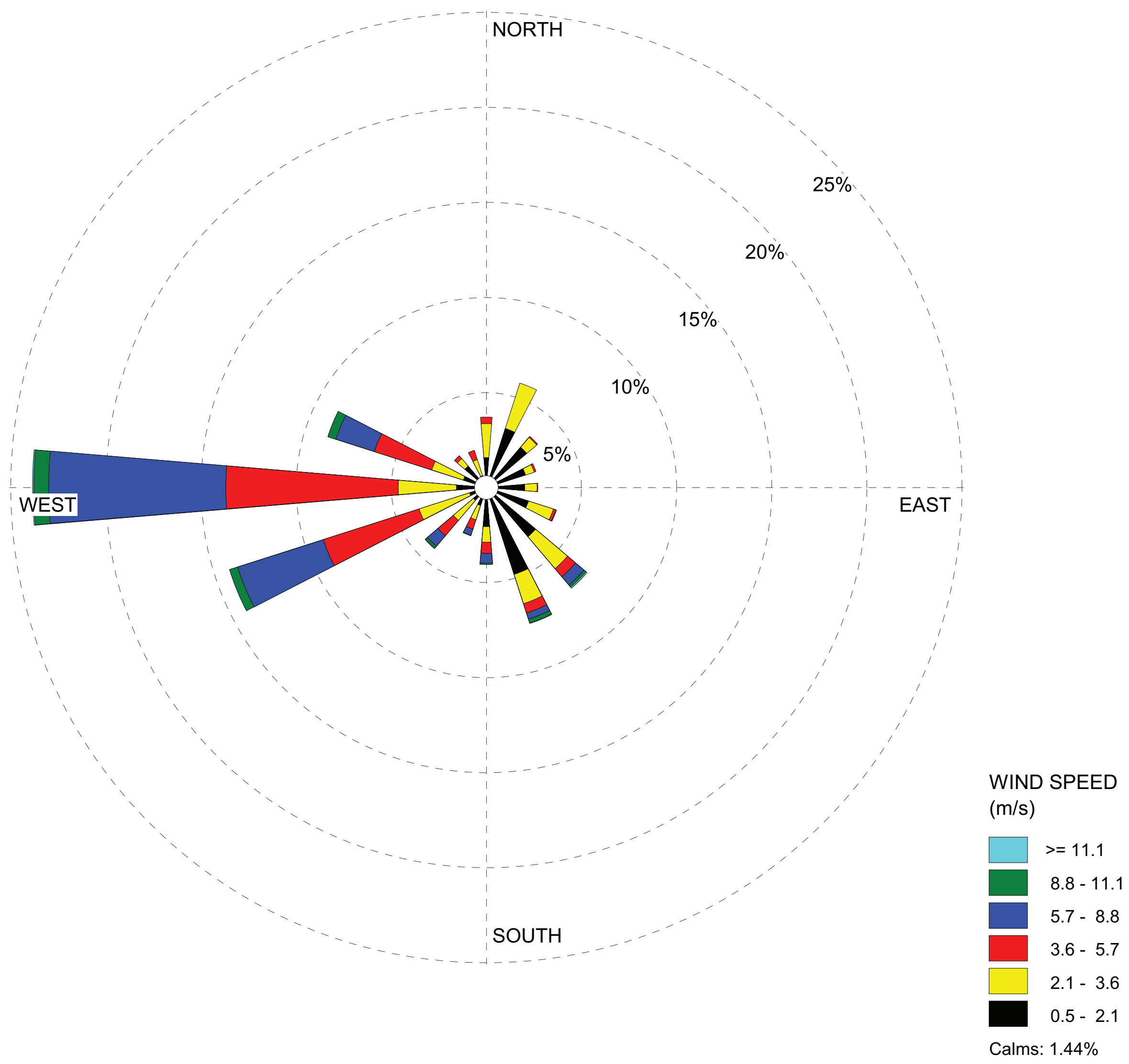
Drafter: EH Date: 09/17/2009 Contract Number: 0320816A Approved: Revised:

WIND ROSE PLOT:

Figure 4-2: Wind Rose Hunters Point Shipyard 2002-2003 7am-3pm (8 hours per day)

DISPLAY:

Wind Speed
Direction (blowing from)



COMMENTS:

DATA PERIOD:

2002-2003
Jan 1 - Dec 31
07:00 - 14:00

COMPANY NAME:

MODELER:

CALM WINDS:

1.44%

TOTAL COUNT:

2920 hrs.

AVG. WIND SPEED:

3.88 m/s

DATE:

07/17/2009

PROJECT NO.:

WRPLOT View - Lakes Environmental Software

ENVIRON

6001 Shellmound St., Suite 700, Emeryville, CA 94608

Modeled Construction Equipment
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Figure 4-3

Drafter: EH | Date: 09/17/2009 | Contract Number: 0320816A | Approved: | Revised:

ENVIRON

6001 Shellmound St., Suite 700, Emeryville, CA 94608

Modeled Offsite Haul Trucks and Commute Vehicles
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Figure 4-4

Drafter: EH Date: 09/17/2009 Contract Number: 0320816A Approved: Revised:

Attachment II:
Human Health Risk Assessment of Chemicals Bound to Airborne PM_{10}

Candlestick Point – Hunters Point Shipyard Phase II Development Plan San Francisco, California

Contents

List of Tables

List of Figures

List of Acronyms

AERMOD	American Meteorological Society/Environmental Protection Agency Regulatory Model
ARB	Air Resources Board
BAAQMD	Bay Area Air Quality Management District
Cal/EPA	California Environmental Protection Agency
Cal/OSHA	California Occupational Safety and Health Administration
CEQA	California Environmental Quality Act
CP	Candlestick Point
CPF	Cancer Potency Factor
EIR	Environmental Impact Report
HARP	Hotspots Analysis Risk Reporting Program
HEAST	Health Effects Assessment Summary Tables
HHRA	Human Health Risk Assessment
HI	Hazard Index
HPS	Hunters Point Shipyard
HQ	Hazard Quotient
HRSA	Health Risk Screening Analysis
IR	Installation Restoration
IRIS	Integrated Risk Information System
ISCST3	Industrial Source Complex Short Term Model
LST	Localized Significance Thresholds
MEI	Maximally Exposed Individual
MEIR	Maximally Exposed Individual Resident
MEIW	Maximally Exposed Individual Worker
MP	Multipathway
Navy	U.S. Department of the Navy
NCEA	National Center for Environmental Assessment
NED	National Elevation Dataset
NFL	National Football League
NRC	National Research Council
NSR	New Source Review
OEHHA	Office of Environmental Health Hazard Assessment
PAHs	Polynuclear Aromatic Hydrocarbons
PBS&J	Post, Buckley, Schuh & Jernigan, Inc.
PCBs	Polychlorinated Biphenyls
PM_{10}	Particulate Matter Less than 10 Microns in Aerodynamic Diameter
PPRTV	Provisional Peer Reviewed Toxicity Value
RAAC	Risk Assessment Advisory Committee
R&D	Research and Development
REL	Reference Exposure Level
SCAQMD	South Coast Air Quality Management District

SFPD	San Francisco Police Department
SFRA	San Francisco Redevelopment Agency
SRA	State Recreation Area
SVOC	Semi-Volatile Organic Compound
TAC	Toxic Air Contaminant
TEF	Toxicity Equivalency Factor
UCSF	University of California, San Francisco
URBEMIS	URBan EMISsions Model
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VOC	Volatile Organic Compound
WHO	World Health Organization

List of Units

°F	degrees Fahrenheit
g	gram
gsf	gross square footage
kg	kilogram
L	liter
m^3	cubic meter
mph	mile per hour
mg	milligram
µg	microgram
µm	micrometer or micron
s	second

1 Introduction

At the request of Post, Buckley, Schuh & Jernigan, Inc. (PBS&J), ENVIRON International Corporation (ENVIRON) performed a human health risk assessment (HHRA) to evaluate health effects associated with potential exposures to chemicals present in soil dust emissions from construction activities at the proposed Candlestick Point – Hunters Point Shipyard Phase II Development Plan ("Project"). This HHRA has been conducted as part of an Environmental Impact Report (EIR) for the Project which is being prepared by PBS&J on behalf of the San Francisco Redevelopment Agency and the San Francisco Planning Department. The HHRA estimates cancer risks and chronic noncancer hazard indices (HIs) for current nearby offsite populations and residents at the Alice Griffith Housing area and compares them to the Bay Area Air Quality Management District (BAAQMD or District) California Environmental Quality Act (CEQA) thresholds of significance.

1.1 Objectives and Methodology

The objective of this HHRA is to evaluate potential human health risks to the surrounding community and to residents at the Alice Griffith Housing area associated with exposures to chemicals bound to dusts generated from soils during Project-related construction activities. The dusts evaluated are referred to as PM_{10}, which refers to particulate matter (PM) with a mean aerodynamic diameter of 10 microns or less. PM_{10} corresponds to particles of a size that can be inhaled and retained in the lungs. The sources of the PM_{10} emissions evaluated are demolition and soil grading activities associated with Project construction. Those Project areas where PM_{10} emissions are from soils where chemicals are present above residential cleanup goals are included in the evaluation.

Historic operations by the U.S. Department of the Navy (Navy) and its tenants at the Hunters Point Shipyard (HPS) Phase II area resulted in a number of hazardous materials release sites and associated contaminated soils. The types, levels, and extent of contamination of soils and other environmental media have been identified for the HPS Phase II area through a series of comprehensive environmental investigations conducted at the direction of the Navy. The Navy is currently remediating the contaminated soils under the oversight of federal and state regulatory agencies. However, some of the required remedial actions may be conducted after the Navy transfers the property, in conjunction with Project development activities. Further, consistent with designated future land use at the HPS Phase II area, some areas are being remediated to industrial or recreational cleanup levels. Chemical concentrations in soils in those areas may be elevated as compared with soils remediated to residential cleanup levels.

Although there are no known hazardous materials release sites at Candlestick Point (CP), soil investigations were conducted at this area in the late 1990s at the direction of DeBartolo Entertainment, Inc. These investigations revealed limited areas with elevated concentrations of metals and/or organic chemicals.

ENVIRON characterized the chemical concentrations associated with airborne PM_{10} from construction activities by developing exposure point concentrations for offsite receptors in the vicinity of the Project and for onsite receptors within the Alice Griffith Housing area. This analysis was conducted by estimating the average annual airborne PM_{10} emissions resulting from Project construction activities and by conducting air dispersion modeling of those emissions. Chemical concentrations associated with airborne PM_{10} were estimated based on the chemical concentrations in soils, referred to as the soil source terms. Potential exposures (or doses) to offsite and onsite receptors were then estimated using conservative exposure parameters consistent with BAAQMD risk screening guidance (BAAQMD 2005a, 2005b).

Using the results of the exposure evaluation, ENVIRON developed quantitative estimates of cancer risks and noncancer hazards associated with the estimated chemical exposures. The estimated risks were then compared to thresholds of significance identified in the BAAQMD CEQA Guidelines. The thresholds in the BAAQMD CEQA Guidelines correspond to levels that would not pose an unacceptable health risk to potentially exposed populations.

The methodology used in this HHRA is consistent with the following risk assessment guidance:

- Air Toxics Hot Spots Program Risk Assessment Guidelines: Part IV Technical Support Document for Exposure Assessment and Stochastic Analysis (California Environmental Protection Agency [Cal/EPA] 2000),
- Air Toxics Hot Spots Program Risk Assessment Guidelines (Cal/EPA 2003),
- BAAQMD CEQA Guidelines: Assessing the Air Quality Impacts of Projects and Plans (BAAQMD 1999),
- BAAQMD Air Toxics Risk Evaluation Procedure and Risk Management Policy (BAAQMD 2000),
- BAAQMD Staff Report (BAAQMD 2005a),
- BAAQMD Air Toxics New Source Review (NSR) Program Health Risk Screening Analysis (HRSA) Guidelines (BAAQMD 2005b),
- U.S. Environmental Protection Agency (USEPA) *Risk Assessment Guidance for Superfund: Volume 1 - Human Health Evaluation Manual (Part A)*. Interim Final. (USEPA 1989a), and
- USEPA *Exposure Factors Handbook* (USEPA 1997a).

1.2 Report Organization

The remainder of this report is organized as follows:

Section 2.0 – Background: presents a description of the Project and regulatory background.

Section 3.0 – Identification of Areas and Chemicals for Evaluation: describes the selection of Project areas and chemicals for evaluation in the HHRA.

Section 4.0 – Exposure Assessment: discusses populations that are potentially exposed to construction PM_{10}, exposure pathways, exposure assumptions, methodology used to estimate airborne PM_{10} concentrations and associated chemical concentrations, and calculation of dose.

Section 5.0 – Toxicity Assessment: describes the toxicity values used to quantify cancer risks and noncancer hazards.

Section 6.0 – Risk Characterization: presents the methods used to estimate cancer risks and chronic noncancer HIs associated with chemicals bound to airborne PM_{10} generated from soils. The risk characterization results are also presented and discussed in this section.

Section 7.0 – Uncertainties: summarizes uncertainties associated with the air dispersion modeling and exposure assumptions used in the HHRA.

Section 8.0 – Conclusions: summarizes the results and conclusions of this HHRA.

Section 9.0 – References: includes all references cited in this HHRA.

2 Background

The following sections describe the Project (Section 2.1) and surrounding area (Section 2.2), and summarize the regulatory framework of the HHRA (Section 2.3).

2.1 Projection Description

Details of the Project have been provided in the Project Description included in Chapter II of the EIR prepared by PBS&J. Based on information provided in this source, the Project will consist of the development of two areas collectively referred to as the Candlestick Point - Hunters Point Shipyard Phase II Development Plan (the "Project"). The description of the Project is organized under two major sub-components: CP and HPS Phase II. The Project comprises the approximately 702-acre area shown on Figure 2-1 and Figure 2-2.

The Project proposed by Lennar Urban includes a mixed-use community with a range of residential, retail, office, research and development (R&D), civic, and community uses, and parks and recreational open space. In addition, a major component would be a new stadium for the San Francisco 49ers, a National Football League (NFL) team. Necessary infrastructure improvements (including several roadway modifications) are also proposed in support of the Project development plan, as shown on Figure 2.2.

A summary of the Project for the CP and HPS Phase II development is provided separately below. A more detailed discussion of the Project is included in Chapter II of the EIR.

Candlestick Point: This area is approximately 281 acres in size. Current land use in the CP area includes Candlestick Park stadium, and associated parking lots and access roadways. The area also includes several vacant, privately-owned parcels that are used primarily for stadium parking. Acquisition of these parcels is anticipated as part of the Project. The CP area also includes the Alice Griffith Housing area, corresponding roughly to CP01 to CP06, shown on Figure 2-2. Approximately 120 acres of the 154-acre Candlestick Point State Recreation Area (SRA) is also included within the Project and forms the southern and eastern shoreline boundary.

The proposed Project for CP includes site preparation activities, including abatement, demolition of existing structures, and grading, and construction of residential units, parks and open space, retail space, community services, office space, hotel accommodations, and a performance arena. The development plan also includes a rebuild of Alice Griffith Housing, which will provide upgraded units to existing residents.

Hunters Point Shipyard Phase II: The HPS Phase II area comprises 421 acres (dry-land) on former Navy Parcels B, C, D, and E. Navy Parcel F comprises approximately 440 acres of submerged lands in San Francisco Bay surrounding the central portion of the HPS Phase II area to the north, east, and south. The entire HPS Phase II area is currently under the jurisdiction of the Navy. The HPS Phase II area includes many structures associated with ship repair, piers, dry-docks, storage, administrative, and other former Navy uses, largely from the World War II era. Most structures are vacant, although several former Navy buildings are currently leased and occupied. Current tenants at the HPS Phase II area include an estimated 252 artists located in studios on Parcels A and B, and a San Francisco Police Department (SFPD) facility on Parcel D-1 in Building 606. The proposed Project plan for this area includes new residential units, parks and open space, R&D, community services, artist studios and centers, neighborhood retail, and a new stadium for the San Francisco 49ers, an NFL team. The stadium parking plan will accommodate parking for stadium events and will serve public recreational uses.

The EIR also examines variants to the Project:

- Variant 1 would include an additional 2.5 million gross square footage (gsf) of R&D space on the proposed stadium site. All other elements of the Project would remain the same.
- Variant 2 would redistribute 1,350 residential units to the proposed stadium site from CP. All other elements of the Project would remain the same.
- A third variant (Variant 3) would include the same land use program and overall description as the Project, with different locations for the residential towers.
- Variant 4 assumes that a new stadium would be constructed and shared between the San Francisco 49ers and the Oakland Raiders football teams. The land use program would remain the same as the proposed Project.

Chapter IV of the EIR analyzes these Variants. Evaluation of the variants in the EIR allows for consideration and approval of these variants without further environmental review. However, a single variant (Variant 4) was selected for evaluation in this HHRA. The construction activities associated with generation of PM_{10} (i.e., demolition and grading) are essentially the same for each of the variants. Consequently, it can be assumed that if, for Variant 4, the risk estimates for chemicals bound to PM_{10} are below BAAQMD significance levels then the risks associated with Variants 1 through 3 would also be below the CEQA significance threshold.

The Project construction activities are anticipated to occur over a 19 year period, beginning in 2010 and concluding in 2028. However, the schedules vary by area as follows: CP (18 years, 2011-2028) and HPS Phase II (nine years, 2010-2018).

2.2 Surrounding Area

The Project comprises an approximately 702-acre area east of U.S. 101 in the southeast area of the City and County of San Francisco and occupies the waterfront area from south of India Basin to Candlestick Cove (Figure 2-1 and Figure 2-2).

The CP area is immediately east of Executive Park, with the Bayview neighborhood to the north, the HPS Phase II area to the northeast, and Candlestick Point SRA along the Bay frontage generally to the east (Figure 2-1). The CP area is generally bounded by Hawes Street to the northwest and Jamestown Avenue to the southwest, the Candlestick Cove and South Basin areas of the Bay are to the south and east, respectively.

The HPS Phase II area is to the southeast of the Bayview Hunters Point neighborhood. As shown on Figure 2-1, the HPS Phase II area is generally bounded by San Francisco Bay to the north, east, and south. The south end of the western boundary extends from Yosemite Slough along Arelious Walker Drive to approximately Crisp Road, excluding the University of California San Francisco (UCSF) property. The northern boundary generally extends along Crisp Road and Spear Avenue. The northernmost end of the HPS Phase II area is contiguous with Earl Street.

Figure 2-3 shows zoning information, obtained from the City of San Francisco, for areas in the immediate vicinity of the Project. To the west of the Project, the city areas are zoned mixed use residential and industrial. The area to the south is zoned for commercial or industrial use. The Project Area is bordered by the San Francisco Bay to the north and east.

2.3 Regulatory Background

This HHRA is prepared in compliance with CEQA. In accordance with CEQA, the excess lifetime cancer risks and chronic noncancer HIs estimated in the HHRA are compared to the BAAQMD CEQA thresholds of significance. Pursuant to BAAQMD *CEQA Guidelines* (BAAQMD 1999), projects that expose the public to toxic air contaminants (TACs)[1] in excess of the following thresholds would be considered to have a significant air quality impact:

- Probability of contracting cancer for the maximally exposed individual (MEI) exceeds 1×10^{-5} (10 in a million);
- Ground level concentrations of noncarcinogenic TACs resulting in a HI greater than 1 for the MEI.

[1] Although the BAAQMD guidelines refer to chemicals specifically identified as TACs, this HHRA evaluates TACs and chemicals not specifically identified as TACs, as described in Section 3.

3 Identification of Areas and Chemicals for Evaluation

This section identifies the areas and associated chemicals within the CP and HPS Phase II areas that are quantitatively evaluated in the HHRA[2]. The approach for HPS Phase II is described first because the approach used for CP is based on ambient soil concentrations and screening levels developed by the Navy for HPS.

3.1 HPS Phase II

The Navy directed a series of comprehensive environmental investigations and HHRAs at the former HPS. The selection of areas and chemicals for evaluation in this HHRA is based on information and analytical results presented in the Navy HHRA reports. The general framework of the Navy HHRAs is summarized below, followed by a description of the approach ENVIRON used for identifying areas and chemicals for quantitative evaluation in this HHRA.

To organize and expedite the environmental investigations, the Navy divided the former HPS into five contiguous geographic parcels (Parcels A, B, C, D, and E). A sixth parcel (Parcel F, the offshore area) was added in 1996, and in 2004, a separate parcel (Parcel E-2) was carved out of Parcel E. Further, in 2008, the Navy divided Parcel D into four new parcels, D-1, D-2, G, and UC-1, and carved Parcel UC-2 out of Parcel C. Parcel A, which was previously transferred to the City and County of San Francisco is not part of the Project. Construction dusts would not be associated with Parcel F, which comprises underwater sediments in the offshore area. Therefore, with the exception of Parcels A and F, all HPS Parcels were evaluated in this HHRA. A detailed discussion of completed and ongoing environmental investigation and remediation activities is given in Chapter III of the EIR prepared by PBS&J.

The Navy applied a consistent investigation and risk assessment approach for each of the Parcels. Specifically, each Parcel was divided into "redevelopment blocks," corresponding to the future reuse (e.g., residential or recreational) outlined in the Hunters Point Shipyard Redevelopment Plan (San Francisco Redevelopment Agency [SFRA] 1997). The Navy HHRAs identified the proposed future use and associated soil cleanup levels (corresponding to residential, industrial, or recreational levels) for each redevelopment block.

The selection of areas for evaluation in this HHRA was based on ENVIRON's understanding of the environmental condition of the Parcels and/or redevelopment blocks within a Parcel at the time Project construction activities will commence, as provided by Lennar Urban and MACTEC. Specifically, if a redevelopment block (within a Parcel) is designated for residential use (including mixed use), ENVIRON assumed that the redevelopment block had been remediated to residential

[2] The constituents evaluated in this HHRA include inorganic and organic chemicals. All radiological contamination at the HPS Phase II area will be remediated and/or institutional controls will be in place to restrict access to radiologically-impacted areas. Further, asbestos is excluded because ENVIRON understands that airborne asbestos levels will be monitored and controlled during Project construction activities.

cleanup levels prior to construction activities, and the redevelopment block was excluded from the analysis; all remaining redevelopment blocks within a Parcel were identified for quantitative evaluation. This is a conservative approach in that it is possible that areas designated for nonresidential uses will also have been remediated prior to construction activities. However, because residual concentrations in soil in these areas may remain above residential levels, as a screening-level approach, ENVIRON conservatively assumed that nonresidential areas had not been remediated.

The assumed environmental condition of each Parcel (or redevelopment block within a Parcel) and the source of the analytical results used for chemical selection is provided below:

- **Parcel B**. ENVIRON assumes that Parcel B is transferred prior to completion of proposed remedial activities, with the exception of one area. The one exception is the area formerly designated as Installation Restoration (IR) Site 7/18. ENVIRON understands that the Navy will remediate the IR Site 7/18 area (identified as having radiological impacts) prior to transfer. The proposed remediation includes placement of a clean soil cover and installation of a demarcation layer to mark the boundary between the existing surface and new soil cover. ENVIRON assumes that the analytical results for chemicals in soils reported in *Final Parcel B Technical Memorandum in Support of a Record of Decision Amendment* (ChaduxTt 2007) are representative of soil conditions for the remaining Parcel B areas at the time of Project construction activities.
- **Parcels C and UC-2**. ENVIRON assumes that all areas within Parcels C and UC-2 that are designated for remediation to residential cleanup levels will have been remediated prior to Project construction activities. The remediated areas are excluded from the quantitative analysis. For the remaining areas (i.e., areas designated for remediation to industrial or recreational cleanup levels), ENVIRON assumes that soils have not been remediated and that the analytical results for chemicals in soils reported in the *Draft Final, Revised Feasibility Study Report for Parcel C* (SulTech 2008) are representative of soil conditions for the unremediated redevelopment blocks at the time of Project construction activities.
- **Parcels D-1, D-2, and UC-1.** ENVIRON assumes that all redevelopment blocks within Parcels D-1, D-2, and UC-1 that are designated for remediation to residential cleanup levels will have been remediated prior to Project construction activities. The remediated areas are excluded from the quantitative analysis. For the remaining areas, ENVIRON assumes that soils have not been remediated and that the analytical results for chemicals in soils reported in the *Final Revised Feasibility Study for Parcel D* (SulTech 2007) are representative of soil conditions at the time of Project construction activities.
- **Parcels E and UC-3**. ENVIRON assumes that all redevelopment blocks within Parcel E that are designated for remediation to residential cleanup levels will have been remediated prior to Project construction activities. The remediated areas are excluded from the quantitative analysis. The area along the shoreline that has been designated as

radiologically-impacted is also excluded based on ENVIRON's understanding that the Navy will remediate the area prior to transfer, including placement of a clean soil cover and installation of a demarcation layer to mark the boundary between the existing surface and the new soil cover. For the remaining areas, ENVIRON assumes that soils have not been remediated and that the analytical results for chemicals in soils reported in the *Final Revised Remediation Investigation Report for Parcel E* (Barajas & Associates 2008) are representative of soil conditions at the time of Project construction activities.

- **Parcel E-2.** Parcel E-2 comprises a closed industrial landfill, and shoreline and lowland coastal areas; much of the area occupied by Parcel E-2 has been designated as radiologically impacted. Designated reuse at Parcel E-2 is for open space, except for a small area designated for industrial and R&D reuse (Engineering/Remediation Resources Group, Inc. and Shaw Environmental, Inc. 2007). ENVIRON understands that at the time of transfer, restrictive covenants will be incorporated to prohibit certain construction activities within a specified distance of the Parcel E-2 boundary, including the area designated for industrial and R&D reuse. Based on these factors, ENVIRON assumes that all remediation activities will have been completed prior to Project construction activities and that covenants would restrict dust-generating activities below the level of clean soil placed over Parcel E-2.
- **Parcel G.** ENVIRON assumes that Parcel G is transferred prior to completion of remedial activities and that the analytical results for chemicals in soils reported in the *Final Revised Feasibility Study Report for Parcel D* (SulTech 2007) are representative of soil conditions at the time of Project construction activities.

For each redevelopment block retained for evaluation in the HHRA, all organic chemicals (other than volatile organic chemicals [VOCs]) detected within the 0 to 10 foot depth interval were identified for evaluation. Although it is likely that only relatively shallow soils from the 0 to 2 foot or 0 to 5 foot interval will be disturbed during demolition and grading activities, ENVIRON used soil analytical results for the 0 to 10 foot depth interval. This is because soil analytical results for the 0 to 2 foot interval were limited in some areas and a separate reporting of results for the 0 to 5 foot depth interval were not available. Thus, the analytical results for the 0 to 10 foot interval provided the most comprehensive set of analytical results. VOCs were excluded because these chemicals would volatilize into the air and not bind to dust particles. The organic chemicals identified for evaluation include semivolatile organic chemicals (SVOCs), polynuclear aromatic hydrocarbons (PAHs), pesticides, polychlorinated biphenyls (PCBs), and dioxins.

For inorganic chemicals, chemicals considered to be essential human nutrients (that is, calcium, magnesium, potassium, and sodium) were excluded from the analysis because of their recognized low toxicities. In addition, because metals occur naturally in soils, metals for which the maximum measured concentrations were equal to or less than ambient levels established in the Navy HHRAs, were also excluded from the analysis. Exclusion of essential nutrients and metals present at ambient levels is consistent with risk assessment guidance (USEPA 1989a). All inorganic chemicals above ambient levels or for which ambient levels were not established were retained and evaluated quantitatively.

The chemicals identified for quantitative evaluation are shown in Table 3-1.

3.2 Candlestick Point

Analytical results for chemicals in soils within the CP area were available from two investigations conducted by Geomatrix Consultants, Inc. (Geomatrix): *Site Investigation and Risk Evaluation Report for the Proposed San Francisco 49ers Stadium and Mall Site: North Park and Last Port Areas* (Geomatrix 1998a) and *Addendum 1 to the Site Investigation and Risk Evaluation Report for the Proposed San Francisco 49ers Stadium and Mall Site: North Park and Last Port Areas* (Geomatrix 1998b).

Chemicals for evaluation were selected using the analytical results for soil samples collected from the 0 to 5 foot depth interval reported in these two documents. Similar to the approach used for HPS Phase II, all organic chemicals detected at concentrations exceeding the residential screening levels derived by the Navy for HPS were retained for evaluation. For inorganic chemicals, essential nutrients and metals at or below ambient levels were excluded from the evaluation. All remaining inorganic chemicals were retained for evaluation. The chemicals identified for quantitative evaluation are shown in Table 3-1.

It is noted that for some analyses, the reported detection limits were elevated. That is, although the analytical results were reported as “not detected,” the detection limits were higher than residential screening levels. The quality of this data was considered inadequate to support the data needs of this HHRA, and these results are not used in the HHRA.

4 Exposure Assessment

The USEPA (1989a) defines exposure as "the contact of an organism with a chemical or physical agent" and defines the magnitude of exposure as "the amount of the agent available at the human exchange boundaries of the organism (e.g., skin, lungs, gut) and available for absorption." Exposure assessments are designed to determine the degree of contact a person has with a chemical. The components of the exposure assessment include the identification of potentially exposed populations, the identification of exposure pathways, estimation of the soil source terms[3] and the chemical concentrations associated with PM_{10} at the receptor locations, and the selection of exposure assumptions to quantify chemical intakes.

4.1 Potentially Exposed Populations

To evaluate the potential human health risks posed by a site or project, it is necessary to identify the populations that may be exposed to the chemicals present and to determine the pathways by which exposures may occur. Identification of potentially exposed populations requires evaluating the human activity and land-use patterns at and in the vicinity of the site or project. The populations considered in this HHRA include offsite receptors in the vicinity of the Project and onsite receptors within the onsite Alice Griffith Housing area.

Land use in the area surrounding the Project is generally zoned for residential, commercial, industrial, or a variety of mixed uses. Consequently, offsite residents (children and adults) and offsite workers are identified for evaluation in this HHRA. Offsite receptor locations evaluated in the HHRA are shown on Figure 4-1a. Consistent with BAAQMD CEQA guidelines (1999), cancer risks and HIs are also reported for the location of the maximally exposed individual resident (MEIR) and the maximally exposed individual worker (MEIW). The MEIR and MEIW are defined as the receptor locations where individuals may reside or work with the maximum estimated excess lifetime cancer risk or noncancer HI (Cal/EPA 2003).

Potential offsite sensitive populations are also identified for evaluation in this HHRA based on guidance from the District (BAAQMD 2005a) and Cal/EPA (2003). The offsite sensitive receptors identified for the HHRA include K-12 schools within a one kilometer (km) radius of the Project Area. The offsite sensitive receptor locations identified for the Project are also shown on Figure 4-1a.

Onsite residents within the Alice Griffith Housing area are also identified for evaluation in this HHRA (Figure 4-1b). As stated in the Chapter II of the EIR, the proposed Project includes rebuilding Alice Griffith Housing to provide one-for-one replacement units and ensuring that

[3] The soil source term represents the soil concentration of each chemical identified for evaluation in Section 3 that is used to estimate the chemical concentration in PM_{10}. The estimated concentration of each chemical in PM_{10} at the point of contact with the receptor is assumed to be proportional to the soil source term.

eligible Alice Griffith Housing residents have the opportunity to move to the new, upgraded units directly from their existing Alice Griffith Housing units without having to relocate to any other area. Based on the proposed plan outlined in the EIR, it is anticipated that construction activities within the Alice Griffith Housing area will be phased by parcel. While construction occurs at one parcel, residents will continue to reside at the remaining parcels.

Onsite workers are not evaluated, as it is ENVIRON's understanding that onsite workers are protected by the California Occupational Safety and Health Administration (Cal/OSHA) in accordance with State health and safety requirements (8 CCR § 5194).

4.2 Exposure Pathways

Once potentially exposed populations are identified, the complete exposure pathways by which individuals in each of these populations may be exposed to chemicals bound to PM_{10} from Project construction activities are determined. An exposure pathway is defined as "the course a chemical or physical agent takes from a source to an exposed organism" (USEPA 1989a). A complete exposure pathway requires the following four key elements:

- Chemical source,
- Migration route (i.e., environmental transport),
- An exposure point for contact (e.g., air), and
- Human exposure route (e.g., inhalation).

An exposure pathway is not complete unless all four elements are present.

Inhalation exposures were quantitatively evaluated for all receptors. In addition, a sensitivity analysis – referred to as a multipath analysis – was conducted for specific chemicals to evaluate the potential contribution of other, noninhalation exposure pathways. Specifically, airborne dusts released during construction activities could deposit on soils such that exposures could also occur through other pathways, including incidental ingestion of and dermal contact with soil (for all receptors), and ingestion of produce grown in residential gardens (for residents). The multipath analysis is presented in the Section 7.

4.3 Exposure Assumptions

The exposure parameters listed below for estimating exposures (intakes)[4] for the evaluation of cancer risks for the offsite and onsite populations evaluated in the HHRA were obtained from risk assessment guidelines from BAAQMD, Cal/EPA, and USEPA, with the exception of Project-

[4] Intake estimates are used only for estimating lifetime cancer risks. Estimates of noncancer health effects are based on air concentrations, as described in Section 6.

specific exposure durations. Project demolition and grading activities are anticipated to occur over a 19-year period beginning in 2010 and ending in 2028, with activities in the CP and HPS Phase II areas spanning various periods during this interval. As such, the exposure duration assumed for each receptor was limited by the planned construction periods for each area and the Project as a whole as follows:

- CP – Planned construction from 2011 to 2028 (18 years)
- HPS Phase II – Planned construction from 2010 to 2018 (9 years)
- Total Project – Planned construction from 2010 to 2028 (19 years)

The population-specific exposure parameters are discussed below and are summarized in Table 4-1. The Project-specific exposure durations are summarized in Table 4-2.

4.3.1 Offsite and Onsite Residents

For this HHRA, as a conservative (i.e., health-protective) approach, ENVIRON assumed that residents are present at their residence for 24 hours per day, 350 days per year (USEPA 1989a, 1991; Cal/EPA 2003). However, adults spend only 68 to 73% of their total daily time at home (USEPA 1997a), rather than the 100% assumed in this HHRA. Accordingly, the actual risks to residents in the vicinity of the Project Area are likely to be lower than those estimated in this HHRA.

The Office of Environmental Health Hazard Assessment (OEHHA) risk assessment guidelines provide guidance for estimating risks based on “average” and “high-end” exposure conditions (Cal/EPA 2003). Consistent with this guidance, the HHRA includes an evaluation of average and high-end exposure conditions. Average exposure conditions represent an exposure scenario based on 50^{th} percentile or average exposure parameters. According to OEHHA, a high-end value should be chosen so that the potential incremental cancer risk will not be underestimated.

For adult residents, the high-end and average inhalation rates are 19 cubic meters per day (m^3/day) (equivalent to 302 liters per kilogram per day [L/kg-day]) (BAAQMD 2005b, Cal/EPA 2003) and 17 m^3/day [271 L/kg/day] (Cal/EPA 2003), respectively. [5] The high-end estimate is representative of the 80th percentile breathing rate recommended by BAAQMD (2005b) and Cal/EPA (2003) for risk management decisions. The default body weight for an adult resident is 63 kg (Cal/EPA 2003).

[5] For the purposes of this analysis, each inhalation rate is presented in units of cubic meters per day (m^3/day) and liters per kilogram day (L/kg-day). The inhalation rates are mathematically equivalent but are presented in both units to reflect differences in the units presented in the reference guidance. The daily inhalation rate is calculated by multiplying the default inhalation rate by the default body weight and a conversion factor of 1000 L/m^3.

For child residents, the high-end and average inhalation rates are 10 m^3/day [581 L/kg-day] (BAAQMD 2005b; Cal/EPA 2003) and 8 m^3/day [452 L/kg/day] (Cal/EPA 2003), respectively. [6] The default body weight for a child resident is 18 kg (Cal/EPA 2003). Child residents are assumed to be exposed for 9 years, as recommended by BAAQMD (2005b) and Cal/EPA (2003). To be conservative (i.e., health-protective), a nine year rolling average PM_{10} concentration was used to estimate potential risks for a child. The nine-year rolling average reflects the highest concentrations that may occur within the 19 year Project period.

The default inhalation absorption factor of one was used for both adult and child offsite residents (Cal/EPA 2003).

4.3.2 Offsite Workers

Offsite workers are assumed to be exposed to Project construction PM_{10} emissions eight hours per day for 245 days per year (BAAQMD 2005b; Cal/EPA 2003). The breathing rate for a worker is 1.3 cubic meters per hour (m^3/hour) over an eight hour work-day, which corresponds to a daily breathing rate of 10 m^3/day [149 L/kg-day]. The default body weight for the offsite worker is 70 kg (Cal/EPA 2003).

The default inhalation absorption factor of one was used for the offsite worker (Cal/EPA 2003).

4.3.3 Offsite Sensitive Receptors

As discussed in Section 4.1, potential offsite sensitive populations were identified for evaluation in this HHRA based on guidance from the District (BAAQMD 2005a) and Cal/EPA (2003). As discussed in Section 4.1, offsite sensitive receptors identified for this evaluation include K-12 schools within a one kilometer radius surrounding the Project.

As recommended by the BAAQMD, the exposure time is assumed to be 10 hours per day and is representative of a school day (BAAQMD 2005b). The exposure frequency and duration were assumed to be 180 days per year for nine years (BAAQMD 2005b). A high-end breathing rate of 10 m^3/day recommended for a child population was used (BAAQMD 2005b; Cal/EPA 2003).[7] The default body weight for a school child is 18 kg (Cal/EPA 2003).

The default inhalation absorption factor of one was used for the offsite sensitive receptors (Cal/EPA 2003).

---

[6] *Ibid.*
[7] *Ibid.*

4.4 Soil Source Terms

Soil source terms, used to estimate chemical concentrations in PM_{10} emissions from Project Areas, are derived as follows:

- A spatial analysis is conducted using overlays of the Project Phase Areas and the CP sampling locations and the HPS redevelopment blocks.
- For CP, soil source terms are derived for each Project Phase Area. For each chemical identified for evaluation within a Project Phase Area (as described in Section 3), the maximum detected concentration for any sample collected within the 0 to 5 foot depth interval is used as the soil source term.
- For HPS Phase II, soil source terms are derived for each redevelopment block included in the evaluation. The maximum exposure point concentration[8] derived by the Navy for grids within the redevelopment block is used as the soil source term.

4.5 Emissions Estimation

This section describes the estimation of PM_{10} emissions associated with construction activities at the Project, including the selection of emission factors and assumptions for the emissions estimates and the mitigation measures considered. These emissions estimates are used to develop PM_{10} concentrations (and the associated concentrations of chemicals bound to PM_{10}) at the receptor locations using air dispersion modeling techniques.

Fugitive PM_{10} emissions are caused by soil-disturbing activities. ENVIRON assumed that such activities would only occur during demolition and grading phases, as discussed below.

For the demolition phase, ENVIRON conservatively assumed that PM_{10} would be emitted from the soils beneath the developed areas (i.e. paved areas or areas with existing buildings) within the designated construction domain during demolition activities (e.g., removal of building slabs, wall foundations, paved areas, including roads and parking lots, and utilities beneath paved areas). These areas were identified based on the construction schedule provided by MACTEC on behalf of Lennar Urban. Based on a recommendation from MACTEC, ENVIRON assumed that for the demolition phases with numerous existing structures (HPS Parcels B, C, D and E), approximately 75% of the effort would be spent on aboveground building demolition which does not disturb soils beneath while 25% would be the activities described above which may disturb soils beneath. For

[8] In the Navy HHRAs, each Parcel (and redevelopment block within a Parcel) was divided into 50-foot by 50-foot exposure areas (referred to as grids). For each combination of grid and detected chemical, the HHRA derived an exposure point concentration. For grids with more than four samples and four detected results, the exposure point concentration was the 95 percent upper confidence limit (95 UCL) of the arithmetic mean, unless the maximum value was less then the 95 UCL, in which case, the maximum concentration was used as the exposure point concentration. For grids with less than four samples and four detected results, the Navy identified the maximum detected concentration as the exposure point concentration.

these parcels, PM_{10} emissions were calculated based on 25% of the total demolition phase duration. For other parcels (HPS Parcel G and all CP parcels), 100% of the demolition phase duration was used to estimate PM_{10} emissions.

For the grading phase, ENVIRON assumed that soils over the entire designated construction domain would be disturbed for the complete grading phase duration.

The PM_{10} emissions associated with demolition and grading activities were calculated using the following formula from URBan EMISsions Model (URBEMIS 2007) version 9.2.4:

$$PM_{10} \text{ Emissions (ton)} = EF \times A \times D$$

where:

EF = Emission Factor (ton/acre-month)

A = Disturbed Area (acre)

D = Phase Duration (month)

ENVIRON used the emission factors for site grading developed for South Coast Air Quality Management District (SCAQMD) by the Midwest Research Institute. As recommended by the URBEMIS 2007, ENVIRON assumed 25% of the total construction area is disturbed on the worst case day.

URBEMIS 2007 specifies that 21% of PM_{10} emissions calculated using the above methodology are from unpaved roads and that the remaining 79% is from soil-disturbing activities. ENVIRON assumed that Lennar would apply the same mitigation measures (presented below) for both PM_{10} emission sources as used during the HPS Phase I construction.

For PM_{10} emissions from soil-disturbing activities, the mitigation measures include:

- Apply soil stabilizer to inactive areas,
- Replace ground cover quickly, and
- Water exposed surfaces twice daily.

For PM_{10} emissions from unpaved roads, the mitigation measures include:

- Reduce vehicle speed on unpaved roads to less than 15 miles per hour (mph), and
- Manage haul road dust by watering the roads three times daily.

Table 4-3 presents the emission reduction percentages associated with these measures.

4.6 Estimated PM_{10} Air Concentrations

This section describes the estimation of PM_{10} air concentrations at offsite receptor locations potentially exposed to chemicals bound to PM_{10} emissions from Project construction activities. Section 4.5.2 details the air dispersion modeling, including model selection, source configuration, use of site-specific meteorological data and identification of receptor locations. The modeled concentrations were then used to estimate potential exposures and health risks, as described in Section 6.

ENVIRON conducted air dispersion modeling to estimate the PM_{10} concentrations associated with construction emissions from the Project as characterized in Section 4.4. The air dispersion analysis was performed in accordance with USEPA, Air Resources Board (ARB), and BAAQMD modeling guidelines (USEPA 2005a; Cal/EPA 2003; BAAQMD 2005b). The air dispersion analysis requires the following: (1) selection of the dispersion model, (2) selection of appropriate dispersion coefficients based on land use, (3) preparation of meteorological data, (4) evaluation of potential terrain considerations, (5) selection of receptor locations, and (6) identification of the source specific release parameters, operational schedule, and averaging time periods. The following sections describe each of these steps.

4.6.1 Air Dispersion Model Selection

ENVIRON used the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) version 07026, which is the USEPA recommended air dispersion model (USEPA 2004). AERMOD was developed as a replacement for USEPA's Industrial Source Complex Short Term (ISCST3) air dispersion model to improve the accuracy of air dispersion model results for routine regulatory applications and to incorporate the progress of scientific knowledge in atmospheric turbulence and dispersion. This change was made in November 2005 (USEPA 2005a).

Air modeling dispersion factors (i.e., concentration per unit emission rate), sometimes called "chi-over-Q" ("χ/Q"), were estimated for the simulated dispersion sources (i.e., PM_{10} generation from construction activities) using AERMOD in conjunction with information about the locations of the sources and receptors, as well as assumptions about the nearby land use.

The following equation was used to estimate annual average concentrations from the modeled dispersion factor:

$$\text{Annual Average Concentration} = \left(Q_{annual} \times \left(\frac{\chi}{Q} \right)_{annual} \right)_i$$

where:

Q = emission rate of PM_{10} (grams [g]/second [s])

$\left(\frac{\chi}{Q}\right)$ = dispersion factor (μg/m^3)/(g/s)

I = stack source

The results of the air dispersion analysis were used in conjunction with the PM_{10} emissions rates discussed in Section 4.5 to estimate concentrations of PM_{10} and associated chemicals at the receptor locations.

4.6.2 Urban Heat Island Effect

As determined in the land use analysis discussed in Attachment V, the sources are not located in an urban area and therefore the urban boundary layer option was not selected in AERMOD.

4.6.3 Meteorological Data

As discussed in Attachment V, ENVIRON used meteorological data collected from a meteorological station installed at the Hunter's Point Shipyard for a period from October 1, 2002 through September 30, 2003. This location was determined to be the most representative meteorological data available for air dispersion modeling for the Project, as it was onsite. Meteorological data for use in AERMOD were processed in accordance with the AERMOD Implementation Guidance released in January 2008. A description of meteorological data processing and processed meteorological data ready for use in AERMOD can be found in Attachment V. As discussed later in Section 4.6.5, construction equipment is assumed to operate eight hours per day (from 7 am to 3 pm) and the wind rose for this period is shown on Figure 4-2.

4.6.4 Terrain

An 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). Complex terrain can affect the results of a dispersion analysis involving point and volume sources, but does not affect the predicted results for area sources (USEPA 2005b). Terrain elevations were obtained from United States Geological Survey (USGS) National Elevation Dataset (NED) for the San Francisco area and imported to sources and receptors using AERMAP, a data preprocessing module associated with AERMOD.

4.6.5 Source Configuration

For the CP and HPS Phase II projects, MACTEC, on behalf of Lennar, provided a detailed map of Project Phase Areas ranging in size from 2 acres to 75 acres. As discussed earlier in Section 4.4, a spatial analysis was conducted using overlays of the Project Phase Areas and the CP sampling locations and the HPS redevelopment blocks to develop distinct areas sources used in air dispersion modeling the construction PM_{10} emissions, as shown in Figure 4-3.

Since the BAAQMD has not developed specific methodologies for modeling construction emissions, construction activity was modeled using the Localized Significance Thresholds (LST) methodology developed by the SCAQMD. The PM_{10} emissions associated with construction activities were represented by ground level area sources with one meter of the initial vertical dimension. ENVIRON conducted the modeling analysis on a year-by-year basis to account for the relocation of construction activities as the Project progresses. The construction source parameters used in the air dispersion model are summarized in Table 4-4.

4.6.6 Receptors

As discussed earlier, a grid receptor spacing of 50 meters was used up to approximately one km from the Project boundaries (as shown on Figure 4-1).

4.6.7 Modeling Adjustment Factors

OEHHA recommends that an adjustment be applied to the modeled air concentration if it is different from the air concentration that the worker breathes when present at the site (Cal/EPA 2003). Since the construction PM10 air concentrations were modeled based on a continuous averaging time (i.e., 24 hours, 7 days per week), an adjustment must be applied to account for receptors that are concurrently present with construction activities resulting in PM_{10} emissions. The modeling adjustment factors for offsite residents, offsite workers, and offsite sensitive receptors are discussed below.

4.6.7.1 Offsite Residents

Offsite residents are assumed to be present at their residence 24 hours per day, seven days per week. This assumption is consistent with the modeled annual average air concentration. Thus, the modeling adjustment factor for the adult and child resident is one.

4.6.7.2 Offsite Worker

As recommended by *Air Toxics Hot Spots Risk Assessment Guidelines* (Cal/EPA 2003), a modeling adjustment factor of 4.2 was applied to the predicted annual average concentration (based on 24 hours per day) for offsite workers to account for a construction schedule of approximately 8 hours per day and 5 days per week ([24/8] * [7/5] = 4.2). This concentration represents the theoretical maximum 8-hour concentration over the 5-day operating period to which the offsite workers might be exposed.

4.6.7.3 Offsite Sensitive Receptors

An adjustment factor of 3.36 was applied to the predicted annual average concentration (24-hour concentration) for the school child to account for a construction schedule of approximately 10 hours per day and five days per week ([24/10] * [7/5] = 3.36). This concentration represents the theoretical maximum 10-hour concentration over the five-day operating period to which the school child might be exposed.

4.6.8 Exposure Point Concentrations

The exposure point concentrations were calculated using the following equation:

$$Ca = \text{Annual Average Concentration} \times T$$

where:

Ca = Exposure point concentration in air (micrograms [µg]/m^3)

T = Modeling-adjustment factor (unitless)

The PM_{10} ambient air concentrations for the MEIR (adult and child), MEIW, and MEI sensitive receptor are shown in Table 4-5.

4.7 Calculation of Dose

For determining exposure to a carcinogenic chemical, the dose estimated for the inhalation pathway is a function of the concentration of a chemical in air, C_i, and the intake of that chemical. The dose for inhalation, $Dose_{inh}$, is calculated as follows:

$$Dose_{inh} = \frac{Ca \times IR \times EF \times ED \times F \times A \times CF}{BW \times AT}$$

where:

$Dose_{inh}$ = Dose of a chemical (milligrams [mg] chemical/kg body weight-day),

Ca = Annual average concentration of chemical in air (µg/m^3)

IR = Inhalation Rate (m^3/day)

EF = Exposure Frequency (days/year)

ED = Exposure Duration (years)

F = Fraction of day exposed (hours/24 hours)

A = Inhalation Absorption Factor (unitless)

CF = Conversion Factor (mg/µg)

BW = Body Weight (kg)

AT = Averaging Time (days)

5 Toxicity Assessment

The toxicity assessment characterizes the relationship between the magnitude of exposure and the nature and magnitude of adverse health effects that may result from such exposure. For purposes of calculating exposure criteria to be used in risk assessments, adverse health effects are classified into two broad categories – cancer and noncancer endpoints. Toxicity values used to estimate the likelihood of adverse effects occurring in humans at different exposure levels are identified as part of the toxicity assessment component of a risk assessment.

This section discusses the source of toxicity values for the chemicals evaluated and outlines the methodology used to evaluate dioxins and PCBs. The inhalation cancer potency factors (CPFs) and Reference Exposure Levels (RELs) used in this HHRA are presented in Table 5-1.

5.1 Sources of Toxicity Values

The hierarchy of sources for the toxicity values used in this assessment corresponds to the Cal/EPA (1994) guidelines as follows:

- Cal/EPA OEHHA Table of Approved Cancer Potency Factors (CPFs) (Cal/EPA 2009) and Table of All OEHHA Acute, 8-hour, Chronic RELs (Cal/EPA 2008).
- USEPA's Integrated Risk Information System (IRIS) (USEPA 2009a). IRIS is an on-line database that contains USEPA-approved oral and inhalation toxicity values.
- USEPA's Provisional Peer Reviewed Toxicity Values (PPRTVs). PPRTVs are interim toxicity values developed by the Office of Research and Development/National Center for Environmental Assessment/Superfund Health Risk Technical Support Center (as cited in USEPA 2009b)
- USEPA's National Center for Environmental Assessment (NCEA)
- USEPA's Health Effects Assessment Summary Tables (HEAST) (USEPA 1997b). HEAST provides an older listing of provisional toxicity values.

To maintain consistency with previous HHRAs completed by the Navy for the former HPS and approved by the regulatory agencies, route-to-route extrapolation from oral to inhalation toxicity values for the noncancer endpoints was used for organic compounds without published inhalation toxicity values in the sources identified above.[9] Route-to-route extrapolations were not conducted for metals because their toxicological endpoints and dose-response relationships are heavily dependent on the exposure route. However, for most metals, a toxicity value was available to

[9] Oral reference doses (RfDs) in units of milligrams per kilogram per day (mg/kg-day) were converted to equivalent RELs assuming a breathing rate of 20 m^3/day and a body weight of 70 kg.

evaluate either the cancer or noncancer health effect for the inhalation exposure route. That is, an inhalation CPF or REL was available to evaluate the inhalation route.

5.2 Dioxins, Furans and Polychlorinated Biphenyls

The methodology for assessing the carcinogenicity of dioxins, furans and PCBs prescribed in Cal/EPA's Technical Support Document for Cancer Potency Factors (Cal/EPA 1999) was used in this HHRA. Cal/EPA (1999) utilizes the 1997 World Health Organizations (WHO) Toxicity Equivalency Factor (TEF) scheme for estimating the cancer risk of dioxins and dioxin-like compounds (including dioxin-like furans and PCBs). For consistency with previous HHRAs completed by the Navy and approved by the regulatory agencies, surrogate toxicity values were used for some PCBs (specifically, Aroclors) for which toxicity values were not available.

6 Risk Characterization

Risk characterization involves the description of the nature and magnitude of human risk, including the associated uncertainty (National Research Council [NRC] 1983). The risk characterization integrates the results of the exposure and effects analyses to evaluate the likelihood of adverse effects associated with exposures to chemicals bound to PM_{10} emitted during Project construction activities. An important step of the risk characterization process is the evaluation of uncertainty associated with the risk estimates (USEPA 1989a). Cancer risks and noncancer HIs were estimated for the populations identified in Section 4.1. The exposure parameters (Section 4.3), representative concentrations (Section 4.5), and agency-approved toxicity values (Section 5.0) are used to estimate the cancer risks and noncancer HIs.

The results of this HHRA are presented as estimated cancer risks and noncancer hazards. Cancer risk estimates represent the probability of cancer (presented as a probability per million people) related to potential exposures to chemicals bound to construction PM_{10} estimated in this HHRA. Noncancer hazards are represented as the ratio between the estimated air concentrations of chemicals bound to PM_{10} and the REL. The cancer risk or noncancer HIs estimated in this HHRA are then compared to CEQA thresholds identified by the BAAQMD (1999) to determine if significant impacts are associated with Project construction PM_{10} emissions.

As outlined in Section 4.1, separate estimates of the cancer risks and noncancer HIs were derived for chemicals bound to construction PM_{10} from demolition and grading activities at CP and HPS Phase II. In addition, human health effects attributed to chemicals bound to construction PM_{10} from the total Project are quantified.

This section presents the methods used to estimate cancer risks and noncancer hazards and the results of the HHRA. The associated uncertainties are discussed in Section 7.

6.1 Risk Characterization Methodology

The sections below discuss the methods used to estimate cancer risks and chronic noncancer hazards for potentially exposed populations.

6.1.1 Estimation of Cancer Risks

Excess lifetime cancer risks are estimated as the upper-bound incremental probability that an individual will develop cancer over a lifetime as a result of exposure to potential carcinogens. The estimated risk is expressed as a unitless probability. The cancer risk attributed to a chemical is calculated by multiplying the chemical intake or dose by the chemical-specific CPF.

The equation used to estimate the potential cancer risk for each year is as follows:

$$Risk_i = \Sigma\ [Dose_{inh,j} \times CPF_j]$$

where:

$Risk_i$ = Cancer Risk for year i; the probability of an individual developing cancer to chemicals bound to airborne PM_{10} (unitless)

$Dose_{inh,j}$ = Inhalation dose of chemical j (mg chemical/kg body weight-day)

CPF_j = Cancer Potency Factor for chemical j ([mg chemical/kg body weight-day]$^{-1}$)

As discussed previously, cancer risks were estimated on a year-by-year basis. To estimate the total excess lifetime risk, the year-by-year risk estimates are summed for each receptor population over the duration of demolition and grading activities for each of CP, HPS Phase II, and total Project as follows:

$$Risk_{Total} = \Sigma\, Risk_i$$

6.1.2 Estimation of Chronic Noncancer Hazard Indices

The potential for exposure to result in chronic noncancer effects is evaluated by comparing the estimated average air concentration (which is equivalent to the average daily air concentration) to the chemical-specific noncancer chronic REL, as follows:

$$HQ_j = C_j/cREL_j$$

$$HI = \Sigma HQ_j$$

where:

HQ_j = Hazard Quotient for chemical j

C_j = Average Daily Air Concentration for chemical j (µg/m^3)

$cREL_j$ = Chronic noncancer Reference Exposure Level for chemical j (µg/m^3)

HI = Hazard Index

6.2 Risk Characterization Results

To focus the presentation and evaluation of the risk assessment results, the estimated cancer risks and noncancer HIs are discussed relative to significance thresholds identified by the

BAAQMD for the MEI (BAAQMD 1999). According to the BAAQMD *CEQA Guidelines*, the current significance threshold is a cancer risk greater than ten in one million (1×10^{-5}) and a noncancer HI of greater than one for the MEI. Planned projects that do not have the potential to expose the public to chemicals of concern in excess of these thresholds would not be considered to have a significant air quality impact.

This section compares the estimated risks and noncancer hazards for each population in relation to significance thresholds under CEQA for CP, HPS Phase II, and the total Project. The cancer risks and noncancer HIs presented below are also summarized in Tables 6-1 and 6-2, respectively.

6.2.1 Offsite Residents

All estimated excess lifetime cancer risks and noncancer HIs for offsite residents associated with chemicals bound to construction PM_{10} emissions attributable to CP, HPS Phase II, and the total Project are below the BAAQMD significance thresholds of 10 in a million and one, respectively.

As summarized in Table 6-1, the estimated cancer risks for the offsite MEIR–adult resident are 1 in 100 million (i.e., 0.01 in a million [0.01×10^{-6}]), 4 in a billion (i.e., 0.004 in a million [0.004×10^{-6}]), and 1 in 100 million (i.e., 0.01 in a million [0.01×10^{-6}]) using high-end exposure assumptions for CP, HPS Phase II, and the total Project, respectively. The estimated cancer risks for the offsite MEIR–adult using average exposures are slightly lower than those estimated using high-end exposure assumptions.

As summarized in Table 6-1, the estimated cancer risks for the offsite MEIR–child resident are 3 in 100 million (i.e., 0.03 in a million [0.03×10^{-6}]), 7 in a billion (i.e., 0.007 in a million [0.007×10^{-6}]), and 3 in 100 million (i.e., 0.03 in a million [0.03×10^{-6}]) using high-end exposure assumptions for CP, HPS Phase II, and the total Project, respectively. The estimated cancer risks for the offsite MEIR–child using average exposures are slightly lower than those estimated for the adult using high-end exposure assumptions.

As shown on Table 6-2, the estimated noncancer HIs for all offsite residents are 0.02 or below.

6.2.2 Onsite Residents

All estimated excess lifetime cancer risks and noncancer HIs for onsite residents associated with chemicals bound to construction PM_{10} emissions attributable to CP, HPS Phase II, and the total Project are below the BAAQMD significance thresholds of 10 in a million and one, respectively.

As summarized in Table 6-1, the estimated cancer risks for the onsite MEIR–adult resident are 2 in 100 million (i.e., 0.02 in a million [0.02×10^{-6}]), 1 in a billion (i.e., 0.001 in a million [0.001×10^{-6}]), and 2 in 100 million (i.e., 0.02 in a million [0.02×10^{-6}]) using high-end exposure assumptions for CP, HPS Phase II, and the total Project, respectively. The estimated cancer risks for the onsite

MEIR–adult resident assuming average exposures are slightly lower than those estimated using high-end exposure assumptions.

As summarized in Table 6-1, the estimated cancer risks for the onsite MEIR–child resident are 4 in 100 million (i.e., 0.04 in a million [0.04×10^{-6}]), 2 in a billion (i.e., 0.002 in a million [0.002×10^{-6}]), and 4 in 100 million (i.e., 0.04 in a million [0.04×10^{-6}]) assuming high-end exposure assumptions for CP, HPS Phase II, and the total Project, respectively. The estimated cancer risks for the onsite MEIR–child resident assuming average exposures are slightly lower than those estimated using high-end exposure assumptions.

As shown on Table 6-2, the estimated noncancer HIs for all onsite residents are 0.01 or below.

6.2.3 Offsite Workers

All estimated excess lifetime cancer risks and noncancer HIs for offsite workers associated with chemicals bound to construction PM_{10} emissions attributable to CP, HPS Phase II, and the total Project are below the BAAQMD significance thresholds of 10 in a million and one, respectively.

As summarized in Table 6-1, the estimated excess lifetime cancer risks for the MEIW are 2 in 100 million (i.e., 0.02 in a million [0.02×10^{-6}]), 1 in a 100 million (i.e., 0.01 in a million [0.01×10^{-6}]), and 2 in 100 million (i.e., 0.02 in a million [0.02×10^{-6}]) for CP, HPS Phase II, and the total Project, respectively. As shown on Table 6-2, the estimated noncancer HIs for all offsite workers are 0.01 or below.

6.2.4 Offsite Sensitive Receptors

All estimated excess lifetime cancer risks and noncancer HIs for sensitive receptors associated with chemicals bound to construction PM_{10} emissions attributable to CP, HPS Phase II, and the total Project are below the BAAQMD significance thresholds of 10 in a million and one, respectively.

As summarized in Table 6-1, the estimated excess lifetime cancer risks for the maximum sensitive receptor are 7 in a billion (i.e., 0.007 in a million [0.007×10^{-6}]), 1 in a billion (i.e., 0.001 in a billion [0.001×10^{-6}]), and 7 in a 1 billion (i.e., 0.007 in a billion [0.007×10^{-6}]) for CP, HPS Phase II, and the total Project, respectively. As shown on Table 6-2, the maximum estimated noncancer HI for all sensitive receptors is 0.004.

7 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 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 Cal/EPA 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 perspective, the results of a risk assessment are 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, ENVIRON has evaluated the uncertainties associated with this HHRA, including emissions estimation, air dispersion modeling, and risk estimation. The following sections summarize the critical uncertainties associated with the emissions estimation, air dispersion modeling and risk estimation components of the risk assessment.

7.1 Estimation of Emissions

There are a number of uncertainties associated with the estimation of emissions from the Project that may affect the subsequent estimation of exposure concentrations and risk characterization. For example, it was assumed that PM_{10} emissions occurred under two phases of construction: demolition and grading. For demolition we assumed that all paved areas or those covered by a structure over the entire Project area would be disturbed and could result in the generation of PM_{10} emissions at a rate similar to that of grading activities. This is likely a conservative assumptions as the areal extent of disturbance would likely be lower and the degree of soil disturbance would likely be lower for demolition than for grading.

Additionally, the default level of emissions estimation methodology from URBEMIS was used as more detailed information about the construction activities is not currently known for the Project. As such, these estimates tend to be more conservative (i.e., higher) than those estimated with more detailed information.

7.2 Estimation of Exposure Concentrations

As discussed in Section 4, the USEPA-recommended dispersion model AERMOD was used to estimate average offsite PM_{10} exposure concentrations at the various offsite 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 2005a). Therefore, offsite exposure concentrations used in this assessment represent approximate offsite exposure concentrations.

As discussed in Section 4.4, chemical concentrations associated with airborne PM_{10} were estimated based on the chemical concentrations in soils (the soil source terms). The soil source terms were estimated using a screening-level approach intended to overestimate chemical concentrations in soils. Specifically, for CP, the maximum detected concentration within a Project Phase area was used as the soil source term, and for HPS Phase II, the maximum soil exposure point concentration derived by the Navy for grids within each redevelopment block was used as the soil source term. Because chemical concentrations bound to PM_{10} are assumed to be the same as the chemical concentrations in soil, use of these upper-end soil concentrations results in an overestimation of the chemical concentrations bound to PM_{10} and potential exposures of the populations evaluated in the HHRA.

7.3 Source Representation

The source parameters (*i.e.*, release velocity and release temperature) used to model emission points are sources of uncertainty. For all emission sources, source parameters were based on methods developed by regulatory agencies for use in their own analyses (e.g., SCAQMD LST or ARB). The BAAQMD has not yet developed a District-specific methodology for evaluating emissions from construction emissions sources. As there might be discrepancies in actual emissions characteristics of a source and its representation used in the Agency methodologies used, offsite exposure concentrations used in this assessment represent approximate offsite exposure concentrations.

7.4 Exposure and Risk Characterization

The following sections discuss the uncertainties associated with the exposure and risk characterization steps.

7.4.1 Exposure Assumptions

Numerous assumptions must be made in order to estimate human exposure to chemicals. These assumptions include parameters such as breathing rates, exposure time and frequency, exposure duration, and human activity patterns. While a mean value derived from scientifically defensible studies is the best estimate of central tendency, most of the exposure variables used in this HHRA are high-end estimates. For example, it is assumed that residential receptor exposure to Project-related dusts occurs 24 hours per day for 350 days per year, a highly conservative assumption since most residents do not remain in their homes for this period of time. The combination of several high-end estimates used as exposure parameters may substantially overestimate chemical intake. The cancer risks calculated in this assessment are therefore likely to be higher than may be required to be protective of public health.

7.4.2 Evaluation of Multipathway Exposures

Airborne PM_{10} released during construction activities could deposit on soils such that exposures to PM_{10}-bound chemicals could also occur through noninhalation exposure pathways. Evaluation of noninhalation exposure pathways is typically referred to as a multipathway analysis. Depending on the specific chemical and receptor, such pathways could include incidental ingestion of and dermal contact with soil and ingestion of mother's milk, homegrown produce, and/or water. ENVIRON used a conservative, screening-level approach to evaluate potential cancer risks and noncancer hazards associated with potential multipathway exposures.

ENVIRON used multipathway factors ("MP factors") derived by the SCAQMD (2005) to conduct the screening-level analysis of these additional exposure pathways. SCAQMD derived the MP factors using the California Air Resource Board's (CARB) Hotspots Analysis Risk Reporting Program (HARP), which is a software program designed to assist in the implementation of the programmatic requirements of Cal/EPA health risk assessment guidelines (Cal/EPA 2003). SCAQMD has developed MP factors for both residential and worker populations (SCAQMD 2005), assuming residential exposures via incidental ingestion of soil, dermal contact with soil, and ingestion of mother's milk and homegrown produce. For worker populations, exposures to soil through incidental ingestion and dermal contact are considered. For the residential and worker populations, the estimated inhalation risks are multiplied by the MP factor to estimate the additional risk associated with multipathway exposures. These pathways are relevant to this HHRA based on the land uses surrounding the Project.

ENVIRON identified the maximum SCAQMD MP factor for all chemicals considered in this HHRA by comparing the available MP factors from SCAQMD (2005) with the chemicals listed in Table 3-1. As a screening-level approach, the estimated total cancer risks and noncancer HIs presented in Tables 6-1 and 6-2 are multiplied by the maximum MP factor. This is a highly conservative approach because agency guidelines identify only specific chemicals for a multipath evaluation and the chemical-specific MP factors for many chemicals are less than the maximum MP factor. In this HHRA, application of the maximum MP factor results in an approximate one order of magnitude increase in the estimated total cancer risks and noncancer HIs presented in Tables 6-1 and 6-2. The consideration of multipathway exposures would not significantly impact the conclusions of this HHRA. That is, excess lifetime cancer risks and noncancer HIs are below BAAQMD CEQA thresholds of significance.

7.4.3 Toxicity Assessment

Available scientific information is insufficient to provide a thorough understanding of all the toxic properties of each of the chemicals to which humans may be exposed. It is generally necessary, therefore, to infer these properties by extrapolating them from data obtained under other conditions of exposure, generally in laboratory animals. Although reliance on experimental animal data has been widely used in general risk assessment practices, chemical absorption, metabolism, excretion, and toxic responses may differ between humans and the species for which experimental toxicity data are available. Uncertainties in using animal data to predict potential effects in humans are introduced when routes of exposure in animal studies differ from human exposure routes, when the exposures in animal studies are short-term or subchronic, and when effects seen at relatively high exposure levels in animal studies are used to predict effects at the much lower exposure levels found in the environment. Uncertainties in the toxicological assessments for carcinogens and noncarcinogens are discussed below.

7.4.3.1 Carcinogens

The use of animal data presents an uncertainty in predicting carcinogenicity in humans. While many substances are carcinogenic in one or more animal species, only a small number of substances are known to be human carcinogens, raising the possibility that not all animal carcinogens are human carcinogens and that not all human carcinogens are animal carcinogens. To prevent the underestimation of carcinogenic risk, regulatory agencies generally assume that humans are at least as sensitive to carcinogens as the most sensitive animal species.

The development of CSFs for carcinogens is predicated on the assumption generally made by regulatory agencies that no threshold exists for carcinogens (i.e., that there is some risk of cancer at all exposure levels above zero). The no-threshold hypothesis for carcinogens, however, may not be valid for all substances.

7.4.3.2 Noncarcinogens

In order to adjust for uncertainties that arise from the use of animal data, regulatory agencies often base the toxicity values for noncarcinogenic effects on the most sensitive animal species (i.e., the species that experiences adverse effects at the lowest dose). These doses are then adjusted via the use of safety or uncertainty factors. The adjustment compensates for the lack of knowledge regarding interspecies extrapolation, and guards against the possibility of humans being more sensitive than the most sensitive experimental animal species tested. The use of uncertainty factors is considered to be protective of health. In addition, when route-specific toxicity data were lacking, RELs were extrapolated from one route to another (i.e., oral to inhalation). Due to the absence of contrary data, equal absorption rates were assumed for both routes.

7.4.4 Risk Calculation

The USEPA (1989b) notes that the conservative assumptions used in a risk assessment are intended to assure that the estimated risks do not underestimate the actual risks posed by a site and that the estimated risks do not necessarily represent actual risks experienced by populations at or near a site. By using standardized conservative assumptions in a risk assessment, USEPA (1989b) further states 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."*

The estimated risks in this HHRA are based primarily on a series of conservative (health-protective) assumptions related to predicted environmental concentrations, exposure, and chemical toxicity. The use of conservative assumptions tends to produce upper-bound estimates of risk. Although it is difficult to quantify the uncertainties associated with all the assumptions made in this risk assessment, the use of conservative assumptions is likely to result in substantial overestimates of exposure, and hence, risk. BAAQMD acknowledges this uncertainty by stating: "the methods used [to estimate risk] are conservative, meaning that the real risks from the source may be lower than the calculations, but it is unlikely that they will be higher" (BAAQMD 2009).

8 Conclusions

In summary, the results of this HHRA indicate that potential excess cancer risks to offsite residents, workers and sensitive receptors surrounding the Candlestick Park – Hunters Point Shipyard Phase II Project are below 10 in a million for exposures to chemicals bound to PM_{10} emissions emitted during construction activities, assuming that certain mitigation measures are implemented. Further, estimated cancer risks for onsite residents at the Alice Griffith Housing area are also below 10 in a million. The estimated chronic noncancer hazard indices are below 1 for all receptors evaluated in this HHRA. Pursuant to BAAQMD CEQA Guidelines (BAAQMD 1999), projects that expose the public to toxic air contaminants in excess of the following thresholds would be considered to have a significant air quality impact:

- Probability of contracting cancer for the MEI exceeds 1×10^{-5} (10 in a million);
- Ground level concentrations of non-carcinogenic toxic air contaminants would result in a Hazard Index greater than 1 for the MEI.

Thus, based on the results of this HHRA, the project should not have a significant impact on air quality according to BAAQMD CEQA Guidelines.

The many conservative assumptions that have been used in this assessment regarding the estimation of emissions, ambient air concentrations, exposure assumptions, and carcinogenic potency lead to an overestimate of potential risks, the magnitude of which is likely substantial.

9 References

Barajas & Associates, Inc. 2008. *Final Revised Remedial Investigation Report for Parcel E.* Hunters Point Shipyard, San Francisco, California.

Bay Area Air Quality Management District (BAAQMD). 1999. *BAAQMD CEQA Guidelines: Assessing the Air Quality Impacts of Projects and Plans*. December.

BAAQMD. 2000. *Bay Area Air Quality Management Air Toxic Risk Evaluation Procedure (REP) and Risk Management Policy (RMP).* February.

BAAQMD. 2005a. *Bay Area Air Quality Management District Staff Report.* Toxic Evaluation Section. June.

BAAQMD. 2005b. *Air Toxics NSR Program Health Risk Screening Analysis (HRSA) Guidelines*. June.

BAAQMD. 2009. *Frequently Asked Questions – Toxic Air Contaminants. Online: http://www.baaqmd.gov/Help/~/~/link.aspx?_id=C8992846AA0045ECABDB489211201B61&_z=z. Accessed August 5.*

ChaduxTt. 2007. *Final Parcel B Technical Memorandum in Support of a Record of Decision Amendment.* Hunters Point Shipyard, San Francisco, California.

California Environmental Protection Agency (Cal/EPA). 1994. *Preliminary Endangerment Assessment Guidance Manual (PEA).* Department of Toxic Substances Control. January.

Cal/EPA. 1999. Technical Support Document for Cancer Potency Factors.

Cal/EPA. 2000. *Air Toxics Hot Spots Program Risk Assessment Guidelines: Part IV Technical Support Document for Exposure Assessment and Stochastic Analysis.* Office of Environmental Health Hazard Assessment. September.

Cal/EPA. 2003. *The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments*. Office of Environmental Health Hazard Assessment. August.

Cal/EPA. 2008. *All Chronic Reference Exposure Levels (cRELs)*. Office of Environmental Health Hazard Assessment. December 18.

Cal/EPA. 2009. *California Cancer Potency Values*. Office of Environmental Health Hazard Assessment. October.

Engineering/Remediation Resources Group, Inc. and Shaw Environmental, Inc. 2007. *Draft Parcel E-2 Remedial Investigation /Feasibility Study,* Hunters Point Shipyard, San Francisco, California.

Geomatrix Consultants. 1998a. *Site Investigation and Risk Evaluation Report for the Proposed San Francisco 49ers Stadium and Mall Site: North Park and Last Port Areas.* San Francisco, California. Volume I of IV.

Geomatrix Consultants. 1998b. *Addendum 1 to the Site Investigation and Risk Evaluation Report for the Proposed San Francisco 49ers Stadium and Mall Site: North Park and Last Port Areas.* Candlestick Point, San Francisco, California. Volume I of II.

Risk Assessment Advisory Committee (RAAC). 1996. *A Review of the California Environmental Protection Agency's Risk Assessment Practices, Policies, and Guidelines.* October.

National Research Council (NRC). 1983. *Risk Assessment in the Federal Government: Managing the Process.* National Academy Press, Washington, DC.

NRC. 1994. *Science and Judgment in Risk Assessment.* National Academies Press. Washington D.C.

South Coast Air Quality Management District (SCAQMD). 2005. Risk Assessment Procedures for Rules 1402 and 212. Version 7.0. July 1.

SulTech. 2007. *Final Revised Feasibility Study for Parcel D.* Hunters Point Shipyard, San Francisco, California.

SulTech. 2008. *Final Revised Feasibility Study for Parcel C.* Hunters Point Shipyard, San Francisco, California.

Urban Emissions Model (URBEMIS 2007) (Version 9.2.4 – 2008). Rimpo and Associates Inc. Available at: http://www.urbemis.com.

U.S. Environmental Protection Agency (USEPA). 1989a. *Risk Assessment Guidance for Superfund: Volume 1 - Human Health Evaluation Manual (Part A).* Interim Final. Washington, D.C. December.

USEPA. 1989b. *Risk Assessment Guidance for Superfund Human Health Risk Assessment:* U.S. EPA Region IX Recommendations (Interim Final). San Francisco, CA. December 15.

USEPA. 1991. *Risk Assessment Guidance for Superfund. Volume 1: Human Health Evaluation Manual. Supplemental Guidance. Standard Default Exposure Factors.* Office of Emergency and Remedial Response. March 25.

USEPA. 1997a. *Exposure Factors Handbook*. EPA/600/P-95/002Fa. August.

USEPA. 1997b. *Health Effects Assessment Summary Tables (HEAST). FY 1997 Update*. Office of Research and Development. EPA 540-R-97-36. July.

USEPA. 2004. United States Environmental Protection Agency (USEPA). 2004b. *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.

USEPA. 2005a. *Guideline on Air Quality Models (Revised). 40 Code of Federal Regulations, Part 51, Appendix W.* Office of Air Quality Planning and Standards. November.

USEPA. 2005b. United States Environmental Protection Agency (USEPA). 2005. *Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions*; Final Rule. 40 CFR Part 51, Appendix W. 70 Federal Register 68218-61. November 9.

USEPA 2009a. *Integrated Risk Information (IRIS) Database.* Available online: http://www.epa.gov/iris. [Accessed: August].

USEPA. 2009b. *Region 9 Regional Screening Level (RSLs) Table. San Francisco, California.* May 19.

Tables

Table 3-1
Chemicals Identified for Evaluation
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Chemical	CASRN	Candlestick Point	Hunters Point Shipyard
Acenaphthene	83-32-9		X
Acenaphthylene	208-96-8		X
Anthracene	120-12-7		X
Benzaldehyde	100-52-7		X
Benzo(a)anthracene	56-55-3	X	X
Benzo(a)pyrene	50-32-8	X	X
Benzo(b)fluoranthene	205-99-2	X	X
Benzo(e)pyrene	192-97-2		X
Benzo(g,h,i)perylene	191-24-2		X
Benzo(k)fluoranthene	207-08-9	X	X
Benzoic Acid	65-85-0		X
Biphenyl	92-52-4		X
bis(2-Ethylhexyl)phthalate	117-81-7		X
Butylbenzylphthalate	85-68-7		X
Carbazole	86-74-8		X
4-Chloro-3-methylphenol	59-50-7		X
2-Chloronaphthalene	91-58-7		X
2-Chlorophenol	95-57-8		X
Chrysene	218-01-9		X
Dibenz(a,h)anthracene	53-70-3	X	X
Dibenzofuran	132-64-9		X
3,3'-Dichlorobenzidine	91-94-1		X
Diethylphthalate	84-66-2		X
2,4-Dimethylphenol	105-67-9		X
Dimethylphthalate	131-11-3		X
Di-n-butylphthalate	84-74-2		X
2,4-Dinitrotoluene	121-14-2		X
Fluoranthene	206-44-0		X
Fluorene	86-73-7		X
Hexachlorobenzene	118-74-1		X
Indeno(1,2,3-cd)pyrene	193-39-5	X	X
Isophorone	78-59-1		X
Organic Lead	----		X
MCPA (2-Methyl-4-chlorophenoxy acetic acid)	94-74-6		X
1-Methylnaphthalene	90-12-0		X
2-Methylnaphthalene	91-57-6		X
2-Methylphenol	95-48-7		X
4-Methylphenol	106-44-5		X
Naphthalene	91-20-3		X
2,3,5-Trimethylnaphthalene	2245-38-7		X
2,6-Dimethylnaphthalene	581-42-0		X
4-Nitrophenol	100-02-7		X
N-Nitrosodiphenylamine	86-30-6		X
N-Nitroso-di-n-propylamine	621-64-7		X
Pentachlorophenol	87-86-5		X

Table 3-1
Chemicals Identified for Evaluation
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Chemical	CASRN	Candlestick Point	Hunters Point Shipyard
Perylene	198-55-0		X
Phenanthrene	85-01-8		X
1-Methylphenanthrene	832-69-9		X
Phenol	108-95-2		X
Pyrene	129-00-0		X
Aldrin	309-00-2		X
alpha-BHC	319-84-6		X
beta-BHC	319-85-7		X
delta-BHC	319-86-8		X
gamma-BHC	58-89-9		X
alpha-Chlordane	5103-71-9		X
gamma-Chlordane	5103-74-2		X
2,4'-DDD	53-19-0		X
4,4'-DDD	72-54-8		X
2,4'-DDE	3424-82-6		X
4,4'-DDE	72-55-9		X
4,4'-DDT	50-29-3		X
2,4-DDT	789-02-6		X
Dibenzothiophene	132-65-0		X
Dibutyltin	1002-53-5		X
Dieldrin	60-57-1		X
Endosulfan I	959-98-8		X
Endosulfan II	33213-65-9		X
Endosulfan sulfate	1031-07-8		X
Endrin	72-20-8		X
Endrin aldehyde	7421-93-4		X
Endrin ketone	53494-70-5		X
Heptachlor	76-44-8		X
Heptachlor epoxide	1024-57-3		X
Methoxychlor	72-43-5		X
Monobutyltin	78763-54-9		X
cis-Nonachlor	5103-73-1		X
trans-Nonachlor	39765-80-5		X
Oxychlordane	27304-13-8		X
Tributyltin	688-73-3		X
Aroclor-1016	12674-11-2		X
Aroclor-1232	11141-16-5		X
Aroclor-1242	53469-21-9		X
Aroclor-1248	12672-29-6		X
Aroclor-1254	11097-69-1		X
Aroclor-1260	11096-82-5		X
Decachlorobiphenyl	2051-24-3		X
2,2',3,3',4,4',5-Heptachlorobiphenyl	35065-30-6		X
2,2',3,4,4',5,5'-Heptachlorobiphenyl	35065-29-3		X
2,2',3,4',5,5',6-Heptachlorobiphenyl	52663-68-0		X

Table 3-1
Chemicals Identified for Evaluation
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Chemical	CASRN	Candlestick Point	Hunters Point Shipyard
2,3,3',4,4',5,5'-Heptachlorobiphenyl	39635-31-9		X
2,2',3,3',4,4'-Hexachlorobiphenyl	38380-07-3		X
2,2',3,4,4',5'-Hexachlorobiphenyl	35065-28-2		X
2,2',4,4',5,5'-Hexachlorobiphenyl	35065-27-1		X
2,3,3',4,4',5-Hexachlorobiphenyl	38380-08-4		X
2,3',4,4',5,5'-Hexachlorobiphenyl	52663-72-6		X
2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	40186-72-9		X
2,2',3,3',4,4',5,6-Octachlorobiphenyl	52663-78-2		X
2,2',4,5,5'-Pentachlorobiphenyl	37680-73-2		X
2,3,3',4,4'-Pentachlorobiphenyl	32598-14-4		X
2,3,4,4',5-Pentachlorobiphenyl	74472-37-0		X
PCB-118	31508-00-6		X
2,2',3,5'-Tetrachlorobiphenyl	41464-39-5		X
2,2',5,5'-Tetrachlorobiphenyl	35693-99-3		X
PCB-66	32598-10-0		X
2,4,4'-Trichlorobiphenyl	7012-37-5		X
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746-01-6		X
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	40321-76-4		X
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	39227-28-6		X
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	57653-85-7		X
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	19408-74-3		X
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	35822-46-9		X
Octachlorodibenzo-p-dioxin	3268-87-9		X
TCDD (total)	41903-57-5		X
PeCDD (total)	36088-22-9		X
HxCDD (total)	34465-46-8		X
HpCDD (total)	37871-00-4		X
2,3,7,8-Tetrachlorodibenzofuran	51207-31-9		X
1,2,3,7,8-Pentachlorodibenzofuran	57117-41-6		X
2,3,4,7,8-Pentachlorodibenzofuran	57117-31-4		X
1,2,3,4,7,8-Hexachlorodibenzofuran	70648-26-9		X
1,2,3,6,7,8-Hexachlorodibenzofuran	57117-44-9		X
2,3,4,6,7,8-Hexachlorodibenzofuran	60851-34-5		X
1,2,3,4,6,7,8-Heptachlorodibenzofuran	67562-39-4		X
1,2,3,4,7,8,9-Heptachlorodibenzofuran	55673-89-7		X
Octachlorodibenzofuran	39001-02-0		X
TCDF (total)	55722-27-5		X
PeCDF (total)	30402-15-4		X
HpCDF (total)	38998-75-3		X
HxCDF (total)	55684-94-1		X
Aluminum	7429-90-5		X
Antimony	7440-36-0	X	X
Arsenic	7440-38-2	X	X
Barium	7440-39-3		X
Beryllium	7440-41-7		X

Table 3-1
Chemicals Identified for Evaluation
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Chemical	CASRN	Candlestick Point	Hunters Point Shipyard
Cadmium	7440-43-9	X	X
Chromium (total)	7440-47-3		X
Chromium VI	18540-29-9		X
Cobalt	7440-48-4		X
Copper	7440-50-8	X	X
Cyanide (total)	57-12-5		X
Iron	7439-89-6		X
Lead	7439-92-1	X	X
Manganese	7439-96-5		X
Mercury	7439-97-6	X	X
Molybdenum	7439-98-7		X
Nickel	7440-02-0	X	X
Selenium	7782-49-2		X
Silver	7440-22-4		X
Thallium	7440-28-0		X
Vanadium	7440-62-2	X	X
Zinc	7440-66-6	X	X

Notes:
CASRN = Chemical abstract services registry number

Table 4-1
Exposure Assumptions for Carcinogens
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Parameter Symbol	Parameter Definition	Units	Receptor Population											
			School Child		Offsite Worker		Resident							
							Adult				Child			
							Average Exposure		High End Exposure		Average Exposure		High End Exposure	
IR	Inhalation Rate	L/kg-day	581	a	149	a	271	b	302	a	452	b	581	a
		m^3/day	10		10		17		19		8		10	
F	Fraction of Day Exposed	unitless	0.42	c	1	c	1	c	1	c	1	c	1	c
EF	Exposure frequency	days/year	180	a	245	a	350	a	350	a	350	a	350	a
T	Modeling Adjustment Factor	unitless	3.4	d	4.2	e	1	f	1	f	1	f	1	f
CF	Conversion Factor	mg/ug	1.E-03		1.E-03		1.E-03		1.E-03		1.E-03		1.E-03	
A	Inhalation Absorption Factor	unitless	1		1		1		1		1		1	
BW	Body Weight	kg	18	b	70	b	63	b	63	b	18	b	18	b
AT	Averaging time	days	25,550		25,550		25,550		25,550		25,550		25,550	

Notes:

L = Liter
kg = kilogram
m^3 = cubic meter
mg = milligram
μg = microgram

[a] BAAQMD 2005.

[b] Cal/EPA 2003.

[c] Fraction of day exposed for the school child calculated assuming a school day of 10 hours per day (BAAQMD 2005). The value was calculated: as follows: 0.42 = 10 hours/24 hours. The fraction of the day adjustment is not necessary for offsite workers or residents.

[d] Since the annual average concentrations were estimated assuming continuous exposure (i.e., 24 hours per day, 7 days per week), an adjustment is applied to the modeling to account for the time the receptor is actually present at school (Cal/EPA 2003). The school child is assumed to be present at a school location 10 hours per day, 5 days per week (BAAQMD 2005). Therefore, a factor of 3.4 (equal to [24 hours/10 hours]*[7 days/5 days]) was applied to account for the difference in exposure time.

[e] Since the annual average concentrations were estimated assuming continuous exposure (i.e., 24 hours per day, 7 days per week), an adjustment is applied to the modeling to account for the time the receptor is actually present at work (Cal/EPA 2003). The off-site worker is assumed to be present at a work location 8 hours per day, 5 days per week (BAAQMD 2005). Therefore, a factor of 4.2 (equal to [24 hours/8 hours]*[7 days/5 days]) was applied to account for the difference in exposure time.

[f] Modeling adjustment not necessary for residential receptors.

Source:

Bay Area Air Quality Management District (BAAQMD). 2005. *BAAQMD Air Toxics NSR Program Health Risk Screening Analysis (HRSA) Guidelines.* June.

California Environmental Protection Agency (Cal/EPA). 2003. *Air Toxics Hot Spots Program Risk Assessment Guidelines: The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments* . Office of Environmental Health Hazard Assessment. August.

Table 4-2
Project-Specific Exposure Durations (in years)
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Project Area	Receptor Population							
	School Child		Offsite Worker		Resident			
					Adult		Child	
Candlestick Point	9	a,b	18	b	18	b	9	a,b
Hunters Point Shipyard	9	a,b	9	b	9	b	9	a,b
Candlestick Point - Hunters Point Shipyard Phase II Development Plan	9	a,b	19	b	19	b	9	a,b

Notes:

[a] BAAQMD 2005.
[b] Project-specific estimate based on planned construction periods, as follows:
Candlestick Point = 2011-2028, Hunters Point Shipyard = 2010-2018,
and Candlestick Point - Hunters Point Shipyard Phase II Development Plan = 2010-2028.

Source:
Bay Area Air Quality Management District (BAAQMD). 2005. *BAAQMD Air Toxics NSR Program Health Risk Screening Analysis (HRSA) Guidelines.* June.

Table 4-3
Fugitive Dust Mitigation Measures and Control Efficiencies
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Fugitive Dust Sources[a]	Fraction of Total Dust Emissions[b]	Mitigation Measures[c]	Fugitive Dust Control Efficiency	
			Individual Measure[d]	Overall
Soil Disturbance	79%	Apply soil stabilizer to inactive areas	84%	93%
		Replace ground cover quickly in disturbed areas	5%	
		Water exposed surfaces two times daily	55%	
Unpaved Road	21%	Reduce speed on unpaved roads to less than 15 miles per hour	44%	78%
		Manage haul road dust by watering the roads three times daily	61%	

Notes:
[a] Based on Urban Emissions Model (URBEMIS) 2007.
[b] Based on URBEMIS 2007 default percentage.
[c] URBEMIS default fugitive dust mitigation measures selected based on those used during Hunters Point Shipyard Phase I Development Plan.
[d] Based on URBEMIS default dust control efficiencies.

Source:
Urban Emission Model (URBEMIS). 2007. Version 9.2.4 - 2008. Rimpo and Associates, Inc. Available at http://urbemis.com

Table 4-4
Summary of Modeled Source Parameters
Candlestick Point - Hunters Point Shipyard Phase II
Development Plan
San Francisco, California

Source Category	Source Type	Release Height[a] (m)	Initial Vertical Dimension[a] (m)
Fugitive Dust	Area	0	1.0

Notes:
[a] SCAQMD 2008.

Source:
South Coast Air Quality Management District (SCAQMD). 2008. *Final Localized Significance Threshold Methodology*. July.

Table 4-5
Annual Average Dust (PM_{10}) Concentrations at the Offsite and Onsite Maximally Exposed Individuals (MEIs)
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Project Area	Off-site Receptor Population				On-site Receptor	
	School Child	Offsite Worker	Resident		Resident	
			Adult	Child	Adult	Child
Candlestick Point	2.0E-01	3.9E-01	3.2E-01	5.8E-01	3.0E-01	5.8E-01
Hunters Point Shipyard	3.1E-02	6.8E-01	6.8E-01	6.8E-01	6.8E-02	6.8E-02
Candlestick Point - Hunters Point Shipyard Phase II Development Plan	1.6E-01	3.7E-01	3.2E-01	5.2E-01	2.9E-01	6.0E-01

Note:
Units are microgram per cubic meter (ug/m^3).

Table 5-1
Toxicity Values for Carcinogens and Noncarcinogens
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Chemical	CASRN	Cancer Potency Factor[a] ([mg/kg-day]$^{-1}$)		Chronic Reference Exposure Level[b] (ug/m^3)	
		Value	Reference	Value	Reference
Acenaphthene	83-32-9	----	----	2.10E+02	IRIS, r-r
Acenaphthylene	208-96-8	----	----	----	----
Anthracene	120-12-7	----	----	1050	IRIS, r-r
Benzaldehyde	100-52-7	----	----	350	IRIS, r-r
Benzo(a)anthracene	56-55-3	0.39	CalEPA 2009	----	----
Benzo(a)pyrene	50-32-8	3.90E+00	CalEPA 2009	----	----
Benzo(b)fluoranthene	205-99-2	0.39	CalEPA 2009	----	----
Benzo(e)pyrene	192-97-2	----	----	----	----
Benzo(g,h,i)perylene	191-24-2	----	----	----	----
Benzo(k)fluoranthene	207-08-9	0.39	CalEPA 2009	----	----
Benzoic Acid	65-85-0	----	----	1.40E+04	IRIS, r-r
Biphenyl	92-52-4	----	----	1.75E+02	IRIS, r-r
bis(2-Ethylhexyl)phthalate	117-81-7	0.0084	CalEPA 2009	70	IRIS, r-r
Butylbenzylphthalate	85-68-7	0.0019	PPRTV, r-r	700	IRIS, r-r
Carbazole	86-74-8	0.02	HEAST, r-r	----	----
4-Chloro-3-methylphenol	59-50-7	----	----	----	----
2-Chloronaphthalene	91-58-7	----	----	2.80E+02	IRIS, r-r
2-Chlorophenol	95-57-8	----	----	17.5	IRIS, r-r
Chrysene	218-01-9	0.039	CalEPA 2009	----	----
Dibenz(a,h)anthracene	53-70-3	4.1	CalEPA 2009	----	----
Dibenzofuran	132-64-9	----	----	----	----
3,3'-Dichlorobenzidine	91-94-1	1.20E+00	CalEPA 2009	----	----
Diethylphthalate	84-66-2	----	----	2800	IRIS, r-r
2,4-Dimethylphenol	105-67-9	----	----	70	IRIS, r-r
Dimethylphthalate	131-11-3	----	----	----	----
2,6-Dimethylnaphthalene	581-42-0	----	----	----	----
Di-n-butylphthalate	84-74-2	----	----	3.50E+02	IRIS, r-r
2,4-Dinitrotoluene	121-14-2	0.31	CalEPA 2009	7	IRIS, r-r

Table 5-1
Toxicity Values for Carcinogens and Noncarcinogens
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Chemical	CASRN	Cancer Potency Factor[a] ($[mg/kg\text{-}day]^{-1}$)		Chronic Reference Exposure Level[b] (ug/m^3)	
		Value	Reference	Value	Reference
Di-n-octylphthalate	117-84-0	----	----	----	----
Fluoranthene	206-44-0	----	----	1.40E+02	IRIS, r-r
Fluorene	86-73-7	----	----	140	IRIS, r-r
Hexachlorobenzene	118-74-1	1.8	CalEPA 2009	2.8	IRIS, r-r
Indeno(1,2,3-cd)pyrene	193-39-5	3.90E-01	CalEPA 2009	----	----
Isophorone	78-59-1	0.00095	IRIS, r-r	2.00E+03	CalEPA 2008
Organic Lead	----	----	----	----	----
MCPA (2-Methyl-4-chlorophenoxy acetic acid)	94-74-6	----	----	----	----
1-Methylnaphthalene	90-12-0	----	----	20	ATSDR, r-r
2-Methylnaphthalene	91-57-6	----	----	1.40E+01	IRIS
1-Methylphenanthrene	832-69-9	----	----	----	----
2-Methylphenol	95-48-7	----	----	1.75E+02	IRIS, r-r
4-Methylphenol	106-44-5	----	----	17.5	HEAST, r-r
Naphthalene	91-20-3	0.12	CalEPA 2009	9	CalEPA 2008
2-Nitroaniline	88-74-4	----	----	0.1	PPRTV
4-Nitrophenol	100-02-7	----	----	----	----
N-Nitrosodiphenylamine	86-30-6	0.009	CalEPA 2009	7.00E+01	PPRTV, r-r
N-Nitroso-di-n-propylamine	621-64-7	7.00E+00	CalEPA 2009	----	----
Pentachlorophenol	87-86-5	0.018	CalEPA 2009	105	IRIS, r-r
Perylene	198-55-0	----	----	----	----
Phenanthrene	85-01-8	----	----	----	----
Phenol	108-95-2	----	----	2.00E+02	CalEPA 2008
Pyrene	129-00-0	----	----	105	IRIS, r-r
2,3,5-Trimethylnaphthalene	2245-38-7	----	----	----	----
Aldrin	309-00-2	17	CalEPA 2009	0.105	IRIS, r-r
alpha-BHC	319-84-6	2.7	CalEPA 2009	28	ATSDR, r-r
beta-BHC	319-85-7	1.50E+00	CalEPA 2009	----	----
delta-BHC	319-86-8	----	----	----	----

Table 5-1
Toxicity Values for Carcinogens and Noncarcinogens
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Chemical	CASRN	Cancer Potency Factor[a] ($[mg/kg\text{-}day]^{-1}$)		Chronic Reference Exposure Level[b] (ug/m^3)	
		Value	Reference	Value	Reference
gamma-BHC	58-89-9	1.1	CalEPA 2009	1.05	IRIS, r-r
alpha-Chlordane	5103-71-9	1.2	CalEPA 2009	7.00E-01	IRIS
gamma-Chlordane	5103-74-2	1.2	CalEPA 2009	0.7	IRIS
2,4'-DDD	53-19-0	----	----	----	----
4,4'-DDD	72-54-8	0.24	CalEPA 2009	10.5	NCEA, r-r
2,4'-DDE	3424-82-6	----	----	----	----
4,4'-DDE	72-55-9	3.40E-01	CalEPA 2009	2.45E+00	NCEA, r-r
4,4'-DDT	50-29-3	0.34	CalEPA 2009	1.75E+00	IRIS, r-r
2,4-DDT	789-02-6	----	----	----	----
Dieldrin	60-57-1	1.60E+01	CalEPA 2009	1.75E-01	IRIS, r-r
Endosulfan I	959-98-8	----	----	21	IRIS, r-r
Endosulfan II	33213-65-9	----	----	2.10E+01	IRIS, r-r
Endosulfan sulfate	1031-07-8	----	----	21	IRIS, r-r
Endrin	72-20-8	----	----	1.05E+00	IRIS, r-r
Endrin aldehyde	7421-93-4	----	----	1.05	IRIS, r-r
Endrin ketone	53494-70-5	----	----	----	----
Heptachlor	76-44-8	4.1	CalEPA 2009	1.75	IRIS, r-r
Heptachlor epoxide	1024-57-3	5.5	CalEPA 2009	0.0455	IRIS, r-r
Methoxychlor	72-43-5	----	----	17.5	IRIS, r-r
Oxychlordane	27304-13-8	----	----	----	----
Dibenzothiophene	132-65-0	----	----	----	----
Dibutyltin	1002-53-5	----	----	----	----
Monobutyltin	78763-54-9	----	----	----	----
cis-Nonachlor	5103-73-1	----	----	----	----
trans-Nonachlor	39765-80-5	----	----	----	----
Tributyltin	688-73-3	----	----	----	----
Aluminum	7429-90-5	----	----	----	----
Antimony	7440-36-0	----	----	----	----

Table 5-1
Toxicity Values for Carcinogens and Noncarcinogens
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Chemical	CASRN	Cancer Potency Factor[a] ($[mg/kg\text{-}day]^{-1}$)		Chronic Reference Exposure Level[b] (ug/m^3)	
		Value	Reference	Value	Reference
Arsenic	7440-38-2	12	CalEPA 2009	0.015	CalEPA 2008
Barium	7440-39-3	----	----	0.5	HEAST
Beryllium	7440-41-7	8.40E+00	CalEPA 2009	7.00E-03	CalEPA 2008
Cadmium	7440-43-9	15	CalEPA 2009	0.02	CalEPA 2008
Chromium (total)	7440-47-3	----	----	----	----
Chromium VI	18540-29-9	5.10E+02	CalEPA 2009	2.00E-01	CalEPA 2008
Cobalt	7440-48-4	----	----	6.00E-03	PPRTV
Copper	7440-50-8	----	----	----	----
Cyanide (total)	57-12-5	----	----	----	----
Iron	7439-89-6	----	----	----	----
Lead	7439-92-1	0.042	CalEPA 2009	----	----
Manganese	7439-96-5	----	----	9.00E-02	CalEPA 2008
Mercury	7439-97-6	----	----	3.00E-02	CalEPA 2008
Molybdenum	7439-98-7	----	----	----	----
Nickel	7440-02-0	0.91	CalEPA 2009	0.05	CalEPA 2008
Selenium	7782-49-2	----	----	20	CalEPA 2008
Silver	7440-22-4	----	----	1.00E-02	NCEA
Thallium	7440-28-0	----	----	----	----
Vanadium	7440-62-2	----	----	----	----
Zinc	7440-66-6	----	----	----	----
Aroclor-1016	12674-11-2	2	CalEPA 2009	2.45E-04	IRIS
Aroclor-1232	11141-16-5	2	CalEPA 2009	7.00E-05	IRIS
Aroclor-1242	53469-21-9	2	CalEPA 2009	7.00E-05	IRIS
Aroclor-1248	12672-29-6	2	CalEPA 2009	0.00007	IRIS
Aroclor-1254	11097-69-1	2	CalEPA 2009	0.00007	IRIS
Aroclor-1260	11096-82-5	2	CalEPA 2009	0.00007	IRIS
Decachlorobiphenyl	2051-24-3	0	CalEPA 2009	0.00007	IRIS
2,2',3,3',4,4',5-Heptachlorobiphenyl	35065-30-6	0.00E+00	CalEPA 2009	7.00E-05	IRIS

Table 5-1
Toxicity Values for Carcinogens and Noncarcinogens
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Chemical	CASRN	Cancer Potency Factor[a] ([mg/kg-day]$^{-1}$)		Chronic Reference Exposure Level[b] (ug/m^3)	
		Value	Reference	Value	Reference
2,2',3,4,4',5,5'-Heptachlorobiphenyl	35065-29-3	0	CalEPA 2009	0.00007	IRIS
2,2',3,4',5,5',6-Heptachlorobiphenyl	52663-68-0	0	CalEPA 2009	0.00007	IRIS
2,3,3',4,4',5,5'-Heptachlorobiphenyl	39635-31-9	13	CalEPA 2009	7.00E-05	IRIS
2,2',3,3',4,4'-Hexachlorobiphenyl	38380-07-3	0	CalEPA 2009	0.00007	IRIS
2,2',3,4,4',5'-Hexachlorobiphenyl	35065-28-2	0.00E+00	CalEPA 2009	7.00E-05	IRIS
2,2',4,4',5,5'-Hexachlorobiphenyl	35065-27-1	0	CalEPA 2009	0.00007	IRIS
2,3,3',4,4',5-Hexachlorobiphenyl	38380-08-4	65	CalEPA 2009	0.00007	IRIS
2,3',4,4',5,5'-Hexachlorobiphenyl	52663-72-6	1.30E+00	CalEPA 2009	7.00E-05	IRIS
2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	40186-72-9	0	CalEPA 2009	7.00E-05	IRIS
2,2',3,3',4,4',5,6-Octachlorobiphenyl	52663-78-2	0.00E+00	CalEPA 2009	7.00E-05	IRIS
2,2',4,5,5'-Pentachlorobiphenyl	37680-73-2	0.00E+00	CalEPA 2009	7.00E-05	IRIS
2,3,3',4,4'-Pentachlorobiphenyl	32598-14-4	13	CalEPA 2009	0.00007	IRIS
2,3,4,4',5-Pentachlorobiphenyl	74472-37-0	6.50E+01	CalEPA 2009	7.00E-05	IRIS
PCB-118	31508-00-6	13	CalEPA 2009	0.00007	IRIS
2,3',4,4',5'-Pentachlorobiphenyl	65510-44-3	1.30E+01	CalEPA 2009	7.00E-05	IRIS
2,2',3,5'-Tetrachlorobiphenyl	41464-39-5	0	CalEPA 2009	0.00007	IRIS
2,2',5,5'-Tetrachlorobiphenyl	35693-99-3	0	CalEPA 2009	0.00007	IRIS
PCB-66	32598-10-0	0	CalEPA 2009	0.00007	IRIS
3,3',4,4'-Tetrachlorobiphenyl	32598-13-3	13	CalEPA 2009	0.00007	IRIS
2,2',5-Trichlorobiphenyl	37680-65-2	0.00E+00	CalEPA 2009	7.00E-05	IRIS
2,4,4'-Trichlorobiphenyl	7012-37-5	0	CalEPA 2009	0.00007	IRIS
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746-01-6	130000	CalEPA 2009	0.00004	CalEPA 2008
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	40321-76-4	130000	CalEPA 2009	----	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	39227-28-6	13000	CalEPA 2009	----	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	57653-85-7	1.30E+04	CalEPA 2009	----	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	19408-74-3	13000	CalEPA 2009	----	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	35822-46-9	1.30E+03	CalEPA 2009	----	
Octachlorodibenzo-p-dioxin	3268-87-9	13	CalEPA 2009	----	

Table 5-1
Toxicity Values for Carcinogens and Noncarcinogens
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Chemical	CASRN	Cancer Potency Factor[a] ($[mg/kg\text{-}day]^{-1}$)		Chronic Reference Exposure Level[b] (ug/m^3)	
		Value	Reference	Value	Reference
2,3,7,8-Tetrachlorodibenzofuran	51207-31-9	1.30E+04	CalEPA 2009	----	
1,2,3,7,8-Pentachlorodibenzofuran	57117-41-6	6500	CalEPA 2009	----	
2,3,4,7,8-Pentachlorodibenzofuran	57117-31-4	65000	CalEPA 2009	----	
1,2,3,4,7,8-Hexachlorodibenzofuran	70648-26-9	13000	CalEPA 2009	----	
1,2,3,6,7,8-Hexachlorodibenzofuran	57117-44-9	13000	CalEPA 2009	----	
1,2,3,7,8,9-Hexachlorodibenzofuran	72918-21-9	13000	CalEPA 2009	----	
2,3,4,6,7,8-Hexachlorodibenzofuran	60851-34-5	13000	CalEPA 2009	----	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	67562-39-4	1300	CalEPA 2009	----	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	55673-89-7	1300	CalEPA 2009	----	
Octachlorodibenzofuran	39001-02-0	13	CalEPA 2009	----	

ATSDR = Agency for Toxic Substances Disease Registry
CalEPA = California Environmental Protection Agency
IRIS = Integrated Risk Information System
$[mg/kg\text{-}day]^{-1}$ = per milligram per kilogram per day
NCEA = National Center for Environmental Assessment
PPRTV = Provisional Peer Reviewed Toxicity Value
r-r = route-to-route extrapolation
ug/m^3 = microgram per cubic meter

Source:
Agency for Toxic Substances Disease Registry. 2009. http://www.atsdr.cdc.gov/toxpro2.html
CalEPA. 2008. *All Chronic Reference Exposure Levels (cRELs)* . Office of Environmental Health Hazard Assessment. December 18.
CalEPA. 2009. *California Cancer Potency Values* . Office of Environmental Health Hazard Assessment. October.
USEPA. 2009a. Integrated Risk Information (IRIS) Database. Available online: http://www.epa.gov/iris. [Accessed: August].

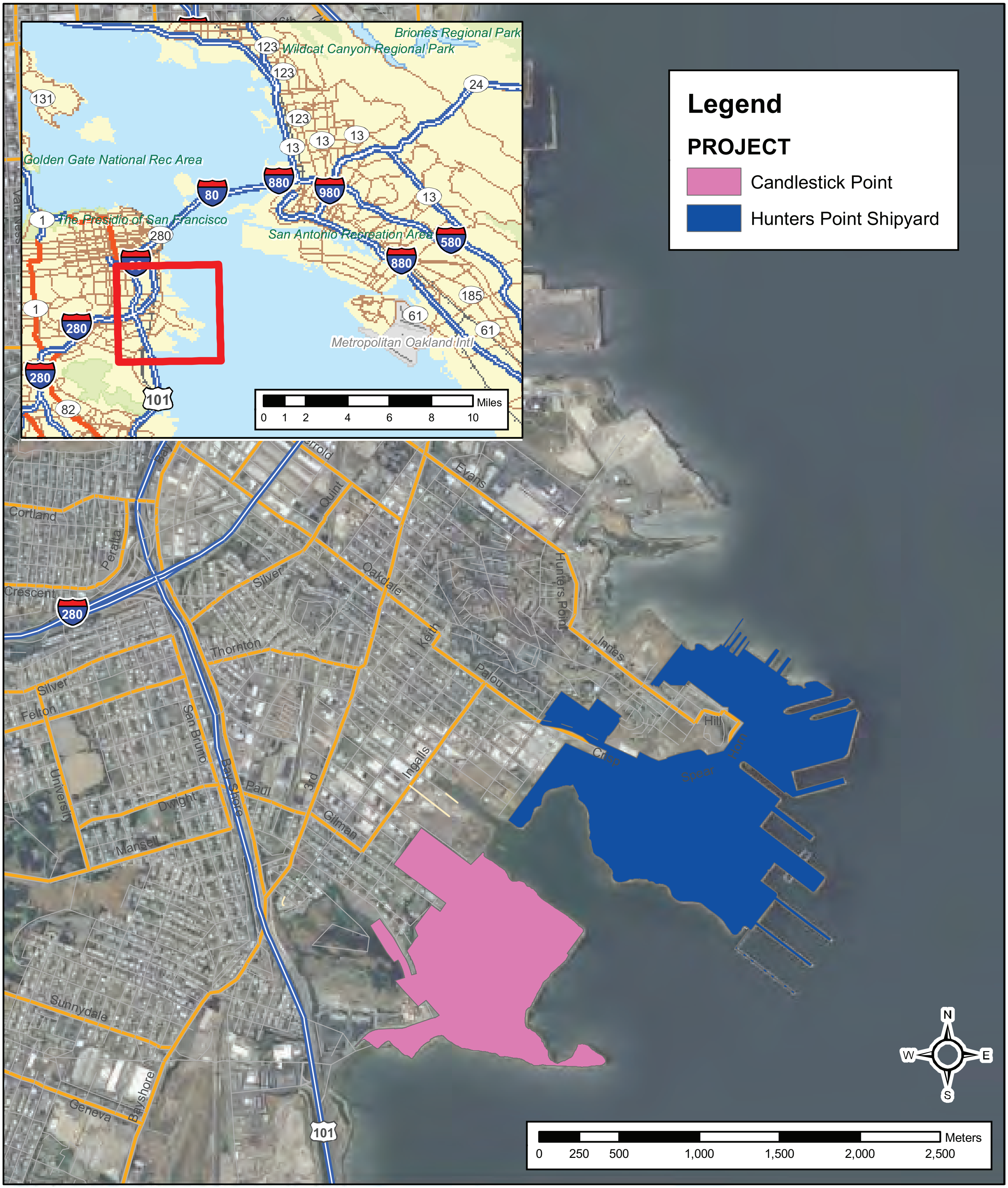
Table 6-1
Summary of Cancer Risks at the Offsite and Onsite Maximally Exposed Individuals (MEIs)
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Project Area	Off-site Receptor Population						On-site Receptor Population			
	School Child	Offsite Worker	Resident				Resident			
			Adult		Child		Adult		Child	
			Average Exposure	High End Exposure	Average Exposure	High End Exposure	Average Exposure	High End Exposure	Average Exposure	High End Exposure
Candlestick Point	7E-09	2E-08	1E-08	1E-08	2E-08	3E-08	2E-08	2E-08	3E-08	4E-08
Hunters Point Shipyard	1E-09	1E-08	3E-09	4E-09	6E-09	7E-09	9E-10	1E-09	1E-09	2E-09
Candlestick Point - Hunters Point Shipyard Phase II Development Plan	7E-09	2E-08	1E-08	1E-08	2E-08	3E-08	2E-08	2E-08	3E-08	4E-08

Table 6-2
Summary of Noncancer Hazard Indices (HIs) at the Offsite and Onsite Maximally Exposed Individuals (MEIs)
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Project Area	Off-site Receptor Population				On-site Receptor Population	
	School Child	Offsite Worker	Resident		Resident	
			Adult	Child	Adult	Child
Candlestick Point	0.0002	0.003	0.004	0.007	0.005	0.01
Hunters Point Shipyard	0.004	0.03	0.02	0.02	0.004	0.004
Candlestick Point - Hunters Point Shipyard Phase II Development Plan	0.004	0.01	0.009	0.02	0.007	0.01

Figures



ENVIRON

6001 Shellmound St., Suite 700, Emeryville, CA 94608

Project Site Vicinity Map
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Figure **2-1**

Drafter: EH Date: 09/17/2009

Contract Number: 0320816A

Legend

Road Improvement Construction

- Carroll Ave
- Gilman Ave
- Harney Way
- Hunter's Point Blvd
- Ingall St
- Palou Ave
- Thomas Ave

PROJECT

- Candlestick Point
- Hunters Point Shipyard

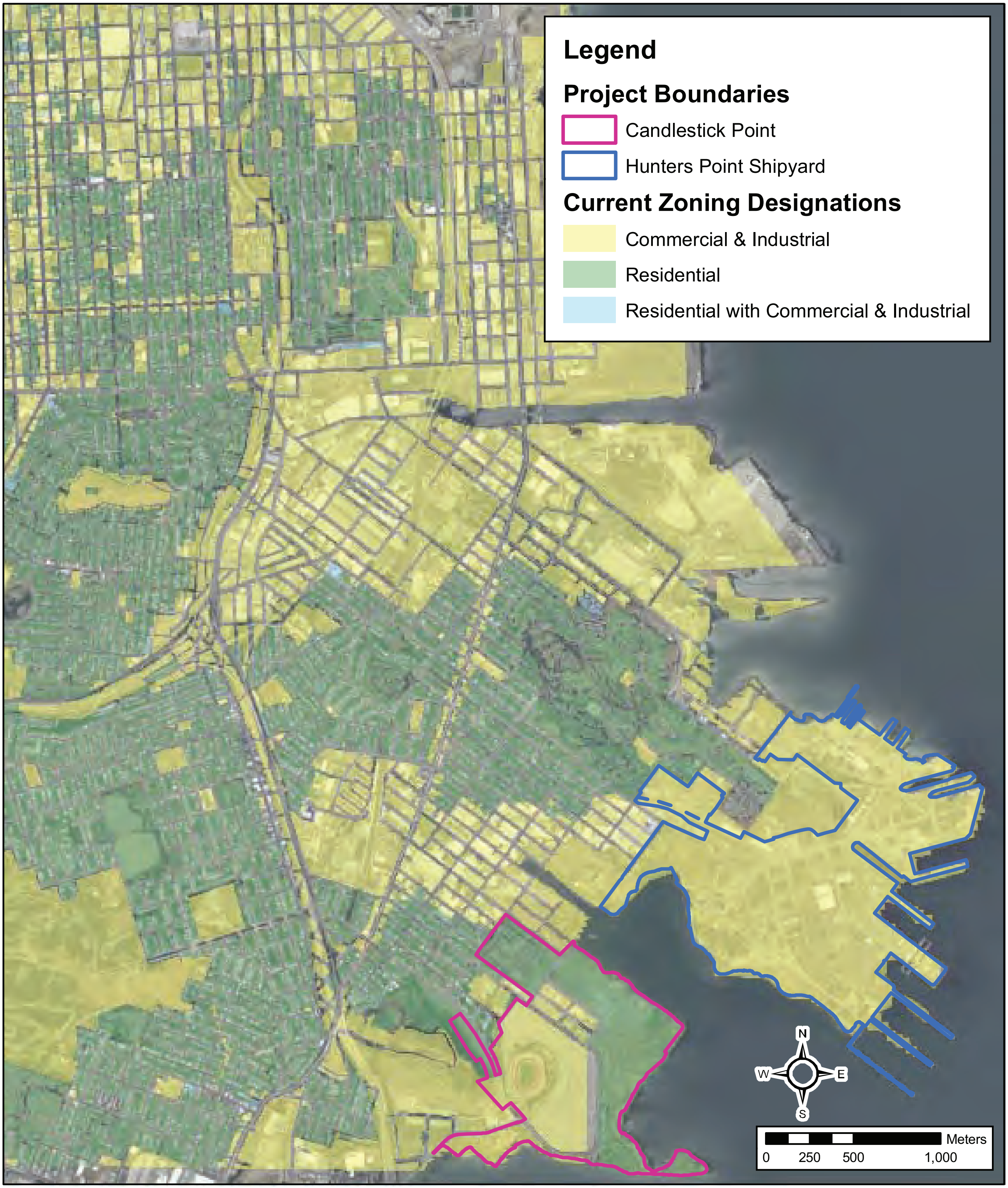
Note:
1. CP, HP designations reflect proposed construction phases.
2. Alice Griffith Housing area is represented by CP-01 through CP-06.

ENVIRON
6001 Shellmound St., Suite 700, Emeryville, CA 94608

Project Overview
Candlestick Point - Hunters Point Shipyard Phase II
Development Plan
San Francisco, California

Drafter: EH Date: 09/21/2009 Contract Number: 0320816A Approved: Revised:

Figure
2-2



ENVIRON

6001 Shellmound St., Suite 700, Emeryville, CA 94608

Surrounding Land Use
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Figure **2-3**

Drafter: EH Date: 09/17/2009 Contract Number: 0320816A

ENVIRON

6001 Shellmound St., Suite 700, Emeryville, CA 94608

Offsite Receptor Locations
Candlestick Point - Hunters Point Shipyard Phase II
Development Plan
San Francisco, California

Figure

4-1a

Drafter: EH | Date: 09/17/2009 | Contract Number: 0320816A | Approved: | Revised:

ENVIRON

6001 Shellmound St., Suite 700, Emeryville, CA 94608

Onsite Receptor Locations
Candlestick Point - Hunters Point Shipyard Phase II
Development Plan
San Francisco, California

Figure

4-1b

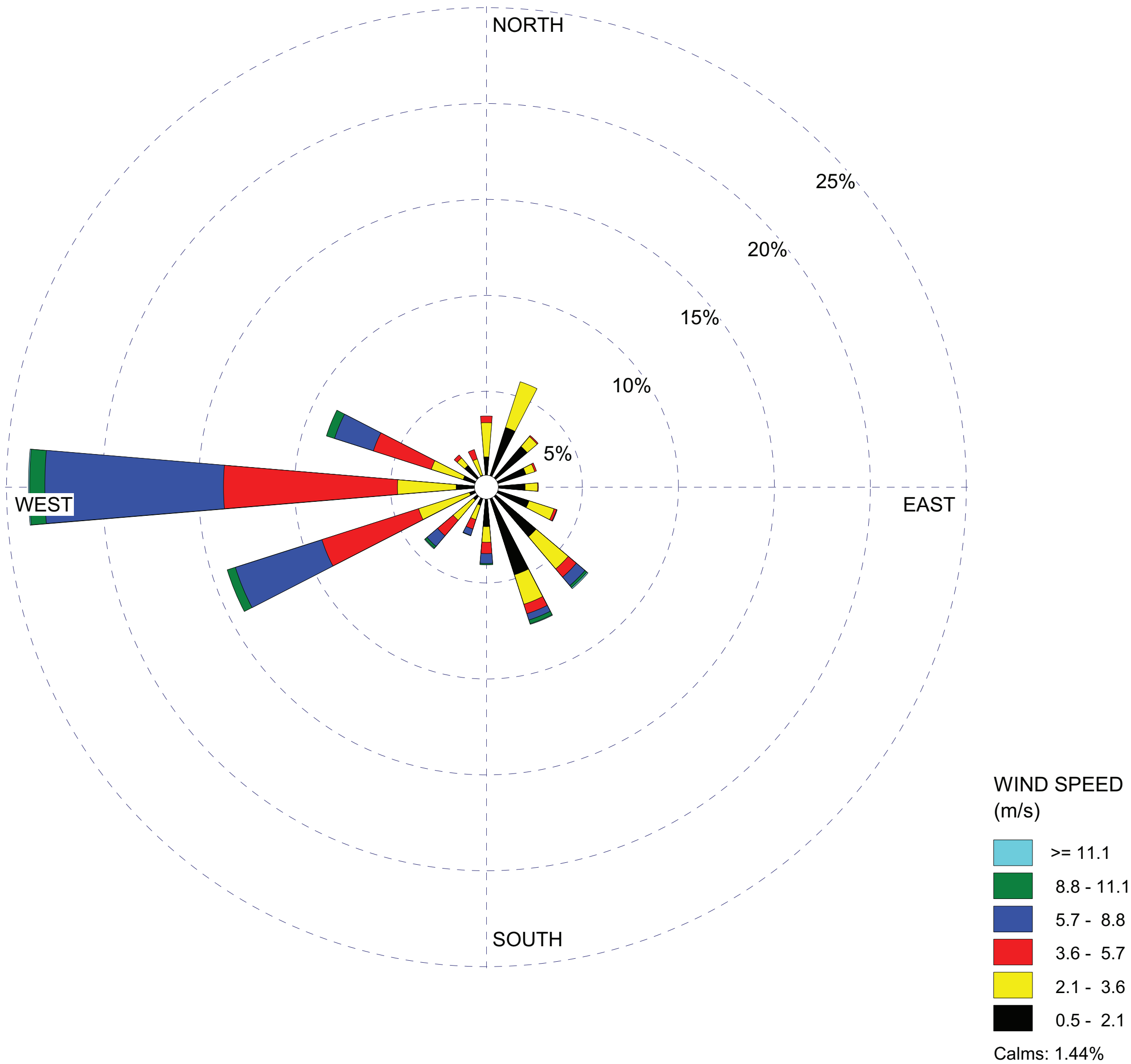
Drafter: EH | Date: 09/17/2009 | Contract Number: 0320816A | Approved: | Revised:

WIND ROSE PLOT:

Figure 4-2: Wind Rose Hunters Point Shipyard 2002-2003 7am-3pm (8 hours per day)

DISPLAY:

Wind Speed
Direction (blowing from)



COMMENTS:	DATA PERIOD:	COMPANY NAME:	
	2002-2003 **Jan 1 - Dec 31** **07:00 - 14:00**	MODELER:	
	CALM WINDS: **1.44%**	TOTAL COUNT: **2920 hrs.**	
	AVG. WIND SPEED: **3.88 m/s**	DATE: **07/17/2009**	PROJECT NO.:

WRPLOT View - Lakes Environmental Software

ENVIRON

6001 Shellmound St., Suite 700, Emeryville, CA 94608

Construction Dust Sources
Candlestick Point - Hunters Point Shipyard Phase II
Development Plan
San Francisco, CA

Figure

4-3

Drafter: Date: Contract Number:

Attachment III:
Analysis of Toxic Air Contaminant Emissions from Stationary Sources in Research & Development Areas

Candlestick Point – Hunters Point Shipyard Phase II Development Plan San Francisco, California

Contents

List of Tables

List of Figures

List of Appendices

List of Acronyms

AERMOD	American Meteorological Society/Environmental Protection Agency Regulatory Model
AERMET	Meteorological data preprocessor for AERMOD
BAAQMD	Bay Area Air Quality Management District
Cal/EPA	California Environmental Protection Agency
CEQA	California Environmental Quality Act
CP	Candlestick Point
EIR	Environmental Impact Report
gsf	Gross Square Footage
HI	Hazard Index
HPS	Hunter's Point Shipyard
ISCST3	Industrial Source Complex Short Term Model
NED	National Elevation Dataset
NFL	National Football League
OEHHA	Office of Environmental Health Hazard Assessment
PBS&J	Post, Buckley, Schuh & Jernigan, Inc.
R&D	Research and Development
SFPD	San Francisco Police Department
SRA	State Recreation Area
TAC	Toxic Air Contaminants
UCSF	University of California, San Francisco
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

1 Introduction

At the request of Post, Buckley, Schuh & Jernigan, Inc. (PBS&J), ENVIRON International Corporation (ENVIRON) performed a screening-level prospective analysis to evaluate potential health impacts from sources of toxic air contaminant (TAC) emissions which may locate in the areas designated for research and development (R&D) within the proposed Candlestick Point – Hunters Point Shipyard Phase II Development Plan ("Project"). This analysis has been conducted as part of an Environmental Impact Report (EIR) for the Project which is being prepared by PBS&J on behalf of the San Francisco Redevelopment Agency and the San Francisco Planning Department.

This analysis evaluates a conservative scenario of TAC emissions from each potential R&D source and estimates the potential cumulative health impacts (i.e., excess lifetime cancer risks and chronic noncancer hazard indices [HIs]) for offsite and future onsite populations and compares them to the Bay Area Air Quality Management District (BAAQMD or District) California Environmental Quality Act (CEQA) thresholds of significance.

1.1 Objectives and Methodology

ENVIRON conducted a prospective analysis; considering potential TAC sources that may locate within the R&D portions of the Project in the future. For this prospective analysis, ENVIRON made a series of assumptions to evaluate a conservative scenario of potential sources and their associated TAC emissions. This approach allows for flexibility in evaluating the type and location of future sources at the Project.

As the Project land use designations provide that a wide range of stationary sources can operate in R&D areas, the exact type of stationary sources and quantity of the TAC emissions from those sources are not known. As a result, a conservative scenario of TAC emissions from each potential individual source was modeled to estimate the potential cumulative health impact from all future TAC emission sources on receptor locations adjacent to the proposed R&D areas.

Key assumptions in this evaluation include:

- The area designated for proposed R&D development would be divided into one acre plots, which is consistent with the minimum size of a parcel based on the expected land uses within the R&D parcels.
- A single R& D facility (or stationary source) would be constructed on the one-acre plot.
- The cancer risk at the boundary of each one-acre plot was set not to exceed a designated cancer risk level or chronic noncancer HI threshold.

- It was conservatively assumed that all receptor locations surrounding the R&D area were residential.

The impacts from TAC emissions from each stationary R&D source were summed to assess the cumulative impact of all potential stationary sources within the area designated for R&D development on surrounding receptors.

1.2 Report Organization

This report is divided into five sections as follows:

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

Section 2.0 – Background: presents a description of the Project and regulatory background.

Section 3.0 – Methodology: describes the methodology used to estimate potential health impacts from TAC emissions within the R&D areas on surrounding receptor locations.

Section 4.0 – Results: presents the estimated cumulative cancer risks and chronic noncancer HIs and compares them to regulatory thresholds.

Section 5.0 – References: includes all references cited in this report.

Supporting documentation is included in the Appendices as follows:

Appendix A – Sample List/Categorization of Bay Area Clean Tech Business – 2009

Appendix B – Hunter's Point Shipyard Residential, Commercial, Public Facilities Land Use Detail, Stadium Option – Revised June 11, 2009

2 Background

2.1 Projection Description

Details of the Project have been provided in the Project Description included in Chapter II of the EIR prepared by PBS&J. Based on information provided in this source, the Project will consist of the development of two areas collectively referred to as the Candlestick Point-Hunters Point Shipyard Phase II Development Plan (the “Project”). The description of the Project is organized under two major sub-components: Candlestick Point (CP) and Hunters Point Shipyard (HPS) Phase II. The Project comprises an approximately 702-acre area shown on Figure 2-1.

The Project proposed by Lennar Urban includes a mixed-use community with a range of residential, retail, office, research and development, civic and community uses, and parks and recreational open space. In addition, a major component would be a new stadium for the San Francisco 49ers, a National Football League (NFL) team. Necessary infrastructure improvements (including several roadway modifications) are also proposed in support of the Project development plan, as shown on Figure 2-2.

A summary of the Project for the CP and HPS Phase II development are summarized separately below. A more detailed discussion of the Project is included in Chapter II of the EIR.

Candlestick Point: This area is approximately 281 acres in size. Current land use in the CP area includes Candlestick Park stadium, and associated parking lots and access roadways. The area also includes several vacant privately owned parcels that are used primarily for stadium parking. Acquisition of these parcels is anticipated as part of the Project. The CP area also includes the Alice Griffith Housing area (Figure 2-2). Approximately 120 acres of the 154-acre Candlestick Point State Recreation Area (SRA) is also included within the Project and forms the south and east shoreline boundary.

The proposed Project for CP includes site preparation activities, including abatement, demolition of existing structures, and grading, and construction of residential units, parks and open space, retail space, community services, office space, hotel accommodations, and a performance arena. The development plan also includes a rebuild of Alice Griffith Housing which will provide upgraded units to existing residents.

Hunters Point Shipyard Phase II: The HPS Phase II area comprises 421 acres (dry-land) on the former Navy Parcels B, C, D and E. Navy Parcel F comprises approximately 440 acres of submerged lands in San Francisco Bay surrounding the central portion of the HPS Phase II area to the north, east and south. The entire HPS Phase II area is currently under the jurisdiction of the Navy. The HPS Phase II area includes many structures associated with ship repair, piers, dry-docks, storage, administrative, and other former Navy uses, largely from the World War II era. Most structures are vacant, although several former Navy buildings are currently leased and occupied. Current tenants at the HPS Phase II area include an estimated 252 artists located in studios on Parcels A and B, and a San Francisco Police Department (SFPD) facility on Parcel D-1 in Building 606. The proposed Project plan for this area includes new residential units, parks and open space, research and development (R&D), community services, artist studios and centers, neighborhood retail, and a new stadium for the San Francisco 49ers, a NFL team. The stadium parking plan will accommodate parking for stadium events and will serve public recreational uses.

The EIR also examines variants to the Project:

- Variant 1 would include an additional 2.5 million gross square footage (gsf) of research and development space on the proposed stadium site. All other elements of the Project would remain the same.
- Variant 2 would redistribute 1,350 residential units to the proposed stadium site from Candlestick Point. All other elements of the Project would remain the same.
- A third variant (Variant 3) would include the same land use program and overall description as the Project, with different locations for the residential towers.
- Variant 4 assumes that a new stadium would be constructed and shared between the San Francisco 49ers and the Oakland Raiders football teams. The land use program would remain the same as the proposed Project.

Chapter IV of the EIR analyzes these Variants. Evaluation of the Variants in the EIR allows for consideration and approval of these variants without further environmental review.

For this analysis, ENVIRON evaluated the Project (with Stadium) and Variant 1, where in place of the Stadium an additional 2.5 million square feet of R&D would be located at South Hunter's Point Shipyard. Variant 1 was chosen for this analysis as it has the maximum potential R&D land use. The development plan for Variant 1 is shown on Figure 2-3.

2.2 Surrounding Area

The Project comprises an approximately 702-acre area east of U.S. 101 in the southeast area of the City and County of San Francisco and occupies the waterfront area from south of India Basin to Candlestick Cove (Figure 2-1).

The CP area is immediately east of Executive Park, with the Bayview neighborhood to the north, the HPS Phase II to the northeast, and Candlestick Point SRA along the Bay frontage generally to the east (Figure 2-1). The CP area is generally bounded by Hawes Street to the northwest and Jamestown Avenue to the southwest, the Candlestick Cove and South Basin areas of the Bay are to the south and east, respectively.

The HPS Phase II area is to the southeast of the Bayview Hunters Point neighborhood. As shown in Figure 2-1, the HPS Phase II area is generally bounded by San Francisco Bay to the north, east, and south. The south end of the western boundary extends from Yosemite Slough along Arelious Walker Drive to approximately Crisp Road, excluding the University of California San Francisco (UCSF) property. The northern boundary generally extends along Crisp Road and Spear Avenue. The northernmost end of the HPS Phase II area is contiguous with Earl Street.

Figure 2-4 shows the zoning information, obtained from the City of San Francisco, for areas in the immediate vicinity of the Project. To the west of the Project, the city areas are zoned mixed-use residential and industrial. The area to the south is zoned for commercial or industrial use. The Project Area is bordered by the San Francisco Bay to the north and east.

2.3 Regulatory Background

Pursuant to BAAQMD *CEQA Guidelines* (BAAQMD 1999), projects that expose the public to TACs in excess of the following thresholds would be considered to have a significant air quality impact:

- Probability of contracting cancer for the maximally exposed individual (MEI) exceeds 1×10^{-5} (10 in a million);
- Ground level concentrations of non-carcinogenic TACs resulting in an HI greater than 1.0 for the MEI.

For this analysis, excess lifetime cancer risks and chronic noncancer HIs are estimated for residential receptors are compared to the BAAQMD CEQA thresholds.

3 Methodology

ENVIRON performed air dispersion modeling to estimate the potential cumulative excess lifetime cancer risk and chronic noncancer HIs at surrounding receptor locations from stationary air emissions sources located in proposed R&D areas. As the Project land use designations allow a wide range of potential uses, ENVIRON made a series of assumptions to evaluate the effect of potential air emission sources on surrounding receptor locations, assuming the maximum possible TAC emissions from each of the individual R&D sources. With these guiding criteria, described below, it was possible to model the impact of emissions in order to determine whether the R&D sources, in aggregate, would have potential adverse effects on the surrounding receptors.

Because the Project land use designations provide that a wide range of stationary sources can operate in the R&D areas (example list of Bay Area clean technology businesses provided by Lennar is attached as Appendix A), the exact type of stationary sources that will locate within R&D areas and quantity of the emissions from those sources are not known. As a result, the following conservative scenario was established so that the impact of the potential aggregate emissions from all future TAC emission sources in these R&D areas could be evaluated at surrounding receptor locations.

For this analysis, it was assumed that no individual TAC emission source could exceed 10 in a million cancer risk (1×10^{-5}) or a 1.0 chronic noncancer HI for a receptor at the boundary of each site. This scenario is consistent with BAAQMD requirements for sources equipped with best available control technology for toxics (T-BACT), and will be a requirement for sources in the R&D areas.

Analyzing this conservative scenario and determining the cumulative effect of any combination of potential sources of TAC emissions on surrounding receptor locations ensures that the aggregate health impacts from air emissions from each source in these R&D areas will be less than, or at most equal to BAAQMD thresholds. This methodology allows for flexibility in the types of TAC emission sources allowed to occupy sites in the R&D areas in accordance with the land use plan.

Although excess lifetime cancer risk and chronic noncancer HIs are explicitly evaluated here, acute risks are not evaluated, as it is highly unlikely that all emissions sources will be operating at their maximum emission rate at the same time (e.g., for any single hour).

This section describes the methodology used to confirm that buffer areas required between business parks/utility zones will prevent exceedence of a cumulative excess lifetime cancer risk (from all sources) of 10 in a million (1×10^{-5}) or a chronic noncancer hazard index of 1.0 at adjacent receptor locations.

3.1 Source and Receptor Locations

Land use designations, as shown in Figures 2-2 and 2-3, were used in this analysis to identify the locations of proposed R&D areas and nearby receptors. In order to determine the number of potential TAC emission sources, these R&D areas were subdivided into roughly one acre sites, which is consistent with the minimum size of a parcel based on the expected uses at the Project (attached as Appendix B). For this analysis, it was assumed that each site contained one air emission source located at the centroid of each site.

Potential health impacts of this maximum emissions scenario were evaluated at receptor locations within approximately 500 meters of the R&D areas. Impacts would be lower beyond this distance. Figure 3-1a and b shows the locations of the potential TAC emission sources and the sites where they reside for the Project (with stadium) and Variant 1 (without stadium; additional R&D areas) options, respectively. These figures also show receptor locations where cancer risk and chronic noncancer HIs were evaluated. For this screening evaluation, all surrounding receptors were conservatively evaluated as residential receptors (i.e., potential exposures/risks for other populations would be less, as the exposure frequency and duration would be less than a residential scenario).

3.2 Air Dispersion Modeling

This section explains the parameters used for modeling TAC emissions, and the rationale for choosing these parameters, and the assumptions inherent in modeling the effect of TAC emissions on surrounding receptor locations.

3.2.1 Model Selection

ENVIRON used the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) version 07026, the United States Environmental Protection Agency (USEPA) recommended air dispersion model (USEPA 2004). AERMOD was developed as a replacement for USEPA's Industrial Source Complex Short Term (ISCST3) 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). AERMOD, with USEPA default model settings, was used to model the transport of air emissions to receptors locations.

3.2.2 Meteorological Data

Air dispersion modeling applications require the use of meteorological data that are both spatially and temporally representative of conditions in the immediate vicinity of the site under consideration. The USEPA and California Environmental Protection Agency's (Cal/EPA's)

Office of Environmental Health Hazard Assessment (OEHHA) typically recommend using a minimum of one year of on-site meteorological data or five years of representative meteorological data from a nearby site for regulatory air dispersion modeling applications.

ENVIRON used meteorological data collected from a meteorological station installed at the Hunter's Point Shipyard for a period from October 1, 2002 through September 30, 2003. This location was determined to be the most representative meteorological data available for air dispersion modeling for the Project. Meteorological data for use in AERMOD were processed in accordance with the AERMOD Implementation Guidance released in January 2008. A description of meteorological data processing and processed meteorological data ready for use in AERMOD can be found in Attachment V.

Average concentrations over the one-year span of the meteorological data were calculated for use in estimating excess lifetime cancer risks and chronic noncancer HIs.

3.2.3 Terrain

An 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). Complex terrain can affect the results of a dispersion analysis involving point and volume sources, but does not affect the predicted results for area sources (USEPA 2005b). Terrain elevations were obtained from United States Geological Survey (USGS) National Elevation Dataset (NED) for San Francisco area and imported to sources and receptors using AERMAP, a data preprocessing module associated with AERMOD.

3.2.4 Urban Heat Island Effect

As determined in the land use analysis discussed in Attachment V, the sources are not located in an urban area as defined for air modeling purposes due to the large expanse of nearby water and therefore the urban boundary layer option was not selected in AERMOD.

3.2.5 Building Downwash

Building downwash is the effect of structures on the dispersion of emissions from nearby stationary (stack) sources. Since the location and types of buildings to be built on each site have not yet been determined, building downwash was not addressed in this analysis.

3.2.6 Receptors

Receptors evaluated in this analysis included: 1) receptors on the boundary of each individual TAC emission source spaced 20 meters apart along the boundary ("boundary receptors"), and 2) grid receptors placed over surrounding receptor locations, both onsite (i.e., within the Project boundaries) and offsite, spaced at 50 meters ("grid receptors").

3.2.7 Source Configuration

Source location and stack parameter information are necessary to model the dispersion of air emissions. Since the actual location and types of air emissions sources have not yet been determined, several assumptions were made.

Each source was placed at the center of each site. All sources were assumed identical with the source parameters presented in Table 2-1. These values are representative of a generic light industrial source with low temperature, low velocity releases. These are conservative assumptions, as they minimize dispersion and thus estimate higher concentrations at the off-site receptors. This analysis does not consider the impact of sources more representative of heavy industry (e.g., high temperature and/or high velocity and/or elevated stack releases, such as those from a refinery or steel mill).

Table 2-1: Source Parameters

Parameter	Units	Values
Stack Height	meters	3.048
Exit Temperature	Kelvin	ambient
Exit Velocity	meters per second	0.001
Stack Diameter	meters	0.3048

Initially all sources were assigned identical release rates and the maximum concentration was determined at the boundary of each individual source using the “boundary receptors” discussed above. This initial run established the maximum emission rate for each individual source such that no single source exceeded the thresholds of 10 in a million cancer risk (1×10^{-5}) or a 1.0 chronic noncancer HI at its boundary.

These scaled emission rates were then modeled in aggregate and evaluated at the “grid receptors” at the surrounding receptor locations to determine the cumulative excess lifetime cancer risk and chronic noncancer HI at each receptor location.

3.3 Cumulative Risk at Sensitive Receptors

The emissions from each generic TAC source were scaled such that the estimated excess lifetime cancer risk and chronic noncancer HI thresholds were not exceeded at the boundary of the site containing that source. All TAC sources, with scaled emissions rates, were modeled together to determine the cumulative excess lifetime cancer risk and noncancer HI at each surrounding receptor location (assuming residential land use) to determine whether it exceeded the BAAQMD CEQA thresholds.

4 Results

As discussed previously, the cumulative excess lifetime cancer risk and chronic noncancer HIs were evaluated at receptor locations adjacent to the R&D areas. In this section, the results of the analysis are presented and compared with BAAQMD CEQA thresholds (10 in a million [1 x 10^{-5}] estimated excess lifetime cancer risk or a chronic noncancer HI of 1.0).

4.1 Project (Stadium Option)

the estimated cumulative excess lifetime cancer risks for all receptors are below the current BAAQMD CEQA significance threshold of 10 in a million (1 × 10^{-5}). The chronic noncancer HIs are below the current threshold of one.

For the Project (with stadium), the estimated cumulative excess lifetime cancer risks and HIs within the area designated for residential use are also below the BAAQMD CEQA significance thresholds of 10 in a million (1 x 10^{-5}) and 1.0, respectively. However, as shown in Figure 4-1a, for the Project (with stadium), estimated cancer risks are above 10 in a million (1 x 10^{-5}) in an area designated as open space or stadium that extends just slightly south beyond the R&D boundary. The maximum estimated risk for a residential receptor in this location is 17 in a million (1.7 x 10^{-5}) and the HI is 1.7.

However, the receptor location that exceeds the BAAQMD CEQA threshold is within an area designated as open space or stadium, not residential. If cancer risks were estimated based on exposure assumptions consistent with recreational use of the open space, the risks would go down by a factor of 17 to an estimated cancer risk of 1 in a million (1 x 10^{-6}); which is below the CEQA significance threshold of 10 in a million.[1] Due to the decrease in the frequency and duration of potential exposures, this is also true for the chronic HI which would go below the threshold of 1.0.

4.2 Variant 1 (No-Stadium Option - Additional R&D)

As shown in Figure 4-1b, for Variant 1 (without stadium; additional R&D areas), areas which exceed the thresholds do not extend into areas zoned for residential use; however, there are mixed-use areas immediately adjacent to the R&D areas which may be impacted. The

[1] A residential receptor is assumed to be exposed 24 hours/day, seven days/week, for 50 weeks/year (or 250 days per year). A recreational receptor is assumed to be exposed less frequently than a residential receptor. The District has not published standard default exposure parameters for a recreational scenario. Because not all sites provide the same opportunities, recreational scenarios are generally developed on a site-specific basis. For this reason, ENVIRON conservatively assumed that a recreational user could spend up to two hours per day, five days/week (or up to 250 days per year) engaging in recreational activities in the proposed open space.

maximum estimated risk for a residential receptor is 26 in a million (2.6×10^{-5}) and the estimated HI is 2.6. Thus, further evaluation may be warranted if the proposed land use for this mixed-use area includes residential use. However, if cancer risks were estimated based on exposure assumptions consistent with commercial use of the mixed-use area, the estimated cancer risks would likely go down by a factor of 4.2 to 6 in a million (6×10^{-6}); which is below the BAAQMD CEQA threshold criteria of 10 in a million[2]. Due to the decrease in the frequency and duration of potential exposures, this is also true for the chronic HI which would go below the threshold of 1.0.

4.3 Summary

This analysis presents a conservative assessment of the cumulative excess lifetime cancer risk and chronic noncancer HI due to TAC emissions from the R&D areas at any surrounding receptor location. All receptors were initially evaluated as residential receptors. It assumes that each allowable location for TAC emissions will emit chemicals at the maximum allowable rate. In fact, the TAC emissions at some of these locations will be below the maximum rate (for example office building emissions for TAC would be zero or close to zero), and the resultant cumulative risks will also be lower.

Under this conservative evaluation, there are limited areas outside of the R&D areas that exceed the BAAQMD CEQA thresholds were they to be used as residential locations. However, none of these areas are designated for residential land use. If these areas were used for commercial or recreational land use, the frequency and duration of potential exposures would be less than that for a resident. Thus, the estimated risks and HIs would decrease below the thresholds.

Further evaluation may be warranted if land use in the vicinity of the Project is modified or if the placement of the stationary sources do not conform to the assumptions made in this screening-level analysis.

[2] A residential receptor is assumed to be exposed 24 hours/day, seven days/week, 50 weeks/year (or 250 days/year). This is compared to a commercial worker who is assumed to be exposed eight hours/day, five days/week, 50 weeks/year.

5 References

Bay Area Air Quality Management District (BAAQMD). 1999. *BAAQMD CEQA Guidelines: Assessing the Air Quality Impacts of Projects and Plans*. December.

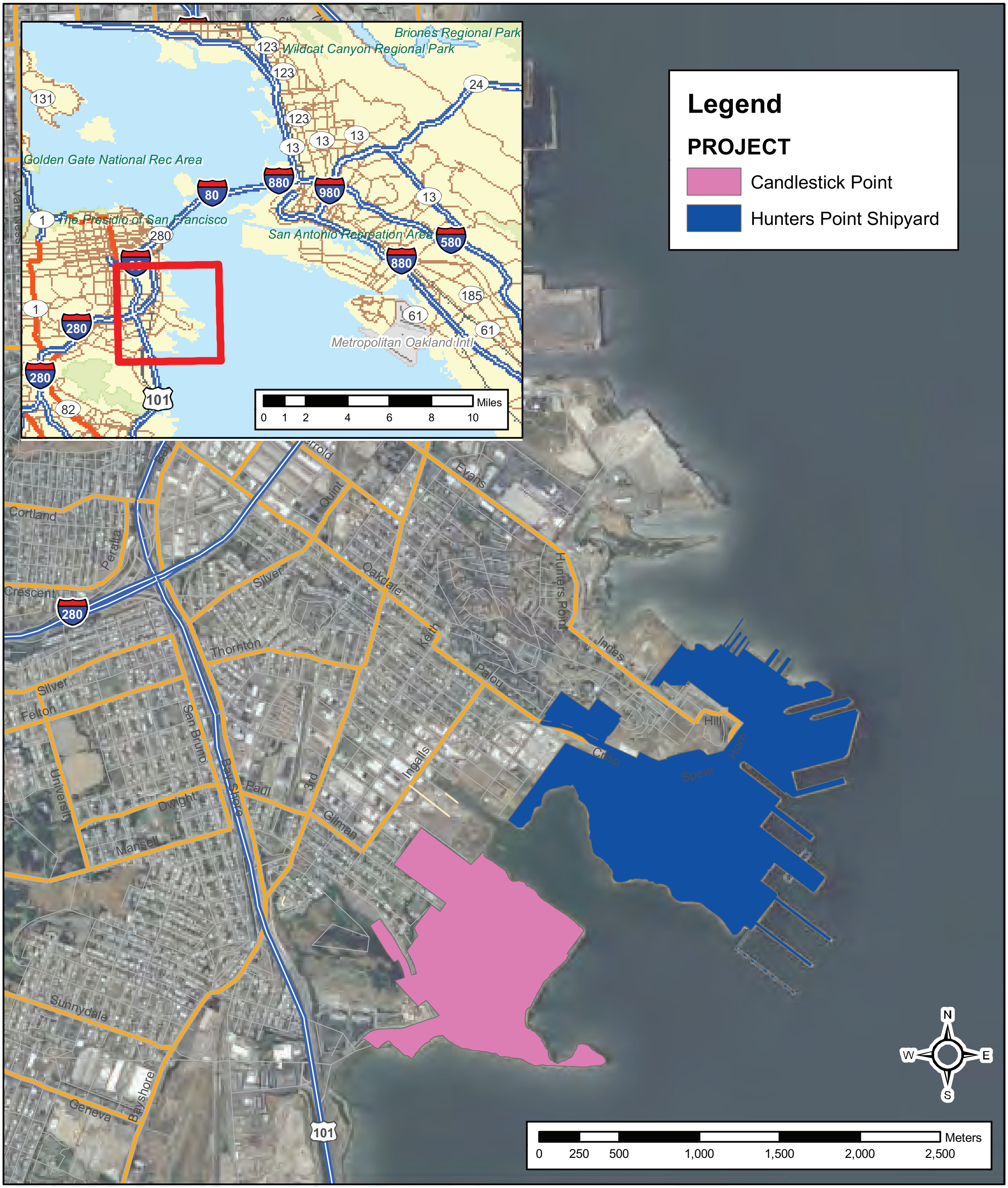
United States Environmental Protection Agency (USEPA). 1995. *User's Guide for the Industrial Source Complex (ISC3) Dispersion Models.* Research Triangle Park, North Carolina. EPA-454/B-95-003a. September.

USEPA. 2004. United States Environmental Protection Agency (USEPA). 2004b. *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.

USEPA. 2005a. *Guideline on Air Quality Models (Revised). 40 Code of Federal Regulations, Part 51, Appendix W.* Office of Air Quality Planning and Standards. November.

USEPA. 2005b. United States Environmental Protection Agency (USEPA). 2005. *Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions*; Final Rule. 40 CFR Part 51, Appendix W. 70 Federal Register 68218-61. November 9.

Figures



ENVIRON

6001 Shellmound St., Suite 700, Emeryville, CA 94608

Project Site Vicinity Map
Candlestick Point - Hunters Point Shipyard Phase II
Development Plan
San Francisco, California

Figure

2-1

Drafter: EH Date: 09/17/2009 Contract Number: 0320816A

SOURCE: Lennar Urban, 2009.

Clement Designs 9-17-09

ENVIRON

6001 Shellmound St., Suite 700, Emeryville, CA 94608

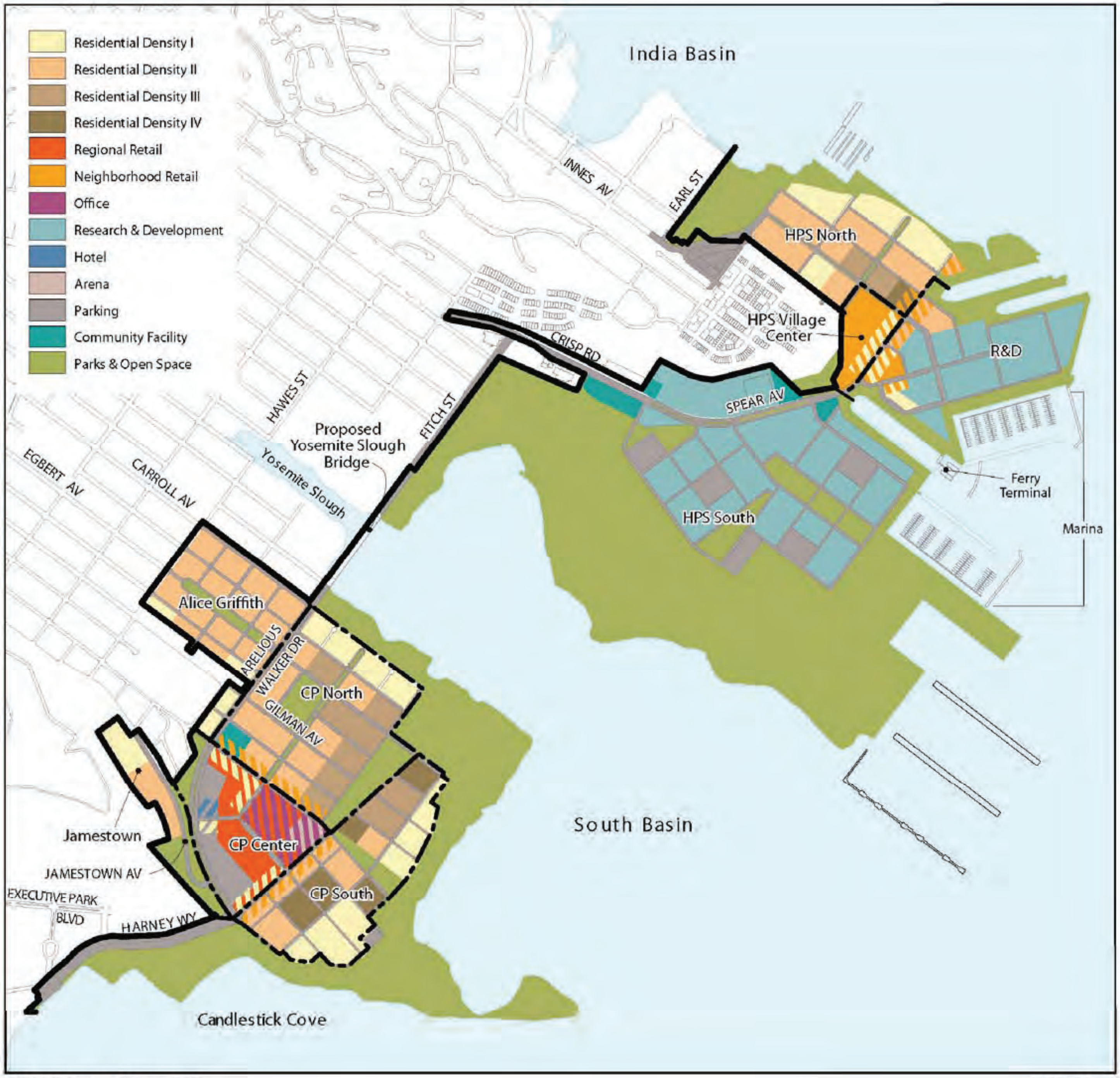
Proposed Land Use Plan
Candlestick Point - Hunters Point Shipyard Phase II
Development Plan
San Francisco, California

Figure

2-2

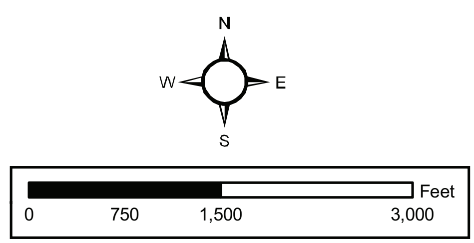
Drafter: RS Date: 09/22/2009

Contract Number: 0320816A



SOURCE: Lennar Urban, 2009.

08068 | JCS | 09



ENVIRON

6001 Shellmound St., Suite 700, Emeryville, CA 94608

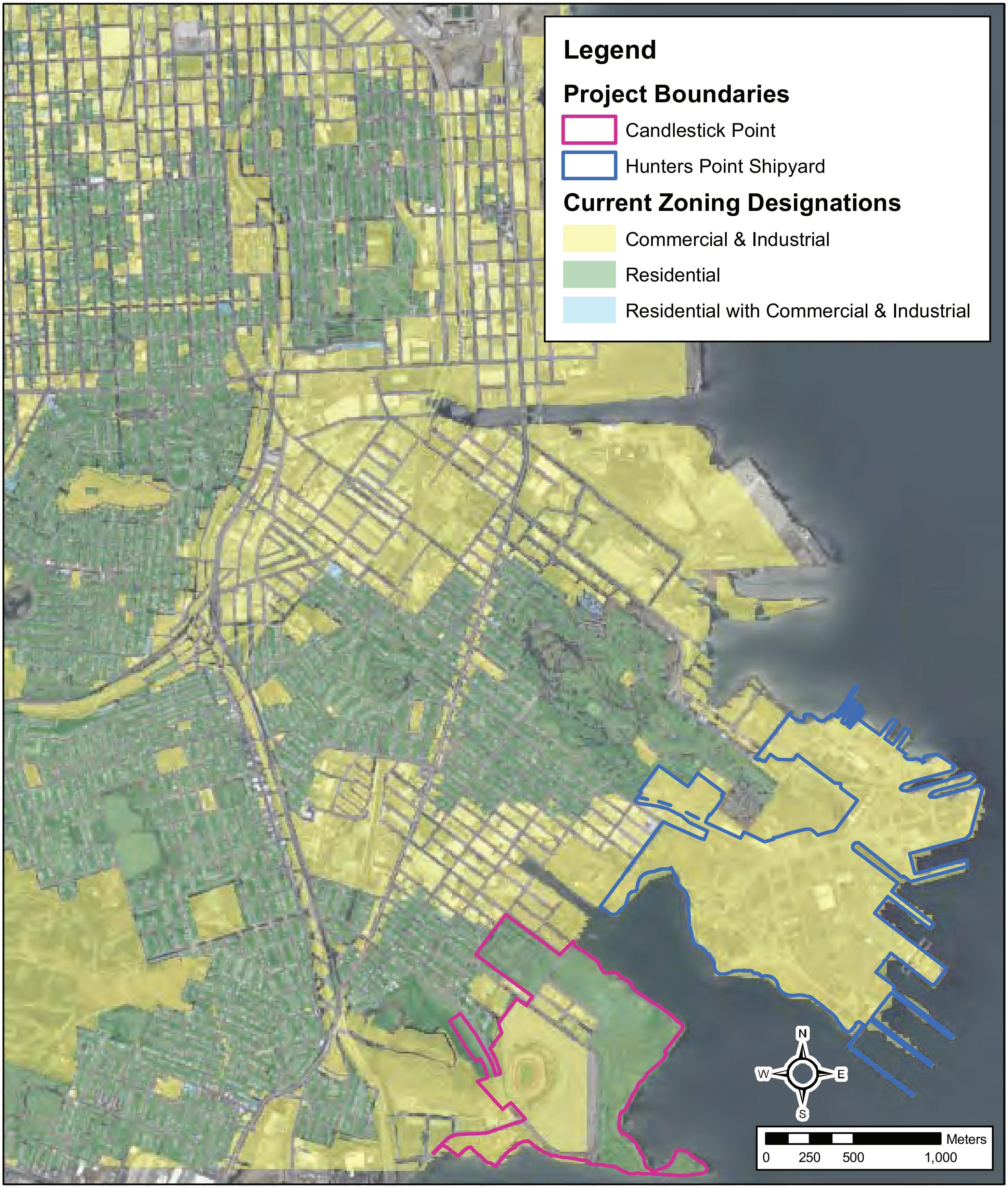
Variant 1 Land Use Plan
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Figure

2-3

Drafter: RS   Date: 09/22/2009

Contract Number: 0320816A



ENVIRON

6001 Shellmound St., Suite 700, Emeryville, CA 94608

Surrounding Land Use
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Figure **2-4**

Drafter: EH Date: 09/17/2009 Contract Number: 0320816A

ENVIRON

6001 Shellmound St., Suite 700, Emeryville, CA 94608

Locations of Potential TAC Sources (Project – with Stadium)
Candlestick Point - Hunters Point Shipyard Phase II
Development Plan
San Francisco, California

Figure
3-1a

Drafter: Date: Contract Number: Approved: Revised:

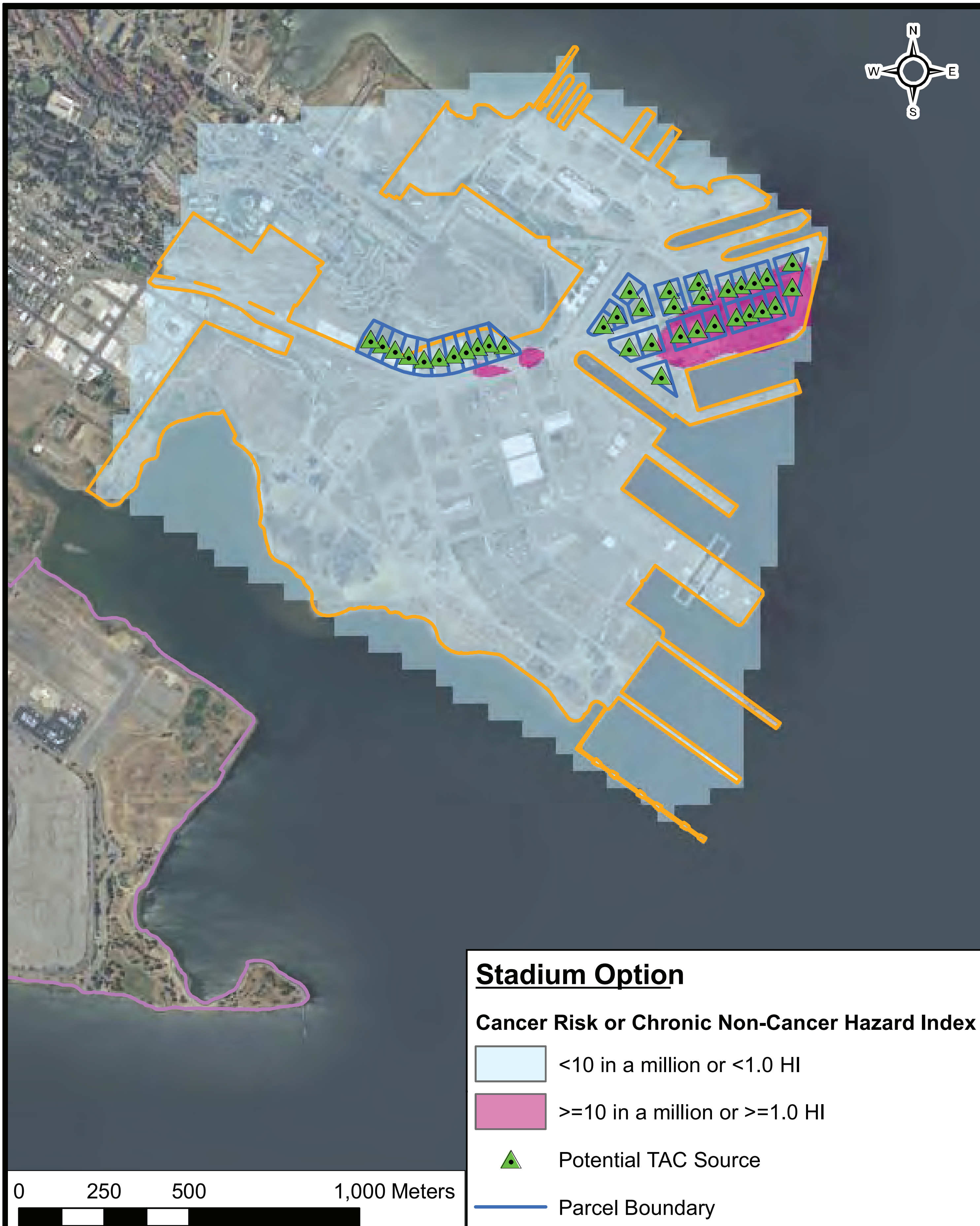
ENVIRON

6001 Shellmound St., Suite 700, Emeryville, CA 94608

Locations of Potential TAC Sources
(Variant 1 - without Stadium/Expanded R&D Areas)
Candlestick Point - Hunters Point Shipyard Phase II
Development Plan
San Francisco, California

Figure
3-1b

Drafter: Date: Contract Number: Approved: Revised:



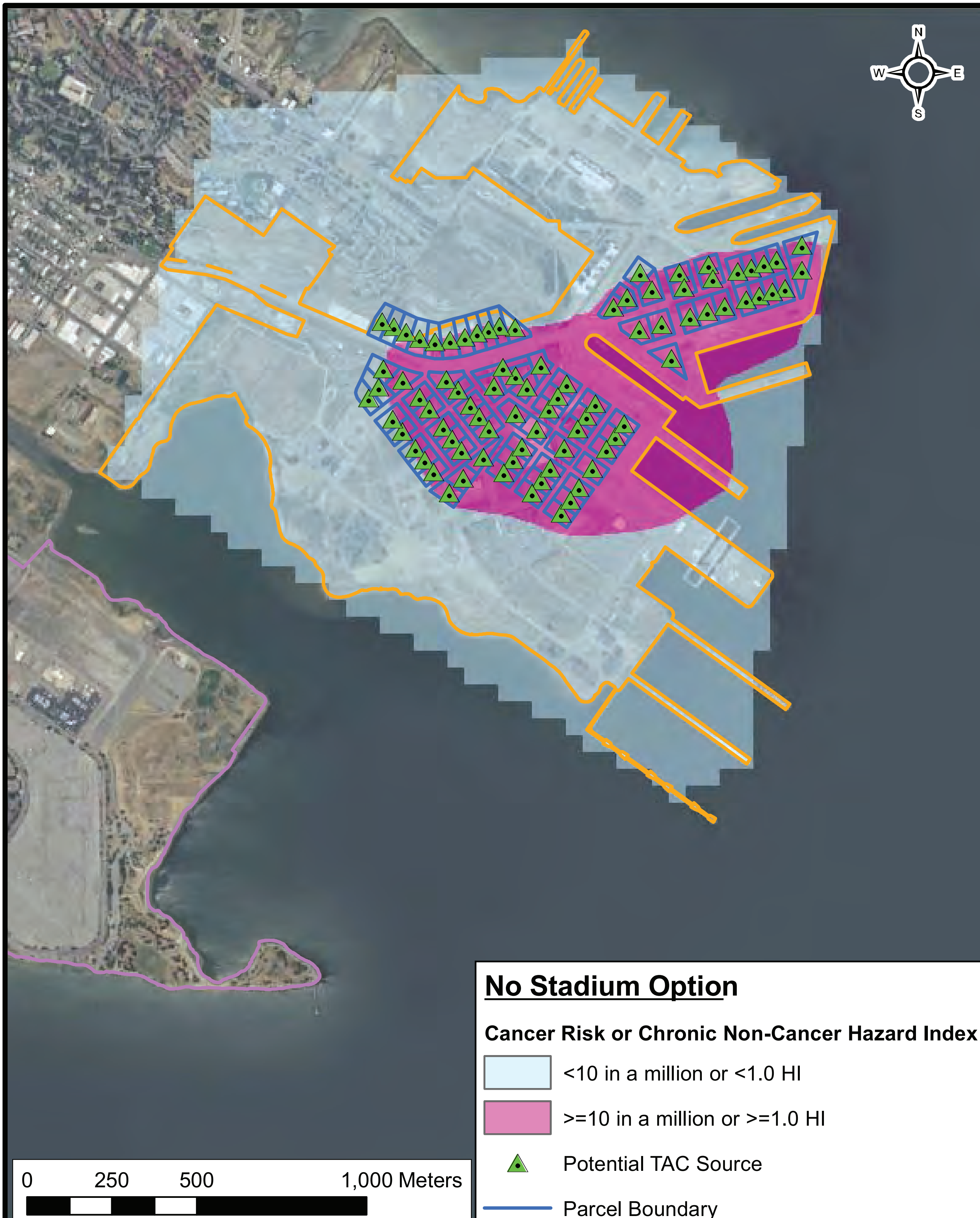
ENVIRON

6001 Shellmound St., Suite 700, Emeryville, CA 94608

Locations of Potential Exceedances
(Project – with Stadium)
Candlestick Point - Hunters Point Shipyard Phase II
Development Plan
San Francisco, California

Figure
4-1a

Drafter: Date: Contract Number: Approved: Revised:



ENVIRON

6001 Shellmound St., Suite 700, Emeryville, CA 94608

Locations of Potential Exceedances
(Variant 1 - without Stadium/Expanded R&D Areas)
Candlestick Point - Hunters Point Shipyard Phase II
Development Plan
San Francisco, California

Figure
4-1b

Drafter:	Date:	Contract Number:	Approved:	Revised:

Appendix A

Sample List/Categorization of Bay Area clean Tech Business - 2009

SAMPLE LIST/CATEGORIZATION of
BAY AREA CLEAN TECH BUSINESSES
2009

Office

- Intelligent Utility Networking
  nonprofit focused on creating sustainable communities by identifying and implementing responsible patterns of land use
- and development
- Wireless lighting management & smart sensors
- PR Company with Cleantech focus
- Develop and enforce regulations, financial assistance, environmental research...
- Non-Profit linking organizations with funders and technical needs
- Legal advising
- trading company with envirotech unit
- Directory, articles and programs on preserving and promoting San Francisco's environmental well being.
- industry research reports, conferences and events, online publications, strategic consulting services
- Supports Clean Energy Entrepreneurs
- Equity investments in emerging clean energy technology firms
- Renewable energy technical support services, green certification, business and promotional services
- Consulting firm offering transaction and trading services and advice on carbon reduction in products and processes
- non-profit providing renewable energy and energy efficiency related services, equipment, and training.

Dry Lab

- products displace conventional electromagnetic motors
- nanotech with renewable energy applications

Wet Lab

- next generation litium battery chemistry w/ high energy density
- electrochemical energy storage
- microfuel cell energy storage
- fuel cells, super capacitors, biomedical sensors, auto diagnostic apps

Bio Lab

- Biomimetic technology to reclaim metal
- Biomimicry
- Alliance of labs and scientists to make algae into fuel by 2010
- nanoscaled catalytic materials for diesel emissions control
- algae biotech; bioproduction sol'ns for energy, industrial, health

Solar Lab

- Develops lower-cost PV solar cells
- Solar Energy, thin film
- Developer of a manufacturing techology that yields low-cost, high efficiency silicon wafers

Dry Lab

- wind power management technology
- Produces technology that cleans the air...

Distribution

- online retailer of enviornmentally sustainable office products
- Solar systems distributor and consultant
- Solar Power Systems distributor and installer
- Solar Energy
- Installation of renewable energy
- PV Module Mounting Systems (Solar Panel installations)
- Solar Power installer
- Solar Energy Equipment-Wholesale

Light Manufacturing

- Manufacturer of digital direct controls for HVAC and light industrial
- improves quality and decreases waste in semiconductor manufacturing
- construction of traction kites to cut fuel costs on ships
- Innovative battery equipment
- environmentally friendly furniture, textiles and accessories
- Energy management controls
- Energy Management and conservation equipment

Heavy Manufacturing

- lithium ion batteries
- electric cars
- Alternative fuel limo service

Appendix B

Hunter's Point Shipyard Residential, Commercial, Public Facilities Land Use Detail, Stadium Option – Revised July 11, 2009

STADIUM OPTION - Revised June 11, 2009

Hunters Point Shipyard residential, commercial, public facilities land use detail

Parcel	Block	Net Parcel Size: Parcel Size (SF)	Net Parcel Size: Parcel Size (Acres)	Residential: Number of Residential Units	Residential: Density[2] (Total Units/Net Acreage)	Commercial: Neighborhood Retail (SF)	Commercial: Artists[3] Space (SF)	Commercial: R & D (SF)	Commercial: Community Facilities (SF) @ *0.24 FAR	Commercial: Total Commercial Square Feet	Commercial: FAR (Total Commercial Square Feet/Net Acreage)
HPS North	1a	74,255	1.70	100	59					0	0.00
	1b	73,318	1.68	120	71					0	0.00
	2a	64,896	1.49	125	84					0	0.00
	2b	57,807	1.33	110	83					0	0.00
	3a	46,260	1.06	30	28					0	0.00
	3b	79,787	1.83	75	41					0	0.00
	4a	64,063	1.47	60	41					0	0.00
	4b	64,060	1.47	115	78					0	0.00
	5a	50,509	1.16	95	82					0	0.00
	5b	50,509	1.16	130	112					0	0.00
	6a	52,932	1.22	95	78					0	0.00
	6b	52,932	1.22	110	91					0	0.00
	7a	49,816	1.14	55	48					0	0.00
	7b	55,717	1.28	70	55					0	0.00
	8a	50,646	1.16	135	116					0	0.00
	8b	49,395	1.13	290	256	15,000				15,000	0.30
	9a	53,075	1.22	95	78					0	0.00
	9b	51,764	1.19	95	80					0	0.00
	10a	55,868	1.28	70	55					0	0.00
	10b	61,974	1.42	70	49					0	0.00
	11	29,564	0.68	40	59	10,000				10,000	0.34
subtotal HPS North		*1,189,147*	*27.30*	*2,085*	*28-256*	*25,000*	*0*	*0*	*0*	*25,000*	*0.02*
HPS Village Center	1	329,062	7.55	125	17	25,000	255,000			280,000	0.85
subtotal Village Center		*329,062*	*7.55*	*125*	*17*	*25,000*	*255,000*	*0*	*0*	*280,000*	*0.85*
R&D	1	68,956	1.58	55	35	37,000				37,000	0.54
	2	106,119	2.44	200	82	12,000		84,000		96,000	0.90
	3a	76,496	1.76	115	65	10,000				186,000	2.43
	3b	70,207	1.61					176,000		197,000	2.81
	4	75,020	1.72					197,000		197,000	2.63
	5	312,323	7.17					643,000		643,000	2.06
	6	101,644	2.33					239,000		239,000	2.35
	7	160,523	3.69					400,000		400,000	2.49
	8	120,994	2.78	70	25	16,000		138,000		154,000	1.27
	9	49,851	1.14					123,000		123,000	2.47
subtotal R&D		*1,142,133*	*26.22*	*440*	*25-82*	*75,000*	*0*	*2,000,000*	*0*	*2,272,000*	*1.99*
HPS South	1	479,469	11.01					500,000	9,908	509,908	1.06
	2	54,413	1.25						13,012	13,012	0.24
	3	113,241	2.60						27,080	27,080	0.24
subtotal HPS South		*647,123*	*14.86*	*0*	*0*	*0*	*0*	*500,000*	*50,000*	*550,000*	*0.85*
Total		***3,307,465***	***75.93***	***2,650***	***17-256***	***125,000***	***255,000***	***2,500,000***	***50,000***	***3,127,000***	***0.95***

1. Net Acreage excludes the street network

2.

415	Residential Density Range I (20-45 units per acre)
1,570	Residential Density Range II (46-90 units per acre)
375	Residential Density Range III (91-175 units per acre)
290	Residential Density Range IV (176+ units per acre)
2,650	**Total Units**

3. **Existing Artist Space**

Buildings	Sq. Ft.
101	119,800
103	14,008
104	14,194
110	20,502
115	13,684
116	18,439
117	14,194
125	10,416
	225,237

Proposed Artist Space

Sq. Ft.	
120,000	Building Renovation
50,000	New Building
55,000	New Building
225,000	
30,000	Net New Building
255,000	Total Building

Attachment IV:
$PM_{2.5}$ Analysis of Traffic/Vehicular Emissions

Candlestick Point– Hunters Point Shipyard Phase II Development Plan, San Francisco, California

Contents

List of Tables

List of Figures

List of Acronyms

AAQS	Ambient Air Quality Standards
ARB	Air Resources Board
CEQA	California Environmental Quality Act
CP	Candlestick Point
DPM	Diesel Particulate Matter
EIR	Environmental Impact Report
EMFAC	EMission FACtor model
gfs	gross square footage
HPS	Hunters Point Shipyard
PBS&J	Post, Buckley, Schuh & Jernigan, Inc.
NAAQS	National Ambient Air Quality Standards
NED	National Elevation Dataset
NFL	National Football League
PAHs	Polynuclear Aromatic Hydrocarbons
PM	Particulate Matter
$PM_{2.5}$	Particulate Matter Less than 2.5 Microns in Diameter
PM_{10}	Particulate Matter Less than 10 Microns in Diameter
R&D	Research and Development
SFDPH	San Francisco Department of Public Health
SFPD	San Francisco Police Department
SRA	State Recreation Area
UCSF	University of California San Francisco
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VMT	Vehicle Miles Traveled
VOC	Volatile Organic Compound

List of Units

m^3	cubic meter
mph	miles per hour
mg	milligram
μg	microgram
μm	micrometer or micron

1 Introduction

At the request of Post, Buckley, Schuh & Jernigan, Inc. (PBS&J), ENVIRON International Corporation (ENVIRON) estimated the concentration of particulate matter (PM) with a mean diameter of 2.5 microns or less ($PM_{2.5}$) in the vicinity of the proposed Candlestick Point (CP) – Hunters Point Shipyard (HPS) Phase II Development Plan ("Project"), and assessed the potential impacts of $PM_{2.5}$ concentrations attributable to Project-related traffic along the thoroughfares and nearby roads. The Project is situated such that there are several major thoroughfares which Project-related traffic would use to access neighboring freeways and other areas of San Francisco. Estimates for the Project-associated traffic, including average speeds, on each of these thoroughfares were taken directly from the traffic report (CHS Consulting Group et al. 2009) developed in support of the Environmental Impact Report (EIR).

1.1 Objectives and Methodology

The objective of this assessment is to estimate Project-related concentrations of $PM_{2.5}$ along major roadways in the vicinity of the Project, and to examine the potential health affects associated with these concentrations.

$PM_{2.5}$ from vehicle exhaust, tire wear, and brake wear were estimated using emission factors generated using the most recent version of the EMission FACtor model (EMFAC), developed by the Air Resources Board (ARB). On December 12, 2008, ARB adopted an On-Road Heavy-Duty Diesel Vehicles (In-Use) Regulation which affects exhaust emission for vehicles larger than 14,000 pounds gross vehicular weight. EMFAC 2007, the most recent EMFAC version, does not yet include impacts for the new ARB Regulation, therefore, ENVIRON used the emission reduction estimates developed for the ARB rulemaking process in order to evaluate the impacts of the new Regulation. Vehicle volumes were estimated from the traffic report (CHS Consulting Group et al. 2009).

The concentration of $PM_{2.5}$ from vehicular emissions was characterized by developing exposure point concentrations at residential receptors surrounding the thoroughfares evaluated. This analysis was conducted by estimating the average annual airborne concentrations of $PM_{2.5}$ expected to result from Project-related traffic emissions, and by conducting air dispersion modeling of those emissions. A Gaussian air dispersion model, approved by the United States Environmental Protection Agency (USEPA) and ARB for use in the environmental documentation of transportation projects, was used to estimate ambient air concentrations. Both free flowing traffic and queuing at intersections were evaluated.

The potential health impacts from Project-associated $PM_{2.5}$ were evaluated by comparing predicted concentrations of $PM_{2.5}$ to the San Francisco Department of Public Health (SFDPH 2008) $PM_{2.5}$ threshold of 0.2 microgram per cubic meter ($\mu g/m^3$). The evaluation of potential health impacts from $PM_{2.5}$ is not required under current CEQA guidelines, but was conducted to comply with SFDPH guidance (2008). The SFDPH (2008) $PM_{2.5}$ threshold is documented in:

- SFDPH. 2008. *Assessment and Mitigation of Air Pollutant Health Effects from Intra-urban Roadways: Guidance for Land Use Planning and Environmental Review*. May 6.

1.2 Report Organization

This report is divided into eight sections as follows:

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

Section 2.0 – Background: presents a description of the Project and provides the regulatory background.

Section 3.0 – Chemical Selection: describes the selection of the chemical evaluated in this Attachment.

Section 4.0 –Estimated $PM_{2.5}$ Concentrations in Air: discusses the methods used to estimate emissions of $PM_{2.5}$, including a description of the emission sources, the air dispersion model used to predict $PM_{2.5}$ concentrations, meteorological data, building and terrain considerations, land use analysis, identification of receptor locations, and results of the modeling.

Section 5.0 –Risk Characterization: presents a comparison of Project-associated $PM_{2.5}$ concentrations to the SFDPH threshold concentration.

Section 6.0 –Conclusions: summarizes the results of this assessment.

Section 7.0 –Uncertainty: discusses the different sources and types of uncertainties in this assessment.

Section 8.0 –References: includes all references cited in this report.

2 Background

2.1 Project Description

Details of the Project have been provided in the Project Description included in Chapter II of the EIR prepared by PBS&J. Based on information provided in this source, the Project will consist of the development of two areas collectively referred to as the Candlestick Point- Hunters Point Shipyard Phase II Development Plan (the "Project"). The description of the Project is organized under two major sub-components: Candlestick Point (CP) and Hunters Point Shipyard Phase II (HPS Phase II). The Project comprises an approximately 702-acre area shown on Figure 2-1 and Figure 2-2. The Project proposed by Lennar Urban includes a mixed-use community with a range of residential, retail, office, research and development, civic and community uses, and parks and recreational open space. In addition, a major component would be a new stadium for the San Francisco 49ers, a National Football League (NFL) team. Necessary infrastructure improvements (including several roadway modifications) are also proposed in support of the Project development plan, as shown on Figure 2-2.

A summary of the Project for the CP and HPS Phase II development are provided separately below. A more detailed discussion of the Project is included in Chapter II of the EIR.

Candlestick Point**:** This area is approximately 281 acres in size. Current land use in the CP area includes Candlestick Park stadium, and associated parking lots and access roadways. The area also includes several vacant privately owned parcels that are used primarily for stadium parking. Acquisition of these parcels is anticipated as part of the Project. Approximately 120 acres of the 154-acre Candlestick Point State Recreation Area (SRA) is also included within the Project and forms the south and east shoreline boundary.

The proposed Project for CP includes site preparation activities, including abatement, demolition of existing structures, and grading, and construction of residential units, parks and open space, retail space, community services, office space, hotel accommodations, and a performance arena. The development plan also includes a rebuild of Alice Griffith Housing which will provide upgraded units to existing residents.

Hunters Point Shipyard Phase II**:** The HPS Phase II area comprises 421 acres (dry-land) on the former Navy Parcels B, C, D and E. Navy Parcel F comprises approximately 440 acres of submerged lands in San Francisco Bay surrounding the central portion of the HPS Phase II area to the north, east and south. The entire HPS Phase II area is currently under the jurisdiction of the Navy. The HPS Phase II area includes many structures associated with ship repair, piers, dry-docks, storage, administrative, and other former Navy uses, largely from the World War II era. Most structures are vacant, although several former Navy buildings are currently leased and occupied. Current tenants at the HPS Phase II area include an estimated 252 artists located in studios on Parcels A and B, and a San Francisco Police Department (SFPD) facility on Parcel D-1 in Building 606. The proposed Project plan for this area includes new residential units, parks and open space, research and development (R&D), community services, artist studios and centers, neighborhood retail, and a new stadium for the San Francisco 49ers, a National Football League team. The stadium parking plan will accommodate parking for stadium events and will serve public recreational uses.

The EIR also examines variants to the Project:

- Variant 1 would include an additional 2.5 million gross square footage (gsf) of research and development space on the proposed stadium site. All other elements of the Project would remain the same.
- Variant 2 would redistribute 1,350 residential units to the proposed stadium site from Candlestick Point. All other elements of the Project would remain the same.
- A third variant (Variant 3) would include the same land use program and overall description as the Project, with different locations for the residential towers.
- Variant 4 assumes that a new stadium would be constructed and shared between the San Francisco 49ers and the Oakland Raiders football teams. The land use program would remain the same as the proposed Project.

Chapter IV of the EIR analyzes these Variants. Evaluation of the Variants in the EIR allows for consideration and approval of these variants without further environmental review.

2.2 Surrounding Area

The Project comprises an approximately 702-acre area east of U.S. 101 in the southeast area of the City and County of San Francisco and occupies the waterfront area from south of India Basin to Candlestick Cove (Figure 2-1 and Figure 2-2).

The CP area is immediately east of Executive Park, with the Bayview neighborhood to the north, the HPS Phase II to the northeast, and Candlestick Point State Recreation Area (SRA) along the Bay frontage generally to the east (Figure 2-1). The CP area is generally bounded by Hawes Street to the northwest and Jamestown Avenue to the southwest, the Candlestick Cove and South Basin areas of the Bay are to the south and east, respectively.

The HPS Phase II area is to the southeast of the Bayview Hunters Point neighborhood. As shown in Figure 2-1, the HPS Phase II area is generally bounded by San Francisco Bay to the north, east, and south. The south end of the western boundary extends from Yosemite Slough along Arelious Walker Drive to approximately Crisp Road, excluding the University of California San Francisco (UCSF) property. The northern boundary generally extends along Crisp Road and Spear Avenue. The northernmost end of the HPS Phase II area is contiguous with Earl Street.

Figure 2-3 shows the zoning information, obtained from the City of San Francisco, for areas in the immediate vicinity of the Project. To the west of the Project, the city areas are zoned mixed use residential and industrial. The area to the south is zoned for commercial or industrial use. The Project Area is bordered by the San Francisco Bay to the north and east.

2.3 Regulations and Guidance

The SFDPH (2008) has developed guidance for $PM_{2.5}$ that draws on a broad regulatory framework and a comprehensive body of scientific literature that has established strong correlations between $PM_{2.5}$ exposures and a number of adverse health effects. For example, under the Clean Air Act (USEPA), 1990, the USEPA regulates PM as a criteria air pollutant (USEPA, 2009), and has established national ambient air quality standards (NAAQS) for both particulate matter with a diameter less than ten microns (PM_{10}) (150 µg/m^3)[1] and $PM_{2.5}$ (15 or 35 µg/m^3)[2]. The State of California also regulates PM, and has ambient air quality standards (AAQS) for PM_{10} (20 or 50 µg/m^3)[3] and $PM_{2.5}$ (12 µg/m^3)[4] (ARB 2005a). Of particular concern to the SFDPH is that $PM_{2.5}$ appears to have health effects below the NAAQS and AAQS as described by ARB (2008a) in their most recent examination of the relationship between particulate matter exposures and premature mortality.

Another information source that is key to the SFDPH guidance (SFDPH 2008) is ARB's 2005 guidance for land use planning (ARB 2005b). That guidance recommends against locating "sensitive land uses, including residential development" within 500 feet of a highway traveled by more than 100,000 vehicles a day (ARB 2005b). (The ARB guidance also addresses the location of sensitive land uses in the vicinity of distribution centers, railyards, and ports, but these sources are not of direct concern to the Project and are not addressed further.)

The SFDPH guidance was also developed to support compliance with the California Environmental Quality Act (CEQA), and to address specific goals of the City of San Francisco's General Plan which include:

> " …to reduce the level of pollutants in the air, to protect and improve public health, welfare, and quality of life…" (SFDPH 2008).

[1] This is a 24-hour concentration that is not to be exceeded more than once per year on average over three years (USEPA 2009).

[2] 15 µg/m^{3}is an annual arithmetic mean concentration. Attainment is achieved if the three-year average of the weighted annual mean $PM_{2.5}$ concentrations from a single or multiple community-oriented monitors must not exceed 15.0 µg/m^3 (USEPA 2009). 35 µg/m^3 is a 24-hour concentration. Attainment is achieved if the three-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area does not exceed 35 µg/m^3 (USEPA 2009)

[3] 20 µg/m^3 is an annual arithmetic mean concentration of PM_{10}; 50 µg/m^3 is the 24-hour annual arithmetic mean concentration of PM_{10} (ARB 2005a).

[4] 12 µg/m^3 is an annual arithmetic mean concentration of $PM_{2.5}$ (ARB 2005a).

2.3.1 Development of SFDPH Criterion for $PM_{2.5}$

The SFDPH is concerned that individuals who live in the proximity of heavily-travelled roads or freeways will incur adverse health effects as a result of exposure to vehicle emissions. To minimize contributions to health impacts associated with locating new residential projects near roadway "hot spots", the SFDPH developed a strategy to assess and mitigate air pollution at these locations. Their strategy is based on the use of an annual average threshold concentration of $PM_{2.5}$ (0.2 µg/m^3) within a 150 meter zone of a new project as a means of assessing the potential for concern. The threshold concentration of $PM_{2.5}$ is meant to serve as a health-protective "proxy" or surrogate for pollutant exposures from vehicles i.e., $PM_{2.5}$ is not the only pollutant of concern. Instead, the $PM_{2.5}$ threshold serves as a concentration meant to protect the health of residents from all vehicle-associated emissions from a project.

Health effects of individual chemicals or of a mixture are typically evaluated by the use of a toxicity criterion. However, despite the establishment of NAAQS and AAQS for $PM_{2.5}$, no toxicity criterion has been developed by either the state or federal government. The reasons for this are complex, and are related both to how these criteria are developed, as well as the properties of $PM_{2.5}$. That is, toxicity criteria are typically derived for a chemical based on standardized exposures to known concentrations or doses of the material; effects (if any) can then be correlated to a specific quantity. However, for $PM_{2.5}$, its toxicity is at least partially dependent on the mixture of metals, polynuclear aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs) or other chemicals sorbed to the surface of the particulate. This heterogeneity of $PM_{2.5}$ depends on the source of the particulate, and varies with the fuel type, engine type, dust, etc. that is the source of the $PM_{2.5}$. This variability precludes the derivation of a single representative toxicity criterion. Instead, epidemiologists have examined the relationship between $PM_{2.5}$ concentrations in ambient air and correlated these to effects within a population. Exposure to $PM_{2.5}$ has been linked to an increase in premature mortality, hospitalizations, cardiovascular events, and asthma attacks, among others (see ARB 2008a). The mathematical expression which relates changes in exposure to ambient concentrations of a pollutant, such as $PM_{2.5}$, to changes in an adverse effect such as premature mortality is known as a concentration-response function.

The concentration-response function incorporates a term for relative risk, which describes the incremental increase in effect for a given concentration of a pollutant i.e., a 1.4% increase in the annual incidence of premature mortality per 1.0 µg /m^3 increase in $PM_{2.5}$. The SFDPH criterion for $PM_{2.5}$ of 0.2 µg/m^3 is based on these concepts (SFDPH 2008). The SFDPH (2008) guidance provides specific rationale for selection of the $PM_{2.5}$ threshold concentration as follows:

- "*A threshold of 0.2 µg/m^3 represents about 8-10% of the intra-urban range of PM 2.5 ambient concentration based on available and reliable monitoring data in San Francisco.*
- *A change in ambient concentration of $PM_{2.5}$ by 0.2 µg/m^3, independent of other vehicle pollutants would result in significant forecasted health impacts.*

- *Based on a recent study of intra-urban pollution in Los Angeles, a 0.2 μg/m^3 increase in PM 2.5 would result in a 0.28% increase in non-injury mortality or an increase of about twenty-one excess death per 1,000,000 population per year from non-injury causes in San Francisco (Jerrett et al. 2005). This effect is well above the one-in-a-million lifetime de minimus risk threshold for premature death considered insignificant by most regulatory agencies (Asante-Duah 2002).*
- *Applying the health effects assessment methodology and Concentration Response Functions in the ARB Staff Report on AAQS for PM published in 2002, a 0.2 μg/m^3 increase in $PM_{2.5}$ affecting a population of 100,000 adults would result in about 20 extra premature deaths per year (ARB 2002). This effect is well above the one-in-a-million lifetime de minimus risk threshold for premature death considered insignificant by most regulatory agencies (Asante-Duah 2002).*
- *A 0.2 μg/m^3 increase in $PM_{2.5}$ would also result in ~ 160 days per year with respiratory symptoms, 108 days with work limitations, and 577 days with minor activity limitations in the same adult population."*

2.3.2 Application of SFDPH Criterion for $PM_{2.5}$

If exposure to $PM_{2.5}$ from Project traffic is below the threshold of 0.2 μg /m^3 (or if traffic exposures are "fully mitigated"), no further analysis of health effects is required (SFDPH 2008). However, if $PM_{2.5}$ concentrations exceed 0.2 μg/m^3, then SFDPH guidance suggests estimating $PM_{2.5}$-related effects on "excess" (or premature) mortality. SFDPH guidance (SFDPH 2008) provides a simplified version of a $PM_{2.5}$ concentration-response function designed to provide a rapid means of estimating excess mortality from $PM_{2.5}$ exposures. The equation suggested by the SFDPH to estimate excess mortality from $PM_{2.5}$ is:

$$\text{Excess Mortality}_{\text{Traffic-attributable PM2.5}} = (\text{Concentration}_{\text{Traffic-attributable PM2.5}}) \times (\text{Incidence Non–Injury Mortality}) \times (\text{Relative Risk}_{\text{PM2.5}}) \qquad \text{(Eq. 1)}$$

Where:

Concentration $_{\text{Traffic-attributable PM2.5}}$	=	Concentration of $PM_{2.5}$ generated by Project sources;
Incidence Non-injury Mortality	=	Annual mortality incidence from all non-injury causes; and
Relative $\text{Risk}_{\text{PM2.5}}$	=	0.014, or a 1.4% increase in annual mortality incidence per 1.0 μg/m^3 increase in $PM_{2.5}$ (based on Jerrett et al. 2005).

3 Chemical Selection

SFDPH guidance (2008) specifies that while the assessment methodologies contained in that document are specific to $PM_{2.5}$, that $PM_{2.5}$ is used as a "proxy" i.e., as a surrogate, for vehicle-related pollutant emissions and associated exposure to these chemicals. Consistent with this framework, analysis of potential Project-associated emissions focuses solely on $PM_{2.5.}$

4 Estimated $PM_{2.5}$ Concentrations in Air

4.1 Roads Evaluated

The Project is situated such that there are several major thoroughfares which Project-related traffic would use to access neighboring freeways and other areas of San Francisco. The traffic throughputs for roads of potential concern were assessed and determined, based upon Project-related traffic volume and expected impact. Those thoroughfares modeled include Third Street, Innes Avenue/Hunters Point Boulevard /Evans Avenue, Palou Avenue, Gilman Avenue/Paul Avenue, and Harney Way. Those thoroughfares are identified in the traffic report as primary or secondary roads which connect the proposed Project site and major arterials to U.S. 101. In addition, Evans Avenue/Hunters Point Boulevard /Evans Avenue, and Harney Way were selected since they have been identified as streets with significant truck traffic and thus are expected to yield more $PM_{2.5}$ compared to other roads. Furthermore, Palou Avenue, Gilman Avenue/Paul Avenue were selected since there are residences in the vicinity of these roads where individuals may incur exposure to $PM_{2.5.}$

4.2 Emissions Estimation

Emission factors and traffic volumes were calculated for each hour of the weekday for all vehicles in order to estimate $PM_{2.5}$ emissions. Weekend traffic conditions were assumed to be the same as weekday conditions. This approach is expected to yield more conservative estimates of $PM_{2.5}$ concentrations, since weekday traffic volumes are generally greater than on the weekend. Three categories of emissions were taken into account: 1) running emissions from exhaust, 2) running emissions from tire wear and brake wear, and 3) idling or queuing emissions from exhaust. There are no emissions of $PM_{2.5}$ during idling (queuing) from tire wear and brake wear.

Information to estimate emissions for the Project-related traffic on each of the modeled thoroughfares, including peak hour traffic volumes, peak hour number of idling cars, and average speeds, was taken directly from the traffic report developed in support of the EIR (CHS Consulting Group et al. 2009).

$PM_{2.5}$ emissions from vehicle exhaust and tire wear and brake wear were estimated using emission factors generated by the ARB's EMFAC 2007 and modified to account for the On-Road Heavy-Duty Diesel Vehicles (In-Use) Regulation (the ARB Regulation, or the Regulation) that was approved by the ARB on December 11, 2008, which affects emissions for vehicles larger than 14,000 pounds gross vehicular weight (ARB 2008b). EMFAC is a mathematical model that was developed to calculate emission rates from motor vehicles that operate on highways, freeways, and local roads in California and is used by ARB to project changes in future emissions of on-road mobile sources. The most recent version of this model, EMFAC 2007, incorporates local motor vehicle data, information and estimates regarding the distribution of VMT by speed, and number of starts per day.

Annual average emission factors were generated using the average temperature and relative humidity for the Project area, as calculated from the meteorological data, discussed in Section 4.6 below. EMFAC allows the estimation of emissions for in-use fleets from 1970 through 2040. The traffic report's future traffic scenario provides estimates of traffic conditions for 2030, and in-use fleet emissions were estimated for that year. EMFAC 2007 does not yet include impacts for the new ARB Regulation mentioned above; therefore, the emission reduction percentage developed for the ARB rulemaking process was applied to the EMFAC-derived emission factors, as discussed below, to account for the impact of the Regulation on project-related emissions.

4.2.1 Emission Factors

Using EMFAC, $PM_{2.5}$ emission factors (in g/vehicle-mile for running emissions, and in g/vehicle-idling hour for idling emissions) were estimated for calendar year 2030 based on the vehicle fleets of San Francisco County for vehicles of all model years. The traffic report (CHS Consulting Group et al. 2009) provided a.m. and p.m. peak hour speeds along about half of the roadway segments modeled; the average peak hour speed was 21.4 miles per hour (mph) with a standard deviation of 2.4 mph. Thus, for all roadway segments, the emission factors corresponding to travel speed of 20 mph (in g/vehicle-mile) were used for running emissions, while emission factors corresponding to 0 mph (in g/vehicle-idling hour) were used for idling emissions.

EMFAC also presents the fraction of trips that each vehicle class makes on roads in San Francisco County at each hour of the weekday. The emission factors from each vehicle class were multiplied by these hourly trip fractions, then summed across all applicable vehicle classes for each hour to estimate hourly emission factors. The applicable vehicle classes for each modeled thoroughfare were determined by whether truck restrictions are designated in the traffic report (CHS Consulting Group et al. 2009). The traffic report identifies truck restrictions that prevent trucks weighing over 6,000 pounds from driving on segments of Gilman Avenue and Palou Avenue (CHS Consulting Group et al. 2009). For these segments, heavy-duty trucks were excluded from the emission factor estimates. For all other roads modeled, the emission factors were used for all vehicle classes and all model years.

Finally, the ratio of the 2025 projected $PM_{2.5}$ emissions under ARB Regulation to the baseline $PM_{2.5}$ emissions without Regulation[5] was used to scale down running emissions for regulated vehicle classes including mid heavy-duty trucks, heavy heavy-duty trucks, school buses, and other buses. For this scaling, the year 2025 was used in absence of 2030 data. Hourly running emission factors in grams per vehicle-mile for all modeled roadway segments are shown in Table 4-1. Since the ARB Regulation is not explicitly applicable to idling emissions, idling emissions were not scaled using the ratio.

[5] The emission inventory was developed by ARB to assist the rulemaking process. http://www.arb.ca.gov/regact/2008/truckbus08/truckbus08.htm

Hourly idling emission factors in grams per vehicle-idling hour for all modeled roadway segments are presented in Table 4-1.

4.2.2 Traffic Volume

Hourly peak a.m. and hourly peak p.m. traffic volumes were obtained for each modeled roadway segment from the traffic report (CHS Consulting Group et al. 2009). As mentioned above, EMFAC generates trips-per-day by vehicle-class by hour for San Francisco. All trips for each hour of the day were summed, and then the hourly trip fractions were calculated. For segments with truck restrictions, the hourly total trips were modified so as to exclude trips made by heavy-duty trucks, then recalculated the hourly trip fractions.

To estimate daily trips, the average of the AM peak hour trips was divided by the appropriate a.m. peak hour trip fraction and the p.m. peak hour trips divided by the appropriate p.m. peak hour trip fraction. To divide the daily trips into hourly trips for each road segment, the segment's daily trips were multiplied by the calculated appropriate hourly trip fractions. For the peak a.m. and peak p.m. hours, the actual estimates from the traffic study were used.

The hourly traffic volumes on all modeled road segments are shown in Table 4-2.

4.2.3 Queuing

Queuing emissions were estimated for all intersections along the modeled thoroughfares, which, according to the traffic report, have traffic signals or stop signs (CHS Consulting Group et al. 2009). Forty-one queues, or locations were identified where vehicles would idle at a traffic signal. No stop signs were identified as affecting traffic on the modeled roads.

To model queuing emissions, the methodology used in CAL3QHCR was followed while employing actual data from the traffic report (CHS Consulting Group et al. 2009). The traffic report provides information by ultimate direction through the intersection: left turn, through, or right turn. To estimate queue emissions per hour for each direction, the following equation was used:

> Queue Emissions (g/hr) = Idling Emission Factor (g/vehicle-hr) x Number of Vehicles Idling (vehicle) x Red & Yellow Phase per Cycle (sec/cycle) x Number of Cycles per Hour (cycle/hr) ÷ 3600 (sec/hr)

The idling emission factors (in g/vehicle-hr) were estimated using the methodology described in Section 4.1.1. For each queue, the number of vehicles idling per direction during the a.m. peak hour and the p.m. peak hour were obtained from the traffic report (CHS Consulting Group et al. 2009). The hourly traffic volumes, calculated as described in Section 4.1.2, were then used to determine the a.m. hour with the maximum number of vehicles. The ratio of hourly traffic volume to this a.m. peak hour traffic volume was then used to estimate the number of vehicles idling per direction during the a.m. hours (hours 24-11). The same approach was used for the p.m. hours (hours 12-23).

The queuing time per cycle was estimated to be equal to cycle time minus duration of the green light presented in the traffic report; this means that cars are assumed to queue during the yellow and red phases. The number of cycles per hour was calculated from the cycle time (seconds/cycle), provided in the traffic report (CHS Consulting Group et al. 2009).

In order to follow the "nominal free flow" methodology as used by CAL3QHCR, the queue emissions were converted from grams per hour to grams per vehicle-mile. The following formula was used for the conversion.

> Queue Emissions (g/vehicle-mile) = Queue Emissions (g/hr) ÷ Hourly Traffic Volume (vehicle/hr) ÷ (Average Queue Length (m) ÷ 1609.344 (m/mile))

The hourly traffic volumes were estimated using the methodology described in Section 4.1.2. The length of the queue in each direction for each hour, according to CAL3QHCR methodology, is estimated to be six meters for each vehicle idling in that direction for the given hour, with a minimum of six meters used. To estimate an average length across the entire day, the hourly queue length was multiplied by the hourly emission factors and summed across all hours. This approach gives queue emissions in grams per vehicle-mile for every hour of the day on all roadway segments, allowing the queuing emissions to be modeled as running emissions.

4.3 Refined Air Dispersion Modeling

The concentration of $PM_{2.5}$ from vehicular emissions was characterized by developing exposure point concentrations at residential receptors surrounding the thoroughfares evaluated. This analysis was conducted by estimating the average annual airborne concentrations of $PM_{2.5}$ that will result from emissions from the Project-related traffic and by conducting air dispersion modeling of those emissions.

To estimate ambient air concentrations, a Gaussian air dispersion model, approved by the USEPA and ARB for use in preparing environmental documentation for transportation projects, was used. CAL3QHCR is a refined version of USEPA's CAL3QHC, which is a multi-source model developed in 1990 to estimate air concentrations of vehicle emissions near roadway intersections. CAL3QHC is based on the same line-source dispersion algorithm used in CALINE3, and CAL3QHCR adds the ability to evaluate multiple-year meteorological observations rather than evaluating only the worst-case meteorological assumptions. CAL3QHCR uses a meteorological data set that incorporates representative hourly surface and twice-daily upper air data for estimating the dispersion of emissions through the atmosphere.

In addition to the observed meteorological data set, the model uses the roadway geometries, receptor locations, vehicular emission factors (from EMFAC), signal timing (if applicable), and intersection configuration. The GIS shapefile developed by the SFDPH for their CAL3QHCR model setup as basis of the SFDPH land use guidance was requested. That shapefile presents roadway geometries, vehicular traffic volume and emission factors. The roadway geometries were used along with refinements (i.e., dividing roads into two directions, adding Project-related vehicular traffic volume and emission factors) whenever applicable in order to estimate $PM_{2.5}$ concentrations due to Project-related traffic.

Annual average concentrations were calculated for all receptors. No differentiation was made for potential differences in daytime versus nighttime traffic, or for daytime and nighttime exposure. Both free flowing traffic and queuing at intersections were evaluated.

4.3.1 Modeled Pollutants and Averaging Periods

$PM_{2.5}$ emissions were modeled using one year of meteorological data. Using those data, a one-year average concentration was calculated.

4.3.2 Modeling Sources

Emissions from all Project-related traffic on the selected thoroughfares was modeled. Those road segments were represented in CAL3QHCR by a series of straight line segments, each with constant height, width, hourly traffic volume, and hourly emission rates. Widths of the segments under consideration were determined from aerial photographs, and heights were set to zero meters as discussed in the terrain section below. For all running emissions, the mixing zone was set to the road width (along the direction of traffic flow) plus three meters on each side to account for wake effects. For all queuing emissions, the mixing zone was set to the road width since there are no wake effects while idling. Tables 4-3 and 4-4 summarize the source parameters used as inputs in CAL3QHCR for running emissions and queuing emissions, respectively. Figures 4-1 and 4-2 show the location of the travel lanes modeled for running emissions and queuing emissions, respectively.

4.3.3 Terrain

The terrain surrounding the selected thoroughfares was evaluated using National Elevation Dataset (NED) files from the United States Geological Survey (USGS). The area is generally flat with roads ranging from three to 50 meters in elevation and surrounding area ranging from three to 80 meters in elevation; the majority of the roads are at elevations between three and 30 meters with only one segment on Palou Avenue rising above 50 meters. CAL3QHCR limits sources to be placed at elevations of ±10 meters, while receptors can be placed at any elevation. Due to the generally flat nature of the area, all sources were modeled at 0 meters with all receptors at 1.8 meters as recommended by CAL3QHCR documentation.

4.3.4 Meteorological Data

Details regarding the meteorological data used for modeling are presented in Attachment V.

4.3.5 Receptor Locations

Residential receptors were evaluated along the modeled thoroughfares, as recommended in the SFDPH land use guidance (SFDPH 2008). A three-tiered approach was employed to determine the location of these residential receptors. First two receptor grids were placed alongside the thoroughfares that were modeled: 1) a coarse grid of receptors spaced 50 meters apart positioned from the edge of the mixing area to 250 meters from the roadway and 2) a fine grid consisting of receptors spaced 10-meters from the edge of the mixing area to 50 meters from the roadway. San Francisco zoning maps obtained from the City and County of San Francisco Planning Department[6] were then overlaid on the receptor grids to identify receptors within residential zones. Finally, visual screening was conducted on Google Street View to indentify possible residential buildings in commercial and/or industrial zones. The modeled residential receptors are shown in Figure 4-3. Land use zoning in relation to modeled roads is shown in Figure 4-4. Sensitive receptors, such as schools and hospitals, within one mile of the site were also modeled and are summarized in Table 4-5.

4.4 Results of Emissions Estimations

The results of the dispersion modeling are shown in Figure 4-5. All modeled $PM_{2.5}$ concentrations are at or below 0.2 μg/m^3. The highest modeled concentrations occur at intersections and along roads that do not have a truck restriction. The maximum modeled $PM_{2.5}$ concentration is 0.2 μg/m^3, which occurs on the northern edge of Innes Avenue, west of Arelious Walker Drive. As can also be seen in Figure 4-5, $PM_{2.5}$ concentrations are dominated by running emissions.

[6] City and County of San Francisco Planning Department zoning maps are available at http://www.municode.com/Resources/gateway.asp?pid=14145&sid=5

5 Risk Characterization

Modeled concentrations of $PM_{2.5}$ attributable to Project traffic do not exceed the SFDPH (2008) threshold concentration of 0.2 μg/m^3 (Figure 4-5). In general, the areas most impacted by Project-associated $PM_{2.5}$ concentrations are major intersections, such as those at 3rd Street and (1) Palou Avenue and (2) Gilman Avenue/Paul Avenue (Figure 4-5). The maximum $PM_{2.5}$ concentration in residential areas is 0.2 μg/m^3, indicating that by comparison to the SFDPH (2008) threshold, residents in the areas impacted by Project traffic are not expected to experience adverse health effects.

This evaluation utilized a number of conservative assumptions in modeling $PM_{2.5}$ concentrations which provide support for the determination that adverse effects of exposure to $PM_{2.5}$ are not likely. These conservative assumptions include:

- The peak traffic speed emission factor (grams/mile) from EMFAC2007 was used for all traffic. Since the traffic speed during non-peak hours would be expected to yield lower emissions than during peak hours, this approach yielded higher modeled concentrations of $PM_{2.5}$ than using separate emission factors for peak and non-peak times.
- Weekday traffic volumes were assumed to occur 365 days per year. This approach is expected to yield more conservative estimates of $PM_{2.5}$ concentrations, since weekday traffic volumes are generally greater than on the weekend.
- It was assumed that vehicles idle for the entire duration of the yellow and red phases of a traffic light. This results in higher estimated $PM_{2.5}$ concentrations than the more realistic assumption that idling occurs only during some or all of the red light phase.
- The ARB (2008b) regulation for On-Road Heavy-Duty Diesel Vehicles (In-Use) was applied to queuing emissions only. This assumption yields higher concentrations of $PM_{2.5}$ than if the regulation had been applied to operating emissions as well.

6 Conclusions

Project-related traffic is predicted to yield concentrations of $PM_{2.5}$ that do not exceed the SFDPH (2008) concentration threshold for residential uses. The maximum $PM_{2.5}$ concentration in residential areas is 0.2 µg/m^3, indicating that by comparison to the SFDPH (2008) threshold, residents in the areas impacted by Project traffic are not expected to experience adverse health effects.

7 Uncertainties

7.1 Method of Emission Estimation

Emission factors were estimated based on the vehicle fleets of San Francisco County, which may differ than the vehicle mix along the thoroughfares evaluated. EMFAC 2007's emission factors for the year 2030 were used and adjusted to account for the ARB Regulation. To account for the ARB regulation, the expected emissions reductions for the year 2025 were used in lieu of 2030 data. Additionally, the emission factors for 2030 contain uncertainties related to future advances in vehicle technology. Similarly, vehicle volumes were estimated based on the traffic report (CHS Consulting Group et al. 2009), which makes estimates of future Project-related vehicle volumes. As the traffic report results are based on a traffic model that contains uncertainties, the vehicle volumes used also contain uncertainties.

Further, peak hour traffic and peak hour number of idling vehicles from the traffic report were used together with the default hour of day fraction of trips to calculate the hourly traffic volume and hourly idling vehicle volumes. The hour of day fraction of trips for the projected area could differ from the default values provided in EMFAC for 2030 for the San Francisco County, thus bringing additional uncertainties.

Finally, ARB's EMFAC provides weekday trip distribution. Weekday traffic volume and number of idling vehicles from the traffic report were used in this analysis and applied to 365 days of the modeled year. However, weekend traffic conditions could differ significantly from weekday traffic conditions.

Together, all of the uncertainties above influence the emissions estimation.

7.2 Estimation of Exposure Concentrations

There are a number of uncertainties associated with the estimation of $PM_{2.5}$ concentrations from air dispersion modeling of potential emissions from the Project. This section briefly describes some of those uncertainties.

7.2.1 Estimates from Air Dispersion Models

As discussed in Section 4, the USEPA-recommended dispersion model CAL3QHCR was used to estimate annual average $PM_{2.5}$ concentrations due to Project-related traffic at the hypothetical receptor locations. This model uses the Gaussian plume equation to calculate ambient air concentrations from vehicular emission sources. For this model, the magnitude of error for the maximum concentration is estimated to range from 10 to 40% (USEPA 2005a). Therefore, modeled exposure concentrations used in this assessment represent approximate exposure concentrations.

7.2.2 Source Representation

The source parameters (*i.e.*, road elevation and width) used to model emissions are sources of uncertainty. As CAL3QHCR limits source elevations to ±10 meters and as the area is generally flat, road elevations were assumed to be uniformly 0 meters. Widths were estimated using aerial photographs and could contain uncertainties related to human error. Therefore, exposure concentrations used in this assessment represent approximate exposure concentrations.

7.2.3 Meteorological Data Selection

Uncertainty also exists in the meteorological data used in the CAL3QHCR air dispersion model. Onsite meteorological data, which should be representative of the meteorological condition of the modeled roadway segments, was used. However, buildings that are near the roads and which may potentially block some of the winds were not considered. Additionally, CALINE-3, a model on which CAL3QHCR is based, is highly sensitive to extremely low mixing heights (USEPA 1995). Since a 300-meter constant mixing height is used in the metrological data (By Area Air Quality Management District 2009), some potentially extreme conditions occurring when the mixing height is below 100 meters are lost.

8 References

Air Resources Board (ARB). 2002. Staff Report: Public Hearing to Consider Amendments to the Ambient Air Quality Standards for Particulate Matter and Sulfates. Available: http://www.arb.ca.gov/research/aaqs/caaqs/pm/pm.htm)

ARB. 2005a. California Ambient Air Quality Standards for PM. http://www.arb.ca.gov/research/aaqs/caaqs/pm/pm.htm Accessed July 23, 2009

ARB. 2005b. Air Quality and Land Use Handbook: A Community Health Perspective. http://www.arb.ca.gov/ch/landuse.htm

ARB. 2008a. Methodology for Estimating Premature Deaths Associated with Long-Term Exposures to Fine Airborne Particulate Matter in California. October 2008.

ARB. 2008b. Proposed Regulation for In-Use On-Road Diesel Vehicles.

Asante-Duah K. 2002. Public Health Risk Assessment for Human Exposure to Chemicals. Springer. 56-57. As cited in SFDPH, 2008.

Bay Area Air Quality Management District, 2009. http://gate1.baaqmd.gov/aqmet/met.aspx

CHS Consulting Group, Fehr & Peers, LCW Consulting 2009. Bayview Waterfront Project Transportation Study: Preliminary Draft 1 Report. Prepared for City of San Francisco Planning Department.

Jerrett, M., et al. 2005. A review and evaluation of intraurban air pollution exposure models Journal of Exposure Analysis and Environmental Epidemiology. 15:185-204. As cited in SFDPH, 2008.

San Francisco Department of Public Health (SFDPH). 2008. *Assessment and Mitigation of Air Pollutant Health Effects from Intra-urban Roadways: Guidance for Land Use Planning and Environmental Review*. May 6.

United States Environmental Protection Agency (USEPA). 1990. Clean Air Act. United States Code, Title 42, Chapter 85.

USEPA. 1995. User's Guide to CAL3QHC Version 2.0: A Modeling Methodology for Predicting Pollutant Concentrations Near Roadway Intersections. EPA-454/R-92-006 (Revised).

USEPA. 2005. *Guideline on Air Quality Models (Revised). 40 Code of Federal Regulations, Part 51, Appendix W.* Office of Air Quality Planning and Standards.

USEPA. 2009. National Ambient Air Quality Standards. http://www.epa.gov/air/criteria.html#3 Accessed July 23, 2009

Tables

Table 4-1
Summary of Emission Factors
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Hour	Running Emission Factor[1] (grams/vehicle-mile)				Idling Emission Factor[1] (grams/vehicle-idling hour)			
	Exhaust[2]		Non-Exhaust[2]		Exhaust[3]		Non-Exhaust[3]	
	All Vehicles[4]	*No HD Vehicles*[5]	All Vehicles[4]	*No HD Vehicles*[5]	All Vehicles[4]	*No HD Vehicles*[5]	All Vehicles[4]	*No HD Vehicles*[5]
1	2.21E-02	*2.03E-02*	7.06E-03	*6.97E-03*	3.01E-02	*1.69E-03*	0.00E+00	*0.00E+00*
2	2.15E-02	*2.03E-02*	7.09E-03	*6.97E-03*	3.24E-02	*1.19E-03*	0.00E+00	*0.00E+00*
3	3.16E-02	*2.27E-02*	7.38E-03	*6.99E-03*	1.42E-01	*1.27E-02*	0.00E+00	*0.00E+00*
4	2.13E-02	*2.05E-02*	7.14E-03	*6.97E-03*	2.40E-02	*5.46E-04*	0.00E+00	*0.00E+00*
5	2.04E-02	*2.03E-02*	7.11E-03	*6.97E-03*	1.97E-02	*1.66E-04*	0.00E+00	*0.00E+00*
6	2.44E-02	*2.07E-02*	7.11E-03	*6.97E-03*	4.70E-02	*2.72E-03*	0.00E+00	*0.00E+00*
7	2.19E-02	*2.06E-02*	7.01E-03	*6.97E-03*	1.69E-02	*3.12E-03*	0.00E+00	*0.00E+00*
8	2.07E-02	*2.01E-02*	6.99E-03	*6.97E-03*	8.79E-03	*1.21E-03*	0.00E+00	*0.00E+00*
9	2.39E-02	*2.04E-02*	7.06E-03	*6.97E-03*	4.37E-02	*3.43E-03*	0.00E+00	*0.00E+00*
10	3.48E-02	*2.19E-02*	7.33E-03	*6.99E-03*	1.66E-01	*1.39E-02*	0.00E+00	*0.00E+00*
11	3.21E-02	*2.15E-02*	7.27E-03	*6.98E-03*	1.36E-01	*1.04E-02*	0.00E+00	*0.00E+00*
12	2.89E-02	*2.10E-02*	7.19E-03	*6.98E-03*	1.00E-01	*7.13E-03*	0.00E+00	*0.00E+00*
13	2.54E-02	*2.05E-02*	7.10E-03	*6.97E-03*	6.14E-02	*3.97E-03*	0.00E+00	*0.00E+00*
14	2.46E-02	*2.04E-02*	7.09E-03	*6.97E-03*	5.39E-02	*3.39E-03*	0.00E+00	*0.00E+00*
15	2.52E-02	*2.05E-02*	7.10E-03	*6.97E-03*	6.03E-02	*3.84E-03*	0.00E+00	*0.00E+00*
16	2.60E-02	*2.07E-02*	7.11E-03	*6.97E-03*	6.66E-02	*4.96E-03*	0.00E+00	*0.00E+00*
17	2.45E-02	*2.05E-02*	7.08E-03	*6.97E-03*	5.09E-02	*3.73E-03*	0.00E+00	*0.00E+00*
18	2.19E-02	*2.02E-02*	7.02E-03	*6.97E-03*	2.24E-02	*1.96E-03*	0.00E+00	*0.00E+00*
19	2.16E-02	*2.01E-02*	7.01E-03	*6.97E-03*	1.84E-02	*1.28E-03*	0.00E+00	*0.00E+00*
20	2.13E-02	*2.01E-02*	7.00E-03	*6.97E-03*	1.54E-02	*1.01E-03*	0.00E+00	*0.00E+00*
21	2.10E-02	*2.00E-02*	7.01E-03	*6.97E-03*	1.46E-02	*8.07E-04*	0.00E+00	*0.00E+00*
22	2.02E-02	*1.99E-02*	6.99E-03	*6.97E-03*	5.77E-03	*2.03E-04*	0.00E+00	*0.00E+00*
23	2.04E-02	*2.00E-02*	7.00E-03	*6.97E-03*	9.77E-03	*3.91E-04*	0.00E+00	*0.00E+00*
24	2.02E-02	*1.99E-02*	7.00E-03	*6.97E-03*	8.36E-03	*2.51E-04*	0.00E+00	*0.00E+00*

Notes:
1. The emission factors for each vehicle class were extracted from EMFAC2007 and were weighted by default hourly fraction of trip in EMFAC2007 to yield composite hourly emission factors. Detailed discussion of the methodology is presented in Attachment IV section 4.2.
2. Exhaust refers to running emissions from vehicle exhaust; non-exhaust refers to running emissions from tire and brake wear.
3. Exhaust refers to idling emissions from vehicle exhaust; non-exhaust refers to idling emissions from tire and brake wear.
4. The emission factors for all vehicles are used for road segments with no truck restrictions.
5. The emission factors for all vehicles, excluding heavy-duty vehicles, are used for road segments with truck restrictions which forbid trucks over 14,000 lbs. Those emission factors are shown in *italics.*

Abbreviations:
HD: heavy duty vehicle, and refers to vehicles with a gross vehicle rating of 10,001 pounds or more.

Table 4-2
Summary of Traffic Volumes by Modeled Road Segment
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Hour	Fraction of Trip/Day, All Vehicles[1]	Fraction of Trip/Day, *No HD Vehicles*[2]	3rd Street Segments					
			101 Ramp to 12		12 to 11		11 to 10	
			Southbound	Northbound	Southbound	Northbound	Southbound	Northbound
1	0.0080	*0.0084*	0	21	0	21	27	21
2	0.0040	*0.0041*	0	11	0	11	14	11
3	0.0020	*0.0015*	0	5	0	5	7	5
4	0.0016	*0.0017*	0	4	0	4	6	4
5	0.0027	*0.0028*	0	7	0	7	9	7
6	0.0044	*0.0045*	0	12	0	12	15	12
7	0.0174	*0.0191*	0	46	0	46	60	46
8	0.0512	*0.0567*	0	137	0	136	176	135
9	0.0545	*0.0563*	0	145	0	145	187	143
10	0.0625	*0.0480*	0	146	0	145	179	154
11	0.0617	*0.0512*	0	165	0	164	211	162
12	0.0795	*0.0723*	0	212	0	212	273	209
13	0.0837	*0.0831*	0	251	0	251	334	234
14	0.0688	*0.0692*	0	184	0	183	236	181
15	0.0744	*0.0738*	0	198	0	198	255	196
16	0.0792	*0.0779*	0	211	0	211	271	208
17	0.0732	*0.0743*	0	195	0	195	251	193
18	0.0730	*0.0786*	0	195	0	194	250	192
19	0.0587	*0.0638*	0	157	0	156	201	154
20	0.0466	*0.0509*	0	124	0	124	160	123
21	0.0312	*0.0340*	0	83	0	83	107	82
22	0.0267	*0.0295*	0	71	0	71	91	70
23	0.0190	*0.0208*	0	51	0	51	65	50
24	0.0160	*0.0175*	0	43	0	43	55	42

Hour	Fraction of Trip/Day, All Vehicles[1]	Fraction of Trip/Day, *No HD Vehicles*[2]	3rd Street Segments					
			10 to 9		9 to 8		8 to 56	
			Southbound	Northbound	Southbound	Northbound	Southbound	Northbound
1	0.0080	*0.0084*	24	24	38	39	55	61
2	0.0040	*0.0041*	12	12	19	20	27	31
3	0.0020	*0.0015*	6	6	9	10	13	15
4	0.0016	*0.0017*	5	5	8	8	11	13
5	0.0027	*0.0028*	8	8	13	13	18	21
6	0.0044	*0.0045*	13	13	21	22	30	34
7	0.0174	*0.0191*	52	52	83	85	119	133
8	0.0512	*0.0567*	153	152	243	251	350	392
9	0.0545	*0.0563*	163	162	259	267	372	417
10	0.0625	*0.0480*	164	163	231	293	268	507
11	0.0617	*0.0512*	185	183	293	302	421	472
12	0.0795	*0.0723*	238	236	377	390	543	609
13	0.0837	*0.0831*	281	279	485	428	784	602
14	0.0688	*0.0692*	206	205	327	338	470	527
15	0.0744	*0.0738*	222	221	353	365	508	569
16	0.0792	*0.0779*	237	235	376	388	541	606
17	0.0732	*0.0743*	219	218	348	359	500	561
18	0.0730	*0.0786*	219	217	347	358	499	559
19	0.0587	*0.0638*	176	174	279	288	401	449
20	0.0466	*0.0509*	139	139	221	229	318	357
21	0.0312	*0.0340*	93	93	148	153	213	239
22	0.0267	*0.0295*	80	79	127	131	182	204
23	0.0190	*0.0208*	57	56	90	93	130	145
24	0.0160	*0.0175*	48	48	76	78	109	122

Table 4-2
Summary of Traffic Volumes by Modeled Road Segment
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Hour	Fraction of Trip/Day, All Vehicles[1]	Fraction of Trip/Day, *No HD Vehicles*[2]	3rd Street Segments 56 to 7 Southbound	56 to 7 Northbound	7 to 6 Southbound	7 to 6 Northbound	6 to 5 Southbound	6 to 5 Northbound
1	0.0080	*0.0084*	55	58	52	58	47	49
2	0.0040	*0.0041*	28	29	26	29	23	24
3	0.0020	*0.0015*	13	14	13	14	11	12
4	0.0016	*0.0017*	11	12	11	12	10	10
5	0.0027	*0.0028*	18	20	17	19	16	16
6	0.0044	*0.0045*	30	32	29	32	26	27
7	0.0174	*0.0191*	120	127	113	125	102	106
8	0.0512	*0.0567*	351	373	333	368	299	310
9	0.0545	*0.0563*	374	397	354	391	318	330
10	0.0625	*0.0480*	269	487	259	477	317	368
11	0.0617	*0.0512*	423	449	401	443	360	374
12	0.0795	*0.0723*	546	579	516	571	464	482
13	0.0837	*0.0831*	788	566	740	563	552	521
14	0.0688	*0.0692*	472	501	447	494	402	417
15	0.0744	*0.0738*	510	541	483	534	434	451
16	0.0792	*0.0779*	543	576	514	569	462	480
17	0.0732	*0.0743*	502	533	476	526	427	444
18	0.0730	*0.0786*	501	532	474	525	426	443
19	0.0587	*0.0638*	403	427	381	422	343	356
20	0.0466	*0.0509*	320	339	303	335	272	282
21	0.0312	*0.0340*	214	227	203	224	182	189
22	0.0267	*0.0295*	183	194	173	192	156	162
23	0.0190	*0.0208*	130	138	123	136	111	115
24	0.0160	*0.0175*	110	116	104	115	93	97

Hour	Fraction of Trip/Day, All Vehicles[1]	Fraction of Trip/Day, *No HD Vehicles*[2]	3rd Street Segments 5 to 57 Southbound	5 to 57 Northbound	57 to 4 Southbound	57 to 4 Northbound	4 to 3 Southbound	4 to 3 Northbound
1	0.0080	*0.0084*	47	49	44	49	56	62
2	0.0040	*0.0041*	24	25	22	25	28	31
3	0.0020	*0.0015*	11	12	11	12	14	15
4	0.0016	*0.0017*	10	10	9	10	12	13
5	0.0027	*0.0028*	16	17	15	17	19	21
6	0.0044	*0.0045*	26	27	24	27	31	34
7	0.0174	*0.0191*	102	107	95	107	122	136
8	0.0512	*0.0567*	299	315	281	315	359	398
9	0.0545	*0.0563*	319	335	299	335	383	424
10	0.0625	*0.0480*	317	376	274	377	394	453
11	0.0617	*0.0512*	361	379	338	380	433	480
12	0.0795	*0.0723*	465	489	436	489	558	619
13	0.0837	*0.0831*	554	526	550	525	647	695
14	0.0688	*0.0692*	403	424	377	424	483	536
15	0.0744	*0.0738*	435	457	407	458	522	578
16	0.0792	*0.0779*	463	487	434	487	556	616
17	0.0732	*0.0743*	428	450	401	451	514	570
18	0.0730	*0.0786*	427	449	400	450	513	568
19	0.0587	*0.0638*	343	361	322	361	412	457
20	0.0466	*0.0509*	273	287	255	287	327	363
21	0.0312	*0.0340*	183	192	171	192	219	243
22	0.0267	*0.0295*	156	164	146	164	187	207
23	0.0190	*0.0208*	111	117	104	117	133	148
24	0.0160	*0.0175*	94	98	88	98	112	124

Table 4-2
Summary of Traffic Volumes by Modeled Road Segment
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Hour	Fraction of Trip/Day, All Vehicles[1]	Fraction of Trip/Day, *No HD Vehicles*[2]	Paul Ave/Gilman Ave Segments				Palou Ave Segments	
			34 to 9		9 to 18		*30 to 54*	
			Eastbound	*Westbound*	Eastbound	Westbound	*Eastbound*	*Westbound*
1	0.0080	*0.0084*	*52*	*64*	37	47	*43*	*40*
2	0.0040	*0.0041*	*25*	*31*	19	24	*21*	*20*
3	0.0020	*0.0015*	*9*	*12*	9	11	*8*	*7*
4	0.0016	*0.0017*	*10*	*13*	8	10	*9*	*8*
5	0.0027	*0.0028*	*17*	*21*	13	16	*14*	*13*
6	0.0044	*0.0045*	*28*	*34*	21	26	*23*	*22*
7	0.0174	*0.0191*	*118*	*145*	82	102	*97*	*92*
8	0.0512	*0.0567*	*204*	*480*	240	299	*434*	*225*
9	0.0545	*0.0563*	*348*	*430*	255	318	*287*	*272*
10	0.0625	*0.0480*	*297*	*366*	165	386	*245*	*232*
11	0.0617	*0.0512*	*316*	*390*	289	360	*261*	*247*
12	0.0795	*0.0723*	*447*	*551*	372	464	*369*	*349*
13	0.0837	*0.0831*	*728*	*564*	562	460	*212*	*472*
14	0.0688	*0.0692*	*427*	*527*	322	402	*353*	*333*
15	0.0744	*0.0738*	*456*	*563*	348	434	*376*	*356*
16	0.0792	*0.0779*	*481*	*594*	370	462	*398*	*376*
17	0.0732	*0.0743*	*459*	*566*	343	427	*379*	*358*
18	0.0730	*0.0786*	*486*	*600*	342	426	*401*	*379*
19	0.0587	*0.0638*	*394*	*487*	275	343	*326*	*308*
20	0.0466	*0.0509*	*314*	*388*	218	272	*259*	*245*
21	0.0312	*0.0340*	*210*	*259*	146	182	*174*	*164*
22	0.0267	*0.0295*	*182*	*225*	125	156	*151*	*142*
23	0.0190	*0.0208*	*128*	*158*	89	111	*106*	*100*
24	0.0160	*0.0175*	*108*	*133*	75	93	*89*	*84*

Hour	Fraction of Trip/Day, All Vehicles[1]	Fraction of Trip/Day, *No HD Vehicles*[2]	Palou Ave Segments				Evans Ave/Innes Ave Segments	
			54 to 55		*55 to 6*		47 to 46	
			Eastbound	*Westbound*	*Eastbound*	*Westbound*	Eastbound	Westbound
1	0.0080	*0.0084*	*38*	*33*	*41*	*35*	57	57
2	0.0040	*0.0041*	*18*	*16*	*20*	*17*	29	29
3	0.0020	*0.0015*	*7*	*6*	*7*	*6*	14	14
4	0.0016	*0.0017*	*8*	*7*	*8*	*7*	12	12
5	0.0027	*0.0028*	*13*	*11*	*14*	*12*	19	19
6	0.0044	*0.0045*	*20*	*18*	*22*	*19*	31	32
7	0.0174	*0.0191*	*86*	*76*	*93*	*80*	124	125
8	0.0512	*0.0567*	*380*	*186*	*396*	*193*	364	366
9	0.0545	*0.0563*	*253*	*225*	*276*	*236*	387	390
10	0.0625	*0.0480*	*215*	*192*	*235*	*201*	565	395
11	0.0617	*0.0512*	*230*	*205*	*250*	*214*	438	441
12	0.0795	*0.0723*	*324*	*289*	*354*	*303*	565	569
13	0.0837	*0.0831*	*189*	*392*	*233*	*414*	432	668
14	0.0688	*0.0692*	*310*	*276*	*338*	*290*	489	492
15	0.0744	*0.0738*	*331*	*295*	*361*	*309*	528	532
16	0.0792	*0.0779*	*350*	*312*	*381*	*327*	562	566
17	0.0732	*0.0743*	*333*	*297*	*363*	*311*	520	524
18	0.0730	*0.0786*	*353*	*314*	*385*	*330*	519	523
19	0.0587	*0.0638*	*286*	*255*	*312*	*267*	417	420
20	0.0466	*0.0509*	*228*	*203*	*249*	*213*	331	333
21	0.0312	*0.0340*	*153*	*136*	*166*	*143*	222	223
22	0.0267	*0.0295*	*132*	*118*	*144*	*124*	189	191
23	0.0190	*0.0208*	*93*	*83*	*102*	*87*	135	136
24	0.0160	*0.0175*	*78*	*70*	*86*	*73*	114	114

Table 4-2
Summary of Traffic Volumes by Modeled Road Segment
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Hour	Fraction of Trip/Day, All Vehicles[1]	Fraction of Trip/Day, *No HD Vehicles*[2]	Evans Ave/Innes Ave Segments					
			46 to 48		48 to 4		4 to 58	
			Eastbound	Westbound	Eastbound	Westbound	Eastbound	Westbound
1	0.0080	*0.0084*	54	52	34	33	11	11
2	0.0040	*0.0041*	27	26	17	16	6	5
3	0.0020	*0.0015*	13	13	8	8	3	3
4	0.0016	*0.0017*	11	11	7	7	2	2
5	0.0027	*0.0028*	18	18	11	11	4	4
6	0.0044	*0.0045*	30	29	18	18	6	6
7	0.0174	*0.0191*	118	113	73	71	24	24
8	0.0512	*0.0567*	346	333	215	208	70	69
9	0.0545	*0.0563*	368	355	229	221	75	74
10	0.0625	*0.0480*	546	359	336	235	118	79
11	0.0617	*0.0512*	416	402	259	250	85	84
12	0.0795	*0.0723*	537	518	334	323	109	108
13	0.0837	*0.0831*	398	609	252	364	72	121
14	0.0688	*0.0692*	465	448	289	279	95	93
15	0.0744	*0.0738*	502	484	312	302	102	101
16	0.0792	*0.0779*	534	516	332	321	109	107
17	0.0732	*0.0743*	494	477	307	297	101	99
18	0.0730	*0.0786*	493	476	306	296	100	99
19	0.0587	*0.0638*	396	382	246	238	81	80
20	0.0466	*0.0509*	315	304	196	189	64	63
21	0.0312	*0.0340*	211	203	131	127	43	42
22	0.0267	*0.0295*	180	174	112	108	37	36
23	0.0190	*0.0208*	128	124	80	77	26	26
24	0.0160	*0.0175*	108	104	67	65	22	22

Hour	Fraction of Trip/Day, All Vehicles[1]	Fraction of Trip/Day, *No HD Vehicles*[2]	Evans Ave/Innes Ave Segments		Harney Way Segments			
			58 to 16		29 to 59		59 to 60	
			Southbound	Northbound	Northbound	Westbound	Eastbound	Westbound
1	0.0080	*0.0084*	11	11	79	87	78	91
2	0.0040	*0.0041*	6	5	40	44	39	44
3	0.0020	*0.0015*	3	3	19	21	19	17
4	0.0016	*0.0017*	2	2	16	18	16	18
5	0.0027	*0.0028*	4	4	27	29	26	30
6	0.0044	*0.0045*	6	6	44	48	43	49
7	0.0174	*0.0191*	24	24	172	189	169	207
8	0.0512	*0.0567*	71	69	506	555	497	555
9	0.0545	*0.0563*	75	74	539	591	529	611
10	0.0625	*0.0480*	118	79	486	570	480	570
11	0.0617	*0.0512*	85	84	610	668	598	555
12	0.0795	*0.0723*	110	108	786	862	771	784
13	0.0837	*0.0831*	73	121	1004	907	980	901
14	0.0688	*0.0692*	95	93	681	746	668	749
15	0.0744	*0.0738*	103	101	735	806	721	800
16	0.0792	*0.0779*	109	107	783	858	768	845
17	0.0732	*0.0743*	101	99	724	793	710	805
18	0.0730	*0.0786*	101	99	722	792	708	852
19	0.0587	*0.0638*	81	80	581	636	569	692
20	0.0466	*0.0509*	64	63	461	505	452	551
21	0.0312	*0.0340*	43	42	309	339	303	369
22	0.0267	*0.0295*	37	36	264	289	259	320
23	0.0190	*0.0208*	26	26	188	206	184	225
24	0.0160	*0.0175*	22	22	158	173	155	190

Notes:

1. Hourly fraction of trips per day calculated from EMFAC total trips per hour for San Francisco County in 2030 were used to convert AM peak hour and PM peak hour traffic volumes into hourly traffic count. AM and PM peak hour traffic volumes were extracted from the Traffic Report. Detailed discussion of the methodology is presented in Appendix IV section 4.2.

2. The fractions of trips per day, excluding heavy-duty vehicles, are used for segments with truck restrictions which forbid trucks over 14,000 lbs. Those segments with truck restrictions are shown in *italics.*

Abbreviations:
HD: heavy duty vehicle, and refers to vehicles with a gross vehicle rating of 10,001 pounds or more.

Table 4-3
CAL3QHCR Source Parameters, Running Emissions
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Segment[1]	Link	Type	$UTMx_{start}$ (meters)	$UTMy_{start}$ (meters)	$UTMx_{end}$ (meters)	$UTMy_{end}$ (meters)	Relative Elevation[2] (meters)	Mixing Zone Width[3] (meters)
10 to 9 Northbound	Link_23	Above ground	553,238	4,175,107	553,267	4,175,189	0	14
	Link_106	Above ground	553,211	4,175,027	553,238	4,175,107	0	14.5
10 to 9 Southbound	Link_62	Above ground	553,229	4,175,112	553,200	4,175,030	0	14.5
	Link_78	Above ground	553,255	4,175,192	553,229	4,175,112	0	12
101 Ramp to 12 Northbound	Link_9	Above ground	553,058	4,174,718	553,106	4,174,787	0	12
11 to 10 Northbound	Link_91	Above ground	553,181	4,174,941	553,211	4,175,027	0	14
11 to 10 Southbound	Link_77	Above ground	553,200	4,175,030	553,189	4,175,003	0	14.5
	Link_83	Above ground	553,189	4,175,003	553,170	4,174,947	0	12
12 to 11 Northbound	Link_8	Above ground	553,106	4,174,787	553,152	4,174,858	0	12
	Link_29	Above ground	553,152	4,174,858	553,181	4,174,941	0	12.5
12 to 11 Southbound	Link_84	Above ground	553,170	4,174,947	553,142	4,174,864	0	12
	Link_103	Above ground	553,142	4,174,864	553,095	4,174,794	0	13
29 to 59 Northbound	Link_157	Above ground	553,692	4,173,849	553,871	4,173,865	0	14.5
	Link_158	Above ground	553,871	4,173,865	554,079	4,173,943	0	13.5
29 to 59 Westbound	Link_161	Above ground	553,868	4,173,873	553,688	4,173,857	0	14.5
	Link_162	Above ground	554,074	4,173,951	553,868	4,173,873	0	14.5
30 to 54 Eastbound	Link_25	Above ground	554,633	4,175,790	554,659	4,175,772	0	13.5
	Link_26	Above ground	554,494	4,175,888	554,633	4,175,790	0	13.5
	Link_88	Above ground	554,329	4,176,005	554,494	4,175,888	0	13.5
30 to 54 Westbound	Link_141	Above ground	554,498	4,175,893	554,332	4,176,010	0	13.5
	Link_142	Above ground	554,663	4,175,777	554,637	4,175,795	0	12.5
	Link_143	Above ground	554,637	4,175,795	554,498	4,175,893	0	13.5

Table 4-3
CAL3QHCR Source Parameters, Running Emissions
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Segment[1]	Link	Type	$UTMx_{start}$ (meters)	$UTMy_{start}$ (meters)	$UTMx_{end}$ (meters)	$UTMy_{end}$ (meters)	Relative Elevation[2] (meters)	Mixing Zone Width[3] (meters)
34 to 9 Eastbound	Link_7	Above ground	553,259	4,175,187	553,426	4,175,074	0	12
	Link_18	Above ground	554,253	4,174,490	554,419	4,174,377	0	15.5
	Link_19	Above ground	554,088	4,174,609	554,253	4,174,490	0	16
	Link_20	Above ground	554,036	4,174,646	554,088	4,174,609	0	15
	Link_21	Above ground	553,922	4,174,725	554,036	4,174,646	0	14
	Link_22	Above ground	553,755	4,174,842	553,922	4,174,725	0	12
	Link_24	Above ground	553,426	4,175,074	553,592	4,174,958	0	12
	Link_28	Above ground	553,592	4,174,958	553,755	4,174,842	0	12
34 to 9 Westbound	Link_122	Above ground	554,040	4,174,651	553,926	4,174,730	0	16
	Link_123	Above ground	553,926	4,174,730	553,759	4,174,847	0	16
	Link_124	Above ground	553,759	4,174,847	553,595	4,174,963	0	16
	Link_125	Above ground	554,423	4,174,382	554,256	4,174,495	0	14.5
	Link_126	Above ground	553,430	4,175,079	553,260	4,175,193	0	15
	Link_129	Above ground	553,595	4,174,963	553,430	4,175,079	0	15
	Link_130	Above ground	554,256	4,174,495	554,091	4,174,614	0	15.5
	Link_133	Above ground	554,091	4,174,614	554,040	4,174,651	0	17.5
4 to 3 Northbound	Link_92	Above ground	553,958	4,177,533	553,980	4,177,616	0	14.5
	Link_99	Above ground	553,931	4,177,442	553,958	4,177,533	0	12
4 to 3 Southbound	Link_105	Above ground	553,962	4,177,595	553,946	4,177,539	0	13
	Link_121	Above ground	553,946	4,177,539	553,921	4,177,447	0	11.5
4 to 58 Eastbound	Link_115	Above ground	553,877	4,177,473	553,925	4,177,439	0	12
	Link_116	Above ground	553,197	4,177,952	553,877	4,177,473	0	15
4 to 58 Westbound	Link_119	Above ground	553,881	4,177,478	553,204	4,177,954	0	15
	Link_120	Above ground	553,927	4,177,451	553,881	4,177,478	0	14.5

Table 4-3
CAL3QHCR Source Parameters, Running Emissions
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Segment[1]	Link	Type	$UTMx_{start}$ (meters)	$UTMy_{start}$ (meters)	$UTMx_{end}$ (meters)	$UTMy_{end}$ (meters)	Relative Elevation[2] (meters)	Mixing Zone Width[3] (meters)
46 to 48 Eastbound	Link_5	Above ground	554,924	4,176,316	555,002	4,176,261	0	14.25
	Link_6	Above ground	555,002	4,176,261	555,168	4,176,145	0	14.25
	Link_10	Above ground	554,703	4,176,889	554,854	4,176,783	0	13
	Link_11	Above ground	554,913	4,176,630	554,905	4,176,539	0	13.5
	Link_12	Above ground	554,907	4,176,666	554,913	4,176,630	0	13.5
	Link_13	Above ground	554,854	4,176,783	554,907	4,176,666	0	13.5
	Link_14	Above ground	554,905	4,176,539	554,894	4,176,440	0	14.5
	Link_15	Above ground	554,898	4,176,346	554,924	4,176,316	0	14.5
	Link_16	Above ground	554,888	4,176,389	554,898	4,176,346	0	14.5
	Link_17	Above ground	554,894	4,176,440	554,888	4,176,389	0	14.5
46 to 48 Westbound	Link_144	Above ground	555,172	4,176,151	555,007	4,176,268	0	15.5
	Link_145	Above ground	554,930	4,176,322	554,905	4,176,350	0	13.5
	Link_146	Above ground	554,905	4,176,350	554,896	4,176,389	0	13.5
	Link_147	Above ground	554,896	4,176,389	554,902	4,176,439	0	13.5
	Link_148	Above ground	555,007	4,176,268	554,929	4,176,323	0	13.5
	Link_149	Above ground	554,902	4,176,439	554,912	4,176,537	0	13.5
	Link_151	Above ground	554,913	4,176,538	554,921	4,176,631	0	13.5
	Link_152	Above ground	554,921	4,176,631	554,915	4,176,668	0	13.5
	Link_153	Above ground	554,915	4,176,668	554,858	4,176,790	0	13.5
	Link_154	Above ground	554,858	4,176,790	554,709	4,176,896	0	15
47 to 46 Eastbound	Link_104	Above ground	555,168	4,176,145	555,334	4,176,028	0	14.5
47 to 46 Westbound	Link_150	Above ground	555,339	4,176,034	555,172	4,176,151	0	15.5

Table 4-3
CAL3QHCR Source Parameters, Running Emissions
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Segment[1]	Link	Type	$UTMx_{start}$ (meters)	$UTMy_{start}$ (meters)	$UTMx_{end}$ (meters)	$UTMy_{end}$ (meters)	Relative Elevation[2] (meters)	Mixing Zone Width[3] (meters)
48 to 4 Eastbound	Link_4	Above ground	554,539	4,177,004	554,703	4,176,889	0	12.8
	Link_31	Above ground	553,925	4,177,439	554,042	4,177,355	0	13
	Link_34	Above ground	554,042	4,177,355	554,206	4,177,240	0	13
	Link_93	Above ground	554,206	4,177,240	554,539	4,177,004	0	16
48 to 4 Westbound	Link_1	Above ground	554,709	4,176,896	554,618	4,176,961	0	12.8
	Link_2	Above ground	554,618	4,176,961	554,595	4,176,986	0	12.8
	Link_3	Above ground	554,595	4,176,986	554,548	4,177,018	0	12.8
	Link_85	Above ground	554,548	4,177,018	554,215	4,177,253	0	16
	Link_98	Above ground	554,051	4,177,368	553,927	4,177,451	0	18
	Link_100	Above ground	554,215	4,177,253	554,051	4,177,368	0	16
5 to 57 Northbound	Link_40	Above ground	553,764	4,176,826	553,788	4,176,913	0	14.5
	Link_43	Above ground	553,740	4,176,739	553,764	4,176,826	0	14.5
	Link_46	Above ground	553,716	4,176,649	553,740	4,176,739	0	14.5
	Link_47	Above ground	553,693	4,176,563	553,716	4,176,649	0	14.5
	Link_108	Above ground	553,788	4,176,913	553,812	4,177,001	0	12.5
5 to 57 Southbound	Link_41	Above ground	553,778	4,176,920	553,754	4,176,832	0	14.5
	Link_42	Above ground	553,754	4,176,832	553,730	4,176,745	0	14.5
	Link_45	Above ground	553,730	4,176,745	553,706	4,176,656	0	14.5
	Link_48	Above ground	553,706	4,176,656	553,683	4,176,569	0	14.5
	Link_109	Above ground	553,801	4,177,007	553,778	4,176,920	0	12.5
54 to 55 Eastbound	Link_89	Above ground	554,165	4,176,121	554,329	4,176,005	0	13.5
	Link_90	Above ground	553,998	4,176,238	554,165	4,176,121	0	13.5
54 to 55 Westbound	Link_139	Above ground	554,168	4,176,126	554,002	4,176,243	0	13.5
	Link_140	Above ground	554,332	4,176,010	554,168	4,176,126	0	13

Table 4-3
CAL3QHCR Source Parameters, Running Emissions
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Segment[1]	Link	Type	$UTMx_{start}$ (meters)	$UTMy_{start}$ (meters)	$UTMx_{end}$ (meters)	$UTMy_{end}$ (meters)	Relative Elevation[2] (meters)	Mixing Zone Width[3] (meters)
55 to 6 Eastbound	Link_96	Above ground	553,662	4,176,475	553,833	4,176,355	0	11.5
	Link_97	Above ground	553,833	4,176,355	553,998	4,176,238	0	12.5
55 to 6 Westbound	Link_137	Above ground	553,836	4,176,360	553,665	4,176,480	0	13.5
	Link_138	Above ground	554,002	4,176,243	553,836	4,176,360	0	14.5
56 to 7 Northbound	Link_44	Above ground	553,526	4,175,948	553,550	4,176,037	0	12
	Link_54	Above ground	553,598	4,176,213	553,622	4,176,300	0	14.5
	Link_58	Above ground	553,574	4,176,126	553,598	4,176,213	0	14.5
	Link_59	Above ground	553,567	4,176,103	553,574	4,176,126	0	14.5
	Link_60	Above ground	553,550	4,176,037	553,567	4,176,103	0	14.5
56 to 7 Southbound	Link_55	Above ground	553,611	4,176,304	553,587	4,176,216	0	14.5
	Link_56	Above ground	553,587	4,176,216	553,563	4,176,129	0	14.5
	Link_57	Above ground	553,563	4,176,129	553,557	4,176,105	0	14.5
	Link_63	Above ground	553,540	4,176,041	553,515	4,175,951	0	12
	Link_64	Above ground	553,557	4,176,105	553,540	4,176,041	0	14.5
57 to 4 Northbound	Link_30	Above ground	553,884	4,177,264	553,907	4,177,351	0	13.5
	Link_32	Above ground	553,907	4,177,351	553,931	4,177,442	0	12
	Link_36	Above ground	553,860	4,177,176	553,884	4,177,264	0	13
	Link_38	Above ground	553,836	4,177,089	553,860	4,177,176	0	12
	Link_94	Above ground	553,824	4,177,045	553,836	4,177,089	0	12
	Link_95	Above ground	553,812	4,177,001	553,824	4,177,045	0	13.5
57 to 4 Southbound	Link_33	Above ground	553,921	4,177,447	553,897	4,177,356	0	12
	Link_35	Above ground	553,897	4,177,356	553,873	4,177,270	0	14
	Link_37	Above ground	553,873	4,177,270	553,849	4,177,182	0	13
	Link_39	Above ground	553,849	4,177,182	553,825	4,177,095	0	14
	Link_107	Above ground	553,825	4,177,095	553,801	4,177,007	0	12

Table 4-3
CAL3QHCR Source Parameters, Running Emissions
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Segment[1]	Link	Type	$UTMx_{start}$ (meters)	$UTMy_{start}$ (meters)	$UTMx_{end}$ (meters)	$UTMy_{end}$ (meters)	Relative Elevation[2] (meters)	Mixing Zone Width[3] (meters)
58 to 16 Northbound	Link_117	Above ground	553,204	4,177,954	553,102	4,178,207	0	15
58 to 16 Southbound	Link_118	Above ground	553,096	4,178,204	553,197	4,177,952	0	15
59 to 60 Eastbound	Link_155	Above ground	553,545	4,173,721	553,652	4,173,828	0	15.5
	Link_156	Above ground	553,652	4,173,828	553,692	4,173,849	0	14.5
59 to 60 Westbound	Link_159	Above ground	553,646	4,173,835	553,539	4,173,727	0	15.5
	Link_160	Above ground	553,688	4,173,857	553,646	4,173,835	0	14.5
6 to 5 Northbound	Link_50	Above ground	553,669	4,176,475	553,693	4,176,563	0	15.5
6 to 5 Southbound	Link_49	Above ground	553,683	4,176,569	553,659	4,176,482	0	14.5
7 to 6 Northbound	Link_51	Above ground	553,646	4,176,388	553,669	4,176,475	0	14.5
	Link_101	Above ground	553,622	4,176,300	553,646	4,176,388	0	14.5
7 to 6 Southbound	Link_52	Above ground	553,659	4,176,482	553,635	4,176,394	0	14.5
	Link_53	Above ground	553,635	4,176,394	553,611	4,176,304	0	14.5
8 to 56 Northbound	Link_65	Above ground	553,475	4,175,777	553,504	4,175,862	0	14.5
	Link_69	Above ground	553,446	4,175,693	553,475	4,175,777	0	14.5
	Link_70	Above ground	553,417	4,175,612	553,446	4,175,693	0	14.5
	Link_71	Above ground	553,386	4,175,526	553,417	4,175,612	0	12
	Link_113	Above ground	553,515	4,175,906	553,526	4,175,948	0	12.5
	Link_114	Above ground	553,504	4,175,862	553,515	4,175,906	0	12
8 to 56 Southbound	Link_66	Above ground	553,515	4,175,951	553,493	4,175,869	0	12
	Link_67	Above ground	553,493	4,175,869	553,464	4,175,783	0	12
	Link_68	Above ground	553,464	4,175,783	553,435	4,175,700	0	14.5
	Link_72	Above ground	553,406	4,175,616	553,376	4,175,533	0	12
	Link_110	Above ground	553,435	4,175,700	553,406	4,175,616	0	12.5

Table 4-3
CAL3QHCR Source Parameters, Running Emissions
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Segment[1]	Link	Type	$UTMx_{start}$ (meters)	$UTMy_{start}$ (meters)	$UTMx_{end}$ (meters)	$UTMy_{end}$ (meters)	Relative Elevation[2] (meters)	Mixing Zone Width[3] (meters)
9 to 18 Eastbound	Link_61	Above ground	552,942	4,175,275	553,019	4,175,252	0	10.5
	Link_75	Above ground	553,171	4,175,208	553,259	4,175,187	0	10.5
	Link_76	Above ground	552,804	4,175,315	552,866	4,175,297	0	10.5
	Link_79	Above ground	553,079	4,175,235	553,171	4,175,208	0	9.5
	Link_80	Above ground	553,019	4,175,252	553,079	4,175,235	0	11
	Link_81	Above ground	552,866	4,175,297	552,942	4,175,275	0	10.5
	Link_82	Above ground	552,691	4,175,348	552,804	4,175,315	0	15.5
9 to 18 Westbound	Link_127	Above ground	553,260	4,175,193	553,172	4,175,214	0	12.5
	Link_128	Above ground	553,020	4,175,258	552,944	4,175,280	0	12.5
	Link_131	Above ground	552,805	4,175,321	552,693	4,175,354	0	12
	Link_132	Above ground	552,868	4,175,303	552,805	4,175,321	0	12.5
	Link_134	Above ground	553,172	4,175,214	553,080	4,175,240	0	12.5
	Link_135	Above ground	552,944	4,175,280	552,868	4,175,303	0	12.5
	Link_136	Above ground	553,080	4,175,240	553,020	4,175,258	0	13
9 to 8 Northbound	Link_27	Above ground	553,298	4,175,276	553,328	4,175,359	0	14
	Link_86	Above ground	553,267	4,175,189	553,281	4,175,227	0	12.5
	Link_87	Above ground	553,281	4,175,227	553,298	4,175,276	0	12.5
	Link_111	Above ground	553,357	4,175,442	553,386	4,175,526	0	12
	Link_112	Above ground	553,328	4,175,359	553,357	4,175,442	0	14.5
9 to 8 Southbound	Link_73	Above ground	553,286	4,175,280	553,255	4,175,192	0	12
	Link_74	Above ground	553,315	4,175,363	553,286	4,175,280	0	14.5
	Link_102	Above ground	553,376	4,175,533	553,315	4,175,363	0	12

Notes:
1. Segments are identified by the bounding intersections, using the intersection numbering developed in Figure 26A of the Traffic Report, and by the direction of traffic flow.
2. CAL3QHCR limits relative elevations to a range of -10 meters to +10 meters. Here, the elevations are fairly flat. Therefore, the site is assigned an elevation of 0 meters.
3. As defined in CAL3QHCR, mixing zone width for a given free flow link is calculated by adding 6 meters to the width of the road. The width of the road is obtained by visual observation of high-resolution aeiral photograph.

Abbreviations:
CAL3QHCR: a steady-state Gaussian dispersion model
UTMx: X coordinate in Universal Transverse Mercator coordinate system, zone 10N
UTMy: Y coordinate in Universal Transverse Mercator coordinate system, zone 10N

Sources:
CHS Consulting Group et al. 2009. Bayview Waterfront Project Transportation Study: Preliminary Draft 1 Report.

Table 4-4
CAL3QHCR Source Parameters, Queuing Emissions
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Segment[1]	Link	Type	$UTMx_{start}$ (meters)	$UTMy_{start}$ (meters)	$UTMx_{end}$ (meters)	$UTMy_{end}$ (meters)	Relative Elevation[2] (meters)	Mixing Zone Width[3] (meters)
10 to 9 Northbound	Link_5	Above ground	553248.4	4175125.8	553266.7	4175189.2	0	8
10 to 9 Southbound	Link_15	Above ground	553209.1	4175055.7	553200.3	4175030.2	0	8.5
101 Ramp to 12 Northbound	Link_3	Above ground	553059.5	4174720.4	553105.8	4174786.9	0	6
11 to 10 Northbound	Link_22	Above ground	553199.4	4174994.8	553210.8	4175026.8	0	8
11 to 10 Southbound	Link_20	Above ground	553183.5	4174986.0	553170.0	4174947.3	0	6
12 to 11 Northbound	Link_7	Above ground	553167.8	4174895.8	553181.1	4174942.0	0	6.5
12 to 11 Southbound	Link_26	Above ground	553145.1	4174862.5	553094.0	4174792.2	0	7
29 to 59 Northbound	Link_43	Above ground	554041.4	4173928.8	554078.8	4173942.9	0	7.5
29 to 59 Westbound	Link_45	Above ground	553703.3	4173858.6	553688.1	4173857.3	0	8.5
30 to 54 Eastbound	Link_6	Above ground	554639.9	4175785.7	554659.5	4175771.9	0	7.5
30 to 54 Westbound	Link_40	Above ground	554433.7	4175938.4	554332.3	4176009.8	0	7.5
34 to 9 Eastbound	Link_4	Above ground	554398.6	4174390.9	554419.3	4174376.9	0	9.5
34 to 9 Westbound	Link_36	Above ground	553334.6	4175160.2	553260.4	4175192.7	0	9
4 to 3 Northbound	Link_23	Above ground	553938.7	4177459.9	553985.5	4177635.7	0	8.5
4 to 3 Southbound	Link_35	Above ground	553965.0	4177612.3	553921.0	4177447.0	0	5.5
4 to 58 Eastbound	Link_31	Above ground	553907.5	4177451.1	553925.4	4177438.3	0	6
4 to 58 Westbound	Link_34	Above ground	553232.5	4177934.3	553203.8	4177954.5	0	9
46 to 48 Eastbound	Link_2	Above ground	555151.2	4176156.0	555167.6	4176144.5	0	8.25
46 to 48 Westbound	Link_41	Above ground	554788.8	4176839.1	554729.3	4176881.4	0	9
48 to 4 Eastbound	Link_1	Above ground	554666.8	4176914.5	554702.7	4176889.2	0	6.8
48 to 4 Westbound	Link_25	Above ground	553974.4	4177426.1	553927.4	4177450.8	0	12
5 to 57 Northbound	Link_28	Above ground	553786.8	4176914.8	553812.1	4177001.2	0	6.5
5 to 57 Southbound	Link_9	Above ground	553706.6	4176657.9	553682.6	4176569.1	0	8.5
54 to 55 Eastbound	Link_21	Above ground	554251.2	4176059.6	554328.8	4176004.9	0	7.5
54 to 55 Westbound	Link_39	Above ground	554051.5	4176207.7	554001.6	4176242.8	0	7.5
55 to 6 Eastbound	Link_24	Above ground	553946.7	4176274.2	553998.1	4176237.9	0	6.5
55 to 6 Westbound	Link_38	Above ground	553771.4	4176405.1	553665.1	4176479.9	0	7.5

Table 4-4
CAL3QHCR Source Parameters, Queuing Emissions
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Segment[1]	Link	Type	$UTMx_{start}$ (meters)	$UTMy_{start}$ (meters)	$UTMx_{end}$ (meters)	$UTMy_{end}$ (meters)	Relative Elevation[2] (meters)	Mixing Zone Width[3] (meters)
56 to 7 Northbound	Link_14	Above ground	553598.6	4176213.3	553621.6	4176300.3	0	8.5
56 to 7 Southbound	Link_16	Above ground	553533.5	4176018.0	553515.0	4175950.5	0	6
57 to 4 Northbound	Link_8	Above ground	553895.3	4177307.0	553931.1	4177442.4	0	6
57 to 4 Southbound	Link_27	Above ground	553824.9	4177093.5	553801.3	4177006.7	0	6
58 to 16 Northbound	Link_32	Above ground	553164.2	4178052.5	553102.3	4178206.5	0	9
58 to 16 Southbound	Link_33	Above ground	553116.8	4178151.2	553197.4	4177951.8	0	9
59 to 60 Eastbound	Link_42	Above ground	553669.3	4173836.8	553692.2	4173849.1	0	8.5
59 to 60 Westbound	Link_44	Above ground	553646.5	4173835.1	553632.4	4173820.9	0	9.5
6 to 5 Northbound	Link_11	Above ground	553669.0	4176476.1	553693.5	4176565.8	0	9.5
6 to 5 Southbound	Link_10	Above ground	553682.5	4176568.7	553658.3	4176478.9	0	8.5
7 to 6 Northbound	Link_12	Above ground	553647.2	4176385.5	553668.9	4176475.9	0	8.5
7 to 6 Southbound	Link_13	Above ground	553625.5	4176362.3	553611.1	4176304.1	0	8.5
8 to 56 Northbound	Link_30	Above ground	553503.7	4175868.8	553526.5	4175947.6	0	6.5
8 to 56 Southbound	Link_17	Above ground	553392.3	4175577.9	553376.1	4175532.8	0	6
9 to 18 Eastbound	Link_19	Above ground	552691.2	4175349.6	553259.4	4175186.7	0	4.5
9 to 18 Westbound	Link_37	Above ground	552945.0	4175280.2	552692.6	4175354.0	0	6
9 to 8 Northbound	Link_29	Above ground	553367.4	4175471.9	553386.3	4175525.6	0	6
9 to 8 Southbound	Link_18	Above ground	553273.7	4175250.3	553255.3	4175192.1	0	6

Notes:

1. Segments are identified by the bounding intersections, using the intersection numbering developed in Figure 26A of the Traffic Report, and by the direction of traffic flow.

2. CAL3QHCR limits relative elevations to a range of -10 meters to +10 meters. Here, the elevations are fairly flat. Therefore, the site is assigned an elevation of 0 meters.

3. As defined in CAL3QHCR, mixing zone width for a given queue link is equal to the width of the road. The width of the road is obtained by visual observation of high-resolution aeiral photograph.

Abbreviations:

CAL3QHCR: a steady-state Gaussian dispersion model

UTMx: X coordinate in Universal Transverse Mercator coordinate system, zone 10N

UTMy: Y coordinate in Universal Transverse Mercator coordinate system, zone 10N

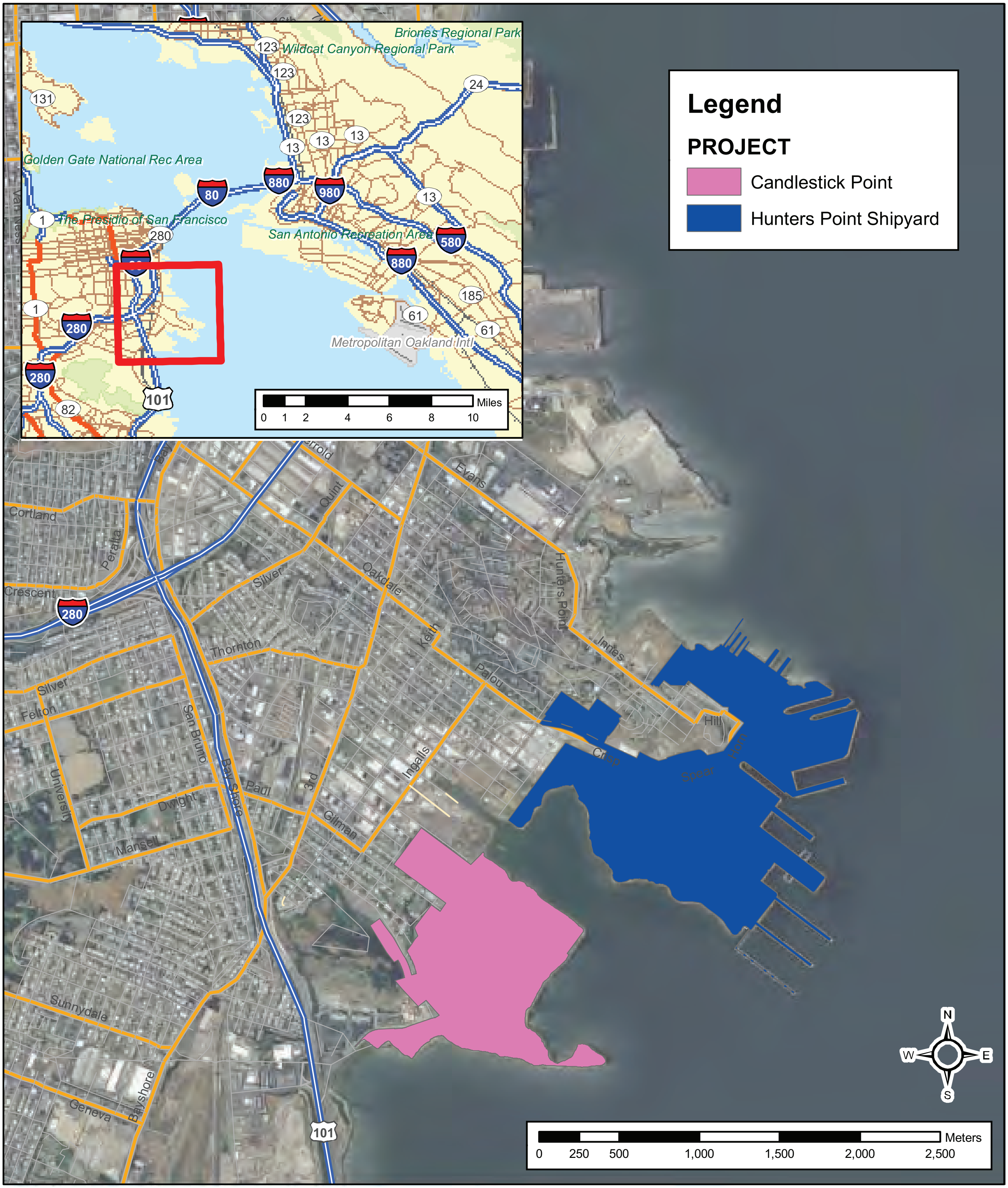
Sources:

CHS Consulting Group et al. 2009. Bayview Waterfront Project Transportation Study: Preliminary Draft 1 Report.

Table 4-5
Summary of Sensitive Receptors
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Facility	Address	City	State	Zip	Type	UTMX	UTMY
Bayview Essential School Of Music, Art, And Social Justice	1195 Hudson Ave.	San Francisco	CA	94124	School	554,459	4,176,382
Bayview Hunters Point Foundation Third St. Clinic	4301 Third Street	San Francisco	CA	94124	Hospital	553,819	4,176,989
Bret Harte Elementary	1035 Gilman Ave.	San Francisco	CA	94124-3710	School	553,855	4,174,760
Burnett Children Center	1520 Oakdale Ave.	San Francisco	CA	94124	School	553,851	4,176,470
Charles Drew College Preparatory Academy	50 Pomona Ave.	San Francisco	CA	94124-2344	School	553,432	4,176,226
Child's Time	3061 San Bruno Avenue	San Francisco	CA	94134	Childcare	552,737	4,175,268
El Dorado Elementary	70 Delta St.	San Francisco	CA	94134	School	552,261	4,174,761
EOC - Busy Bee	548 Delta Street	San Francisco	CA	94134	Childcare	552,046	4,174,192
EOC - Martin Luther King Child Care Center	200 Cashmere	San Francisco	CA	94124	Childcare	554,119	4,176,788
EOC - Soujourner Truth Child Care Center	1 Cashmere	San Francisco	CA	94124	Childcare	554,430	4,176,649
Frandelja Enrichment Center (Preschool)	950 Gilman Street	San Francisco	CA	94124	Childcare	553,991	4,174,701
George Washington Carver Elementary	1360 Oakdale Ave.	San Francisco	CA	94124-2724	School	554,074	4,176,310
Kipp Bayview Academy	1060 Key Ave.	San Francisco	CA	94124	School	553,176	4,174,859
Malcolm X Academy	350 Harbor Rd.	San Francisco	CA	94124-2474	School	554,582	4,176,461
Martha Hills Learning Center - Preschool	1044 Jamestown Avenue	San Francisco	CA	94124	Childcare	553,381	4,174,820
Muhammad University Of Islam	5048 Third Street	San Francisco	CA	94124	School	553,607	4,176,356
North East Medical Services-Leland Avenue	82 Leland Avenue	San Francisco	CA	94134	Hospital	552,421	4,174,022
Our Lady Of The Visitacion Elementary	785 Sunnydale Avenue	San Francisco	CA	94134	School	552,032	4,173,809
Phillip And Sala Burton Academic High	400 Mansell St.	San Francisco	CA	94134	School	552,421	4,174,988
S. R. Martin College Preparatory	5 Thomas Mellon Circle, Suite 225	San Francisco	CA	94134	School	553,552	4,173,936
SFCCD - Grace Child Development Center - Preschool	1551 Newcomb	San Francisco	CA	94124	Childcare	553,840	4,176,545
SFSU - Hunter's View Head Start	125 West Point Road	San Francisco	CA	94124	Childcare	554,535	4,176,681
SFSU - Southeast Headstart Center	1300 Phelps Avenue	San Francisco	CA	94124	Childcare	553,425	4,176,843
Southeast Families United/Mission Head Start	1337 Evans Avenue	San Francisco	CA	94124	Childcare	554,319	4,177,143
Visitacion Valley Child And Family Dev. Center	103 Tucker Avenue	San Francisco	CA	94134	Childcare	552,335	4,174,457
Visitacion Valley Community Center	50 Raymond Avenue	San Francisco	CA	94134	Childcare	552,514	4,174,066
Whitney Young Child Dev. Ctr. - Preschool	100 Whitney Young Circle	San Francisco	CA	94124	Childcare	554,215	4,176,579

Figures



ENVIRON

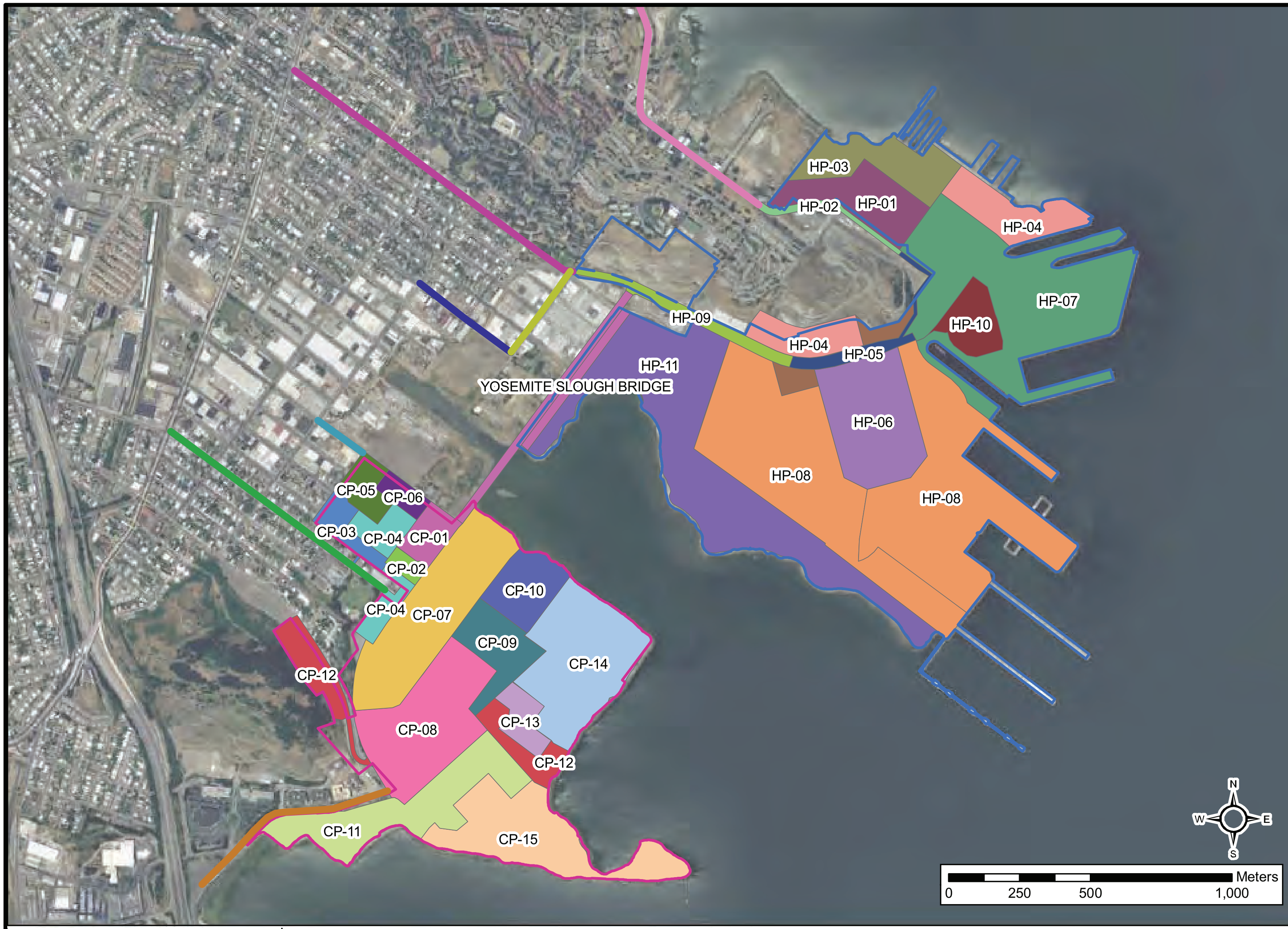
6001 Shellmound St., Suite 700, Emeryville, CA 94608

Project Site Vicinity Map
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Figure **2-1**

Drafter: EH Date: 09/17/2009

Contract Number: 0320816A



Legend

Road Improvement Construction

- Carroll Ave
- Gilman Ave
- Harney Way
- Hunter's Point Blvd
- Ingall St
- Palou Ave
- Thomas Ave

PROJECT

- Candlestick Point
- Hunters Point Shipyard

Note:
1. CP, HP designations reflect proposed construction phases.
2. Alice Griffith Housing area is represented by CP-01 through CP-06.

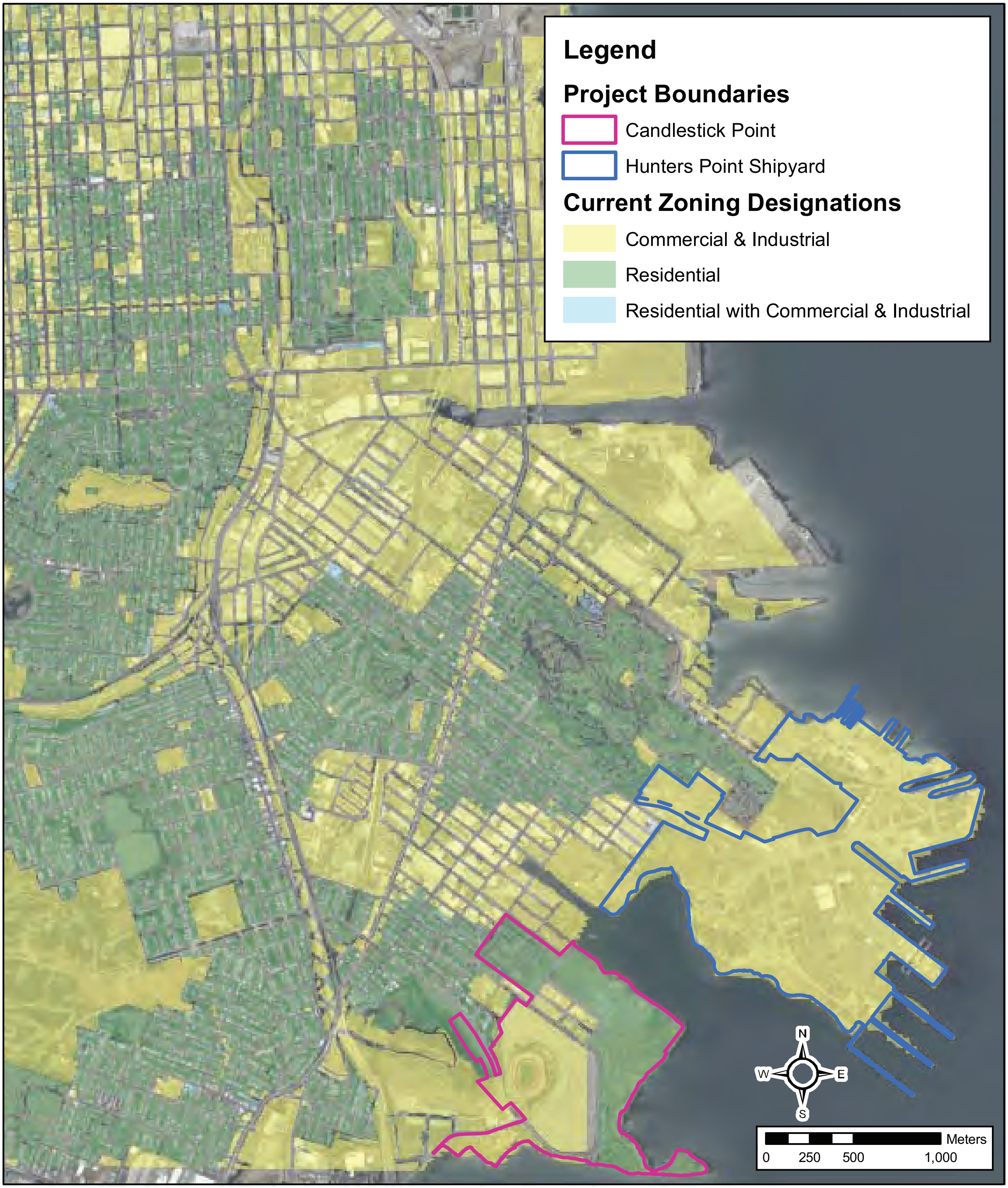
ENVIRON

6001 Shellmound St., Suite 700, Emeryville, CA 94608

Project Overview
Candlestick Point - Hunters Point Shipyard Phase II
Development Plan
San Francisco, California

Drafter: EH Date: 09/21/2009 Contract Number: 0320816A Approved: Revised:

Figure
2-2



ENVIRON

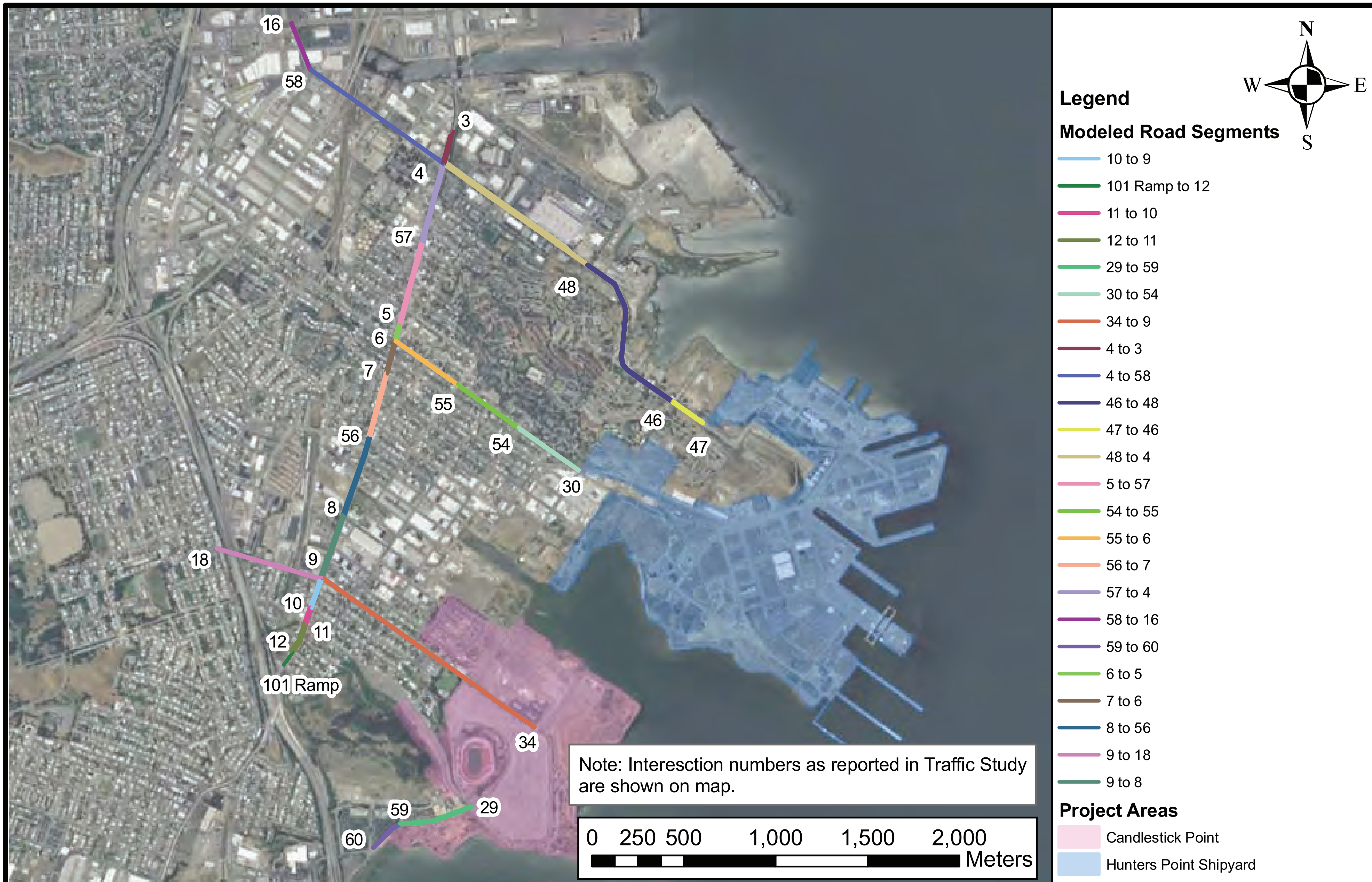
6001 Shellmound St., Suite 700, Emeryville, CA 94608

Surrounding Land Use
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Figure **2-3**

Drafter: EH Date: 09/17/2009 Contract Number: 0320816A

DRAFT



ENVIRON

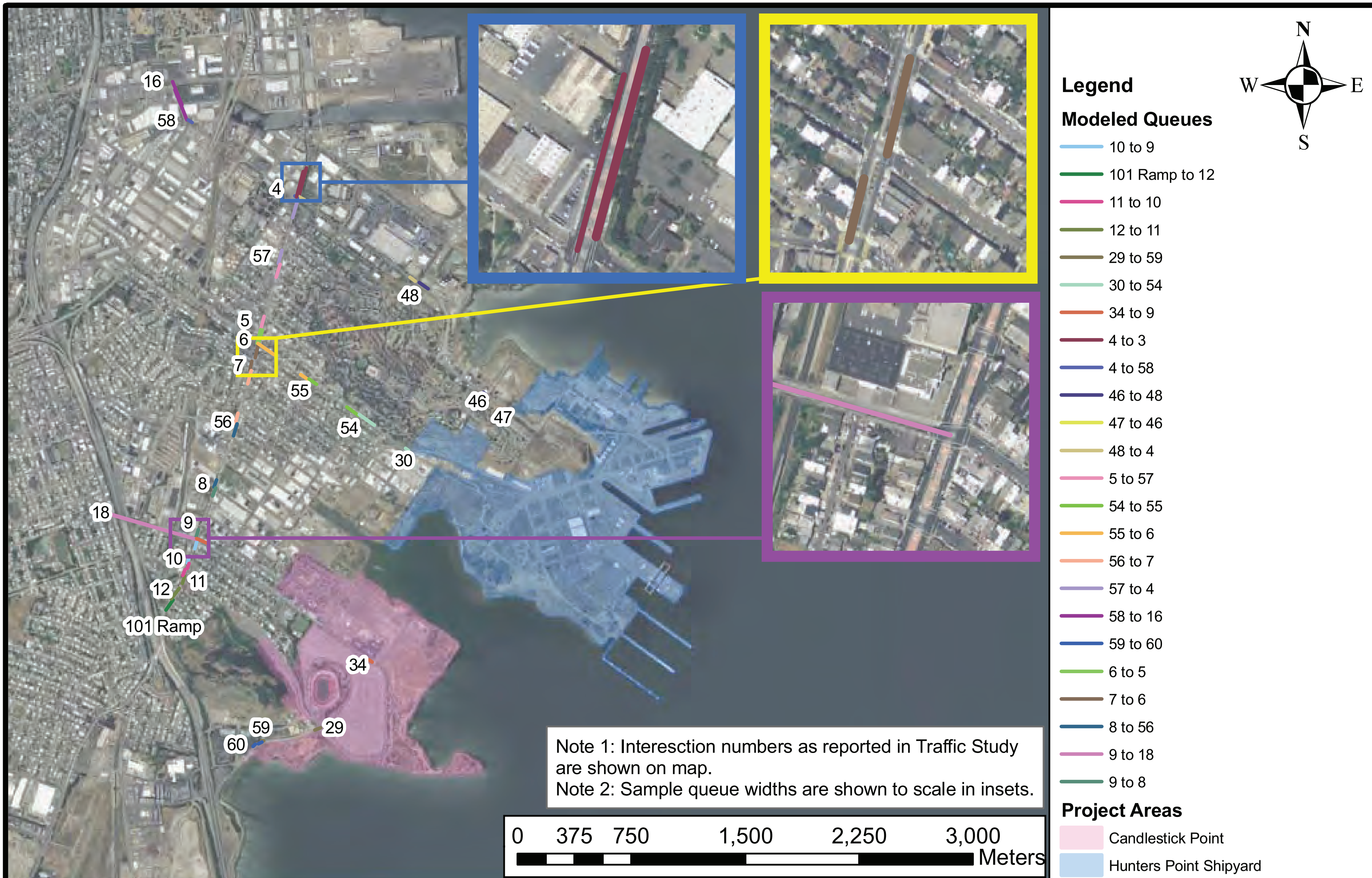
6001 Shellmound St., Suite 700, Emeryville, CA 94608

Location of Travel Lanes Modeled, Running Emissions
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Figure **4-1**

Drafter: KD Date: 7/29/2009 Contract Number: 03-20816A Approved: Revised:

DRAFT



ENVIRON

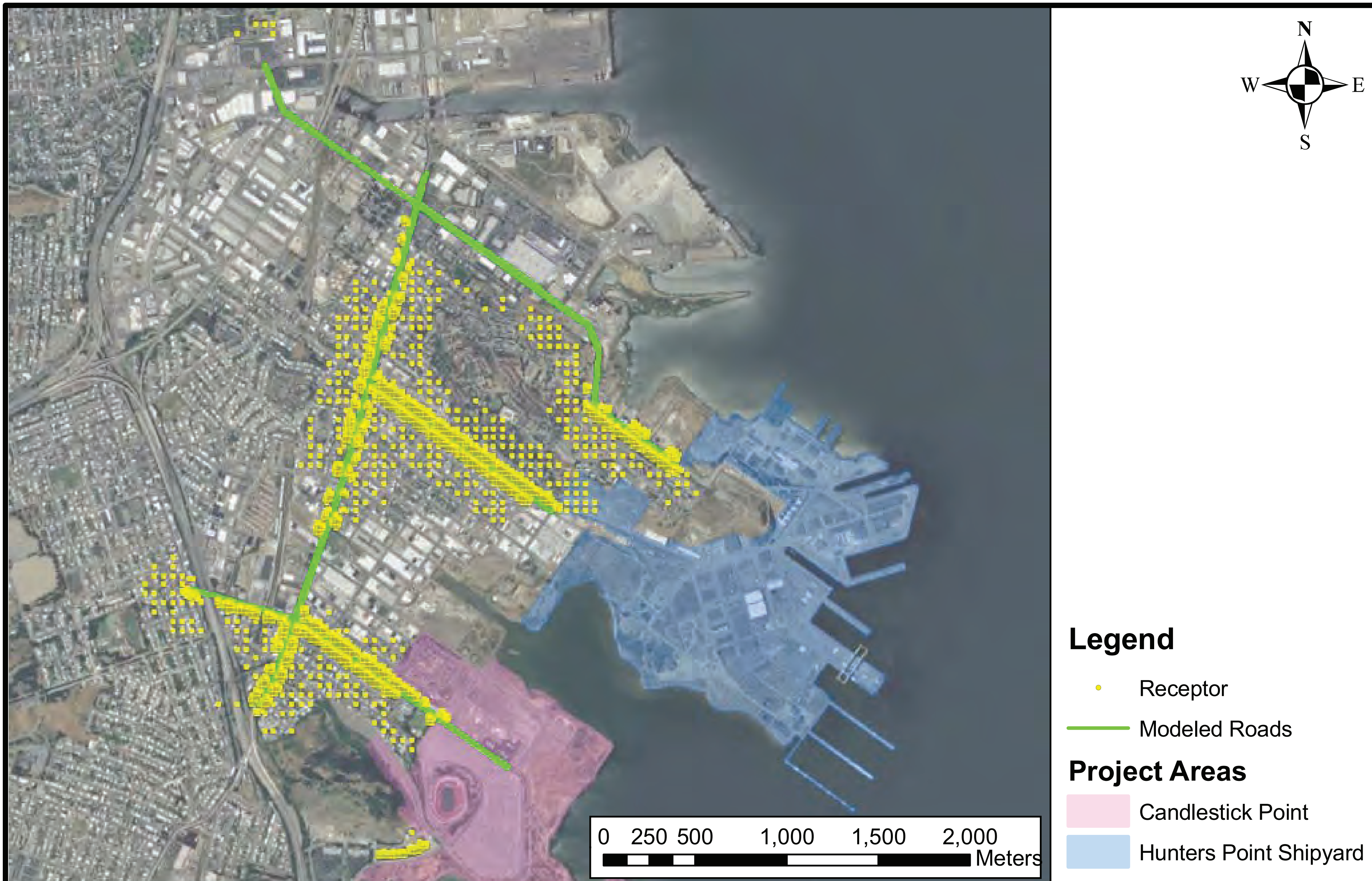
6001 Shellmound St., Suite 700, Emeryville, CA 94608

Location of Modeled Queues
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Figure **4-2**

Drafter: KD | Date: 7/29/2009 | Contract Number: 03-20816A | Approved: | Revised:

DRAFT



ENVIRON

6001 Shellmound St., Suite 700, Emeryville, CA 94608

Location of Modeled Residential Receptors
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Figure **4-3**

Drafter: KD | Date: 7/29/2009 | Contract Number: 03-20816A | Approved: | Revised:

DRAFT

ENVIRON

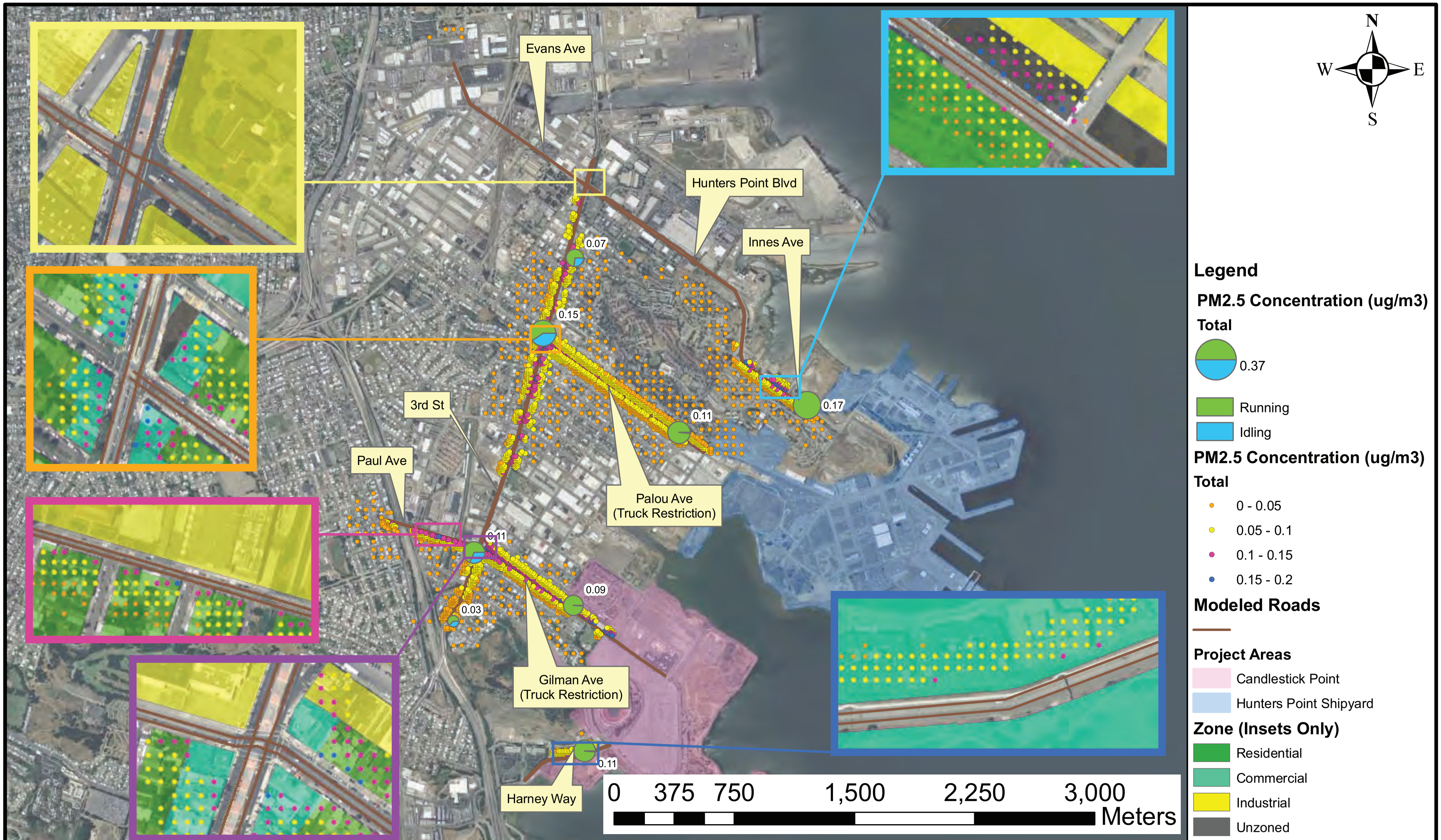
6001 Shellmound St., Suite 700, Emeryville, CA 94608

Land Use Zoning in Relation to Modeled Roads
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Figure **4-4**

Drafter: KD | Date: 7/23/2009 | Contract Number: 03-20816A | Approved: | Revised:

DRAFT



ENVIRON

6001 Shellmound St., Suite 700, Emeryville, CA 94608

Modeled Concentrations of PM2.5
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Drafter: KD Date: 7/23/2009 Contract Number: 03-20816A Approved: Revised:

Figure
4-5

Attachment V:
Meteorological Documentation

Candlestick Point – Hunters Point Shipyard
Phase II Development Plan
San Francisco, California

Contents

List of Tables

List of Figures

List of Acronyms

AERMOD	American Meteorological Society/Environmental Protection Agency Regulatory Model
AERMET	Meteorological data preprocessor for AERMOD
AMS	American Meteorological Society
AP	Airport
ARB	Air Resources Board
BAAQMD	Bay Area Air Quality Management District
DPM	Diesel Particulate Matter
ISCST3	Industrial Source Complex Short Term Model
NCDC	National Climatic Data Center
NLCD	National Land Cover Database
NWS	National Weather Service
$PM_{2.5}$	Particulate Matter with a mean aerodynamic diameter of 2.5 microns or less
PM_{10}	Particulate Matter with a mean aerodynamic diameter of 10 microns or less
SFO	San Francisco International Airport
TAC	Toxic Air Contaminant
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WSO	Weather Service Office

1 Introduction

ENVIRON conducted air dispersion modeling to estimate concentrations of diesel particulate matter (DPM), particulate matter with a mean diameter of 10 microns or less (PM_{10}), particulate matter with a mean diameter of 2.5 microns or less ($PM_{2.5}$) and gaseous toxic air contaminants (TACs) attributed to Project activities such as exhaust from construction equipment, dust generated during construction activities, TACs from operational sources and particulate matter from vehicle exhaust, as discussed in Attachments I, II, III, and IV. Meteorological data is a necessary component of air dispersion modeling in order to accurately characterize the transport and dispersion of TACs, DPM, PM_{10} and $PM_{2.5}$ in the atmosphere. This attachment describes the meteorological data process, including the selection of hourly surface meteorological data, selection of upper air meteorological data, data processing methods, surface parameter values, and land use analysis.

2 Meteorological Data

The American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) requires a meteorological input file to characterize the transport and dispersion of pollutants in the atmosphere. Surface and upper air meteorological data inputs, along with 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 the United States Environmental Protection Agency (USEPA) guidance documents (USEPA 2004 a,b). This section describes the selection of representative surface and upper air meteorological data for the Site. Section 3.2 describes the proposed methodology for processing this meteorological data using AERMET. For traffic/vehicle emissions modeling, CAL3QHCR also requires a meteorological input file. However, the input file format is different than that used by AERMOD. The meteorological data used for CAL3QHCR modeling is discussed in Section 4. Finally, a land use analysis is performed in Section 5.

2.1 Hourly Surface Meteorological Data Selection

For air dispersion modeling purposes, the USEPA typically recommends using a minimum of one year of onsite meteorological data or five years of representative meteorological data from a nearby site (USEPA 2009).

The Bay Area Air Quality Management District (BAAQMD) has meteorological data measured on Hunters Point Shipyard available for a complete, continuous one-year period from 4th Quarter 2002 to 3rd Quarter 2003. Other nearby BAAQMD meteorological sites, such as the Sanitary Fill station and the San Francisco STP station were also considered. However, the Hunters Point Shipyard station was chosen as the most representative meteorological site, as it is situated on one of the Project subcomponents, and immediately adjacent to and on the shoreline with Candlestick Point. The wind rose for data collected at Hunters Point Shipyard meteorological station is shown in Figure 1. Winds are typically from the west, blowing offshore. The frequency of the onshore winds is less than 15%.

When characterizing near-field air dispersion using models such as AERMOD, representative hourly surface meteorological data inputs are required in order to characterize the atmospheric transport and dispersion in the area to be studied. AERMET, the meteorological preprocessor to AERMOD, requires certain surface meteorological parameters in order to prepare an AERMOD meteorological data input file. The minimum surface meteorological parameters required include wind speed, wind direction, temperature, and cloud cover (USEPA 2004b). Onsite meteorological data from the BAAQMD for October 1, 2002 through September 30, 2003 were used, which include wind speed, wind direction, and temperature. Since cloud cover data was not measured at the onsite station, hourly cloud cover data was obtained from the National Climatic Data Center's (NCDC) nearby San Francisco International Airport (SFO) station. Missing data were substituted using procedures outlined in Atkinson and Lee (1992). Station pressure is also recommended, but not required for AERMET (USEPA 2004a). Station pressure and cloud ceiling from the SFO station were used to complete the data set. A combined year-long dataset using both onsite and SFO meteorological datasets from 2002 and 2003 was used for dispersion modeling for the Project. The USEPA recommends that a 90% completeness criteria is met for all modeled parameters for the combined meteorological data set. The period described above was used, rather than a calendar year, because data collected during other periods at the Hunters Point Shipyard meteorological station did not meet those criteria.

2.2 Upper Air Meteorological Data Selection

AERMET, the meteorological preprocessor to AERMOD, also requires upper air sounding data in order to prepare an AERMOD meteorological data input file (USEPA 2004a). The upper air sounding data are typically only available from NCDC and National Weather Service (NWS) stations and are measurements of various meteorological parameters such as wind speed and direction, temperature, and pressure usually taken at multiple levels in the atmosphere. Oakland International Airport is the only upper-air station in Northern California that the NCDC recommends for reliable, complete, and representative upper-air data for air dispersion modeling purposes for projects in Northern California[1]. Thus, upper air data from the Oakland International Airport was used in AERMET processing for the Project.

[1] Personal communication, William Brown of NCDC by telephone to C. Mukai of ENVIRON on May 5, 2006.

3 AERMOD/AERMET Data Processing Methods

This section discusses additional data requirements and processing methods used for conducting air dispersion modeling using AERMOD. The estimation of surface parameters is a required data input to AERMET in addition to the surface and upper air meteorological data discussed previously. The methods used to develop AERMET surface parameters for the Project are discussed below.

Prior to running AERMET, it is necessary to specify the surface parameters to be used. The surface parameters include surface roughness, Albedo, and Bowen ratio, and are used to compute fluxes and stability of the atmosphere (USEPA 2004b). Evaluation of nearby land use and temporal impacts on these surface parameters is required. Typically, characteristics around both the primary project area and the surface meteorological data collection site are recommended for evaluation by the USEPA (USEPA 2004b) and the California Air Resources Board (ARB) draft Guidelines (2006). Because the primary meteorological station is situated essentially on site, surface parameters calculated for the meteorological station are also representative of the Project.

The surface parameter analysis was performed using the 2001 United States Geological Service (USGS) land cover maps in conjunction with recent aerial photographs of the onsite meteorological station. The Hunters Point Shipyard area is expected to become more developed than that represented by the 2001 USGS land use designations. Using the current, less developed land use designations yields more conservative results, as less development areas are represented by lower surface roughness which causes the air dispersion model to predict higher pollutant concentrations because there is reduced turbulence created by the movement of air through the area. Surface roughness length was obtained by determining radial land-use sectors around the station and specified values for each sector using default seasonal values adjusted for the local climate. Albedo and Bowen ratio are not sector specific, but still use the locally-adjusted default seasonal values based on the surrounding land use. When a radial land-use sector consisted of multiple land-use types, an inverse-distance weighted geometric mean for surface roughness length was used, as recommended by USEPA (2008). Land-use data in the form of the National Land Cover Database (NLCD) from 2001[2] were analyzed to assign the surface parameter matrix that was used for AERMET.

Where available and appropriate, USEPA guidance (USEPA 2004b, 2009) was followed. However, USEPA guidance was developed based on nationwide averages. There are instances in which known local characteristics differ from national norms and would impact the methods used to evaluate the surface parameters. In addition, large differences in surface parameters (such as surface roughness) between the upwind and downwind direction from the primary project area can result in significant inaccuracies in predicted airborne concentrations if not addressed

[2] United States Geological Survey (USGS) National Land Cover Database (NLCD) 2001 data were downloaded from: http://seamless.usgs.gov

during the development of the AERMET surface parameters. Both of those topics are discussed in additional detail below.

3.1 Surface Parameter Values

This section discusses additional data input and data processing methods to be used when conducting the air dispersion for the Project. As discussed above, the estimation of surface parameters, such as surface roughness, Albedo, and Bowen ratio, is required data input for AERMET, in addition to the surface and upper air meteorological data. The methods used to develop AERMET surface parameters for the Project are discussed below.

3.2 AERMET Surface Parameters

Prior to running AERMET, it is necessary to specify the surface parameters to be used. Typically characteristics around both the primary project area and the surface meteorological data collection site are recommended for evaluation by USEPA (USEPA 2004a) and the draft Guidelines (ARB 2006). Because the selected meteorological station is situated on the Project, surface parameters calculated for the meteorological stations should be representative of the Project. Thus, in accordance with the AERMOD Implementation Guide (USEPA 2009), surface parameters supplied to the model were specified for the area surrounding the meteorological monitoring site. The surface parameters include surface roughness, Albedo, and Bowen ratio, and are used to compute fluxes and stability of the atmosphere (USEPA 2004a). Evaluation of nearby land use and seasonal impacts to those surface parameters is required.

Land-use sectors around the Hunters Point Shipyard meteorological station were determined using United States Geological Survey (USGS) topographical maps. Land-use data in the form of the NLCD from 2001 (USGS 2001) were analyzed to assign the surface parameter matrix that was entered into AERMET. Surface roughness length, radial land-use sectors around the station were determined and specified values for each sector using default seasonal values adjusted for the local climate. Albedo and Bowen ratio are not sector specific but still use the locally-adjusted default seasonal values based on the surrounding land use. When a radial land-use sector consisted of multiple land-use types, an inverse-distance weighted geometric mean for surface roughness length was used, as recommended by the USEPA (2008).

The USEPA (2008) recommends the use of an upwind fetch distance of one kilometer for estimation of the surface roughness length, corresponding to a circle with a radius of one kilometer surrounding the meteorological station. The recommendation is based on the estimated typical distance required to obtain a new turbulent boundary layer height after a roughness transition (USEPA 2008). Figure 2 shows the selection of sectors for the surface roughness length analysis.

As recommended by the USEPA (2008), an inverse-distance weighted geometric mean of each surface roughness length was used. Inverse-distance weighting accounts for the fact that the width of the sector increases with distance from the meteorological station, whereas area-weighting would inaccurately assign more weight to tland cover farther from the meteorological station. The geometric mean is recommended because AERMOD uses the natural log of the surface roughness lengths, so the geometric mean accounts for this formulation.

Albedo and Bowen ratio values affect plume dispersion differently than surface roughness length. Thus it is more appropriate to use effective values of those parameters determined over a larger domain. The USEPA (2008) recommends the use of a 10-kilometer by 10-kilometer region centered over the meteorological station. This recommendation was used to perform an evaluation of Albedo and Bowen Ratio values for a 10-kilometer square region centered over the onsite meteorological station. Figure 3 shows the domain used to calculate Albedo and Bowen ratio. Albedo and Bowen ratio values were evaluated and averaged over the domain without any area or distance dependencies in order to obtain an effective representation of the general surrounding area, as recommended by the USEPA (2008). An arithmetic mean was used to calculate Albedo, while a geometric mean was used for Bowen ratio values to account for the fact that ratio values are more accurately averaged geometrically.

The analysis of surface parameters for AERMET preprocessing is an area that, because of relatively undeveloped guidance, requires the application of professional judgment. Where available and appropriate, USEPA guidance (USEPA 2004a) was followed. However, USEPA guidance was developed based on nationwide averages; there are instances in which known local characteristics differ from national norms and would impact the methods used to evaluate the surface parameters.

3.2.1 Surface Parameter Values

For surface roughness length calculations, radial land-use sectors around the meteorological monitoring site were determined using USGS land cover maps in conjunction with recent aerial photographs. Surface parameters were then specified for each sector using default seasonal values adjusted for the local climate. For Albedo and Bowen ratio, the same locally-adjusted default seasonal values were applied to the non-sector-specific area around the meteorological monitoring site.

The AERMET User's Manual contains tables of values for the surface parameters based on four seasonal vegetative cycles (i.e. 'Spring' refers to the period of re-growth after the last frost). AERMET accepts surface parameters for temporal annual, seasonal, or monthly temporal periods. The determination of the appropriate seasonal value for a given period, in addition to the choice of monthly, seasonal, or hourly temporal divisions, is left to the user. The determination is particularly crucial in California (and thus for the Project), which has seasonal weather that is atypical from the rest of the country. For example, values assigned to winter typically assume the presence of snow cover. Each temporal division was assigned a corresponding seasonal category based on the local conditions and USEPA Guidance as explained below (USEPA 2004a). The methodologies for determining those temporal divisions, as described below, and the Bowen ratio condition, also described below, have been approved by the BAAQMD for use at other sites in the Bay Area. Methodologies for the determination of months in each season, presented below and discussed in a previous protocol to the BAAQMD (ENVIRON 2006), have been approved by the District (BAAQMD 2006) and have since been used in multiple analyses approved by the District.

As mentioned earlier, the AERMET user's guide provides general characteristics for the various seasons. "Spring" refers to the period when vegetation is emerging and partially green and applies to the 1-2 months after the last killing frost. "Summer" applies to the period when vegetation is lush. "Autumn" refers to the period of the year when freezing conditions are common, deciduous trees are leafless, soils are bare after harvest, grasses are brown, and no snow is present. "Winter" conditions apply to snow covered surfaces and subfreezing temperatures. By default, the AERMET user's guide says winter includes December, January, and February; spring includes March, April, and May; summer includes June, July, and August; and autumn includes September, October, and November. However, the AERMET user's guide also cautions that the seasons do not correspond to a particular group of months, but more on latitude and the annual vegetative growth cycles (USEPA 2004a).

The climate in the Bay Area is very different from national norms and the months of the year do not always correspond to the default seasons provided in the AERMET user's guide. For example, "Winter" values were not considered for the Project because snow cover is rare in South San Francisco. Likewise, a season between summer and autumn (summer/autumn) would be more representative of conditions for some months of the Bay Area's dry season due to the prolonged dry period after the growth of summer vegetation and the browning of grasses. Therefore, the following guidelines were developed for determining which months belong in each season for the Project Site:

- Autumn applies during the first several months of the rainy season until the frost potential no longer exists; it is characterized by brown grasses and the lack of leaves on deciduous trees;
- Spring applies when vegetation is emerging or partially green, approximately 1-2 months after significant frost potential;
- Summer applies when vegetation is lush; and
- Summer/Autumn, which is an average of the surface parameter values from summer and autumn, is typically a few months after the last significant rains when grasses begin to brown.

In order to determine which months belong to those seasons, precipitation and temperature data from the San Francisco Mission Dolores and San Francisco Weather Service Office Airport (WSO AP) meteorological stations were surveyed. The months selected for each season for the Project are presented in Table 1.

Land-use data in the form of the NLCD from 2001 (USGS) were analyzed to assign the surface parameter matrix that was used for AERMET. The NLCD 2001 categories were mapped to the NLCD 1992 categories (USGS 1992) based on their class names (descriptions), as shown in

Table 2. ENVIRON used surface parameters values for NLCD 1992 land classes as presented in the AERSURFACE User's Guide (USEPA 2008)[3].

In addition to defining the months of the seasons at the Project, precipitation data were evaluated in order to select a condition (wet, dry, average) for the Bowen ratio. ENVIRON first tabulated seasonal precipitation totals from meteorological stations in the vicinity of the Project for each of the modeling years of interest. As suggested by the AERSURFACE's User's Guide, those precipitation totals were then compared to the 30-year historical precipitation averages (USEPA 2008). If the tabulated values were in the upper 30th-percentile, a wet Bowen ratio condition was selected. If the tabulated values in the lower 30th-percentile, a dry Bowen ratio condition was selected. Otherwise, an average Bowen ratio condition was selected if precipitation was in the middle 40th percentile. Selected Bowen ratio conditions are presented in Table 3.

The methodologies for determining the months in each season and the Bowen ratio condition (wet, dry, average), as described above, have been approved by the BAAQMD for use at other sites in the Bay Area.

3.2.2 Sector Selection and Analysis

AERMET accepts inputs as a table of surface parameters defined according to radial sectors covering segments of wind direction. A maximum of twelve sectors of at least 30 degrees can be chosen based on patterns in the local land use. The number of sectors and the directions included in each are left to the determination of the user. For the Hunters Point Shipyard meteorological station, sectors were defined in each case to include homogenous areas within each sector and minimize significant transitions within sectors, as shown in Figure 2.

ENVIRON has performed the surface parameter analysis described above. The surface parameter matrix input for AERMET is presented in Table 4.

[3] For NLCD 2001 land class 23 (medium intensity residential), in which there is no direct NLCD 1992 land class, the average of surface parameter values for NLCD 1992 class 21 (low intensity residential) and NLCD 1992 class 22 (high intensity residential) were used.

4 CAL3QHCR Meteorological Data

The BAAQMD provided meteorological data in Industrial Source Complex Short Term Model (ISCST3) format for their Hunters Point Shipyard station for a complete, continuous one-year period covering the last quarter of 2002 and the first three quarters of 2003. Those files contain hourly wind speed, wind direction, temperature, stability class, and mixing height information. ENVIRON combined the two files into a single file in order to obtain one full year of meteorological data. As CAL3QHCR requires the start date and end date to be within the same year, the last quarter of 2002 data was relabeled as 2003 and moved to the end of the file to create one continuous, chronological year of data that CAL3QHCR could use. A completeness check was performed to verify that completeness exceeded 90% for all modeled parameters. The file was used directly in CAL3QHCR without further modifications.

5 Land Use Analysis

AERMOD can evaluate heat island effects from urban areas to atmospheric transport and dispersion using an urban boundary layer option. Per USEPA guidance (USEPA 2005, 2009), Auer's method of classifying land-use as either rural or urban (Auer 1978) was used. Those methods call for analysis of the land within a three-kilometer radius from the meteorological station and primary project area to determine if the majority of the land can be classified as either rural (i.e. undeveloped) or urban.

To conduct the Auer analysis, USGS NLCD 2001 Land Cover Data (USGS) was obtained as part of the surface parameter determination discussed above to evaluate areas around the Project. Table 5 shows the descriptions of the land use designations used in the NLCD 2001 data set and the corresponding Auer land use type and descriptions used in the analysis. Figure 4 shows the Auer land use designation around the Project, and Table 6 shows the total area of each Auer land use designation and its percentage of total area.

As shown in Table 6, less than fifty percent of the area circumscribed by the three-kilometer radius circle around the Project consists of Auer land-use urban land types. Thus, the rural boundary layer option in the model was used.

6 References

Air Resources Board (ARB). 2006. *DRAFT Health Risk Assessment Guidance for Rail Yard and Intermodal Facilities.*

Auer, Jr., A.H. “Correlation of Land Use and Cover with Meteorological Anomalies”. *Journal of Applied Meteorology*, 17:636-643, 1978.

Bay Area Air Quality Management District (BAAQMD). 2006. Weather Tower Network Map. http://www.baaqmd.gov/tec/maps/met_map.htm.

ENVIRON International Corporation (ENVIRON). 2006. *Protocol for Conducting an Air Toxics Health Risk Assessment for Emergency Standby Generators at Genentech’s South San Francisco Campus*. 03-15205D. October.

National Climatic Data Center (NCDC). 2006a. Hourly surface meteorological data for San Francisco Airport, 1996 – 2005 in TD 3280 format.

United States Environmental Protection Agency (USEPA). 2004a. *User's Guide for the AERMOD Meteorological Preprocessor (AERMET)*. Office of Air Quality Planning and Standards. Emissions Monitoring and Analysis Division. Research Triangle Park, North Carolina. EPA-454/B-03-002. November.

United States Environmental Protection Agency (USEPA). 2004b. *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.

United States Environmental Protection Agency (USEPA). 2005. *Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions*; Final Rule. 40 CFR Part 51, Appendix W. 70 Federal Register 68218-61. November 9.

United States Environmental Protection Agency (USEPA). 2008. “AERSURFACE User’s Guide”. Office of Air Quality Planning and Standards. Air Quality Assessment Division. Air Quality Modeling Group. Research Triangle Park, North Carolina. EPA-454-B-08-001. January.

United States Environmental Protection Agency (USEPA). 2009. *AERMOD Implementation Guide*. Research Triangle Park, North Carolina. March.

United States Geological Survey (USGS) National Land Cover Dataset (NLCD). 2001 http://seamless.usgs.gov.

United States Geological Survey (USGS) National Land Cover Dataset (NLCD). 1992 http://landcover.usgs.gov/natllandcover.php.

Tables

Table 1
Summary of Seasons for AERMET Surface Parameter Analysis
Candlestick Point – Hunters Point Shipyard
Phase II Development Plan
San Francisco, California

Location	Winter	Spring	Summer	Summer/Autumn	Autumn
San Francisco, CA	N/A[2]	February	April	July	November
		March	May	August	December
			June	September	January
				October	

Notes:
1. Seasons were determined based on a California-specific adaptation of the default values presented in the United States Environmental Protection Agency's (USEPA) *User's Guide for the AERMOD Meteorological Preprocessor (AERMET)*, November 2004.
Spring: Vegetation is emerging or partially green; approximately 1 month after significant frost potential
Summer: Vegetation is lush
Summer/Autumn: A few months after the last significant rain
Autumn: First several months of the rainy season until significant frost potential no longer exists; grasses are brown and vegetation dried out
2. Winter conditions (snow covered surfaces and subfreezing temperatures) do not typically exist at this location.

Table 2
Land Use Designations for Surface Parameter Analysis
Candlestick Point – Hunters Point Shipyard
Phase II Development Plan
San Francisco, California

Class Name	1992 NLCD Class[a]	2001 NLCD Class[b]
Open Water	11	11
Perennial Ice/Snow	12	12
Urban/Recreational Grasses	85	21
Low Intensity Residential	21	22
Medium Intensity Residential		23
High Intensity Residential	22	24
Bare Rock/Sand/Clay (Non-arid Region)	31	31
Deciduous Forest	41	41
Evergreen Forest	42	42
Mixed Forest	43	43
Shrubland (Non-arid Region)	51	52
Grasslands/Herbaceous	71	71
Pasture/Hay	81	81
Row Crops	82	82
Woody Wetlands	91	90
Emergent Herbaceous Wetlands	92	95
Commercial/Industrial/Transp (Site at Airport)	23	
Commercial/Industrial/Transp (Not at Airport)		
Quarries/Strip Mines/Gravel	32	
Transitional	33	
Orchards/Vineyards/Other	61	
Small Grains	83	
Fallow	84	

Notes:
a. NLDC 1992 land cover class codes and definitions were taken from the USGS website at http://landcover.usgs.gov/classes.php, accessed 2008-10-13.
b. NLDC 2001 land cover class codes and definitions were taken from the MRLC website at http://www.mrlc.gov/nlcd_definitions.php, accessed 2008-10-13.

Abbreviations:
MRLC: Multi-Resolution Land Characteristics Consortium
NLDC: National Land Cover Dataset
USGS: United States Geological Survey

Table 3
Summary of Bowen Ratio Conditions for AERMET Surface Parameter Analysis
Candlestick Point – Hunters Point Shipyard
Phase II Development Plan
San Francisco, California

Location	Year	Winter	Spring	Summer	Summer/Autumn	Autumn
Hunters Point Shipyard	2002-03 (Oct 02 - Sept 03)	N/A	dry	wet	dry	wet
MONTHS:		--	FEB-MAR 03	APR-JUNE 03	JUL -SEP 03, OCT 02	NOV - DEC 02, JAN 03

Notes:
1. Bowen ratio conditions were determined by comparing the average precipitation for that season to the average long-term precipitation of that season. The following guidelines were used:

dry: the average precipitation for that season is less than half the long-term average precipitation for that season
wet: the average precipitation for that season is more than twice the long-term average precipitation for that season
average: the average precipitation for that season is greater than or equal to half the long-term average precipitation for that season, and less than or equal to twice the long-term average precipitation for that season

If insufficient data was collected from the station nearest to the Site, the next closest station with data was used.

Source:
Western Regional Climate Center (http://www.wrcc.dri.edu/)

Table 4
Surface Parameters Input to AERMET
Candlestick Point – Hunters Point Shipyard
Phase II Development Plan
San Francisco, California

Sector	Month	2002 - 2003		
		Albedo	Bowen Ratio	Surface Roughness
1	January	0.1285	0.2292	0.1877
1	February	0.1285	0.3613	0.1866
1	March	0.1285	0.3613	0.1866
1	April	0.1285	0.2243	0.1888
1	May	0.1285	0.2243	0.1888
1	June	0.1285	0.2243	0.1888
1	July	0.1285	0.3736	0.1882
1	August	0.1285	0.3736	0.1882
1	September	0.1285	0.3736	0.1882
1	October	0.1285	0.3736	0.1882
1	November	0.1285	0.2292	0.1877
1	December	0.1285	0.2292	0.1877
2	January	0.1285	0.2292	0.0333
2	February	0.1285	0.3613	0.0330
2	March	0.1285	0.3613	0.0330
2	April	0.1285	0.2243	0.0336
2	May	0.1285	0.2243	0.0336
2	June	0.1285	0.2243	0.0336
2	July	0.1285	0.3736	0.0335
2	August	0.1285	0.3736	0.0335
2	September	0.1285	0.3736	0.0335
2	October	0.1285	0.3736	0.0335
2	November	0.1285	0.2292	0.0333
2	December	0.1285	0.2292	0.0333
3	January	0.1285	0.2292	0.6344
3	February	0.1285	0.3613	0.6240
3	March	0.1285	0.3613	0.6240
3	April	0.1285	0.2243	0.6443
3	May	0.1285	0.2243	0.6443
3	June	0.1285	0.2243	0.6443
3	July	0.1285	0.3736	0.6397
3	August	0.1285	0.3736	0.6397
3	September	0.1285	0.3736	0.6397
3	October	0.1285	0.3736	0.6397
3	November	0.1285	0.2292	0.6344
3	December	0.1285	0.2292	0.6344

Table 5
Land Use Designations for Auer Urban/Rural Determination
Candlestick Point – Hunters Point Shipyard
Phase II Development Plan
San Francisco, California

USGS Code	2001 USGS Land Use Type	2001 USGS Land Use Type Description	Auer Land Use Type	Auer Land Use Name	Auer Classification for Urban/Rural Determination
11	Open Water	Open Water - All areas of open water, generally with less than 25% cover of vegetation or soil.	A5	Water Surfaces - Rivers, lakes	Rural
12	Perennial Ice/Snow	Perennial Ice/Snow - All areas characterized by a perennial cover of ice and/or snow, generally greater than 25% of total cover.	A5	Water Surfaces - Rivers, lakes	Rural
21	Developed, Open Space	Developed, Open Space - Includes areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.	R4	Estate Residential - Expansive family dwelling on multi-acre tracts; Abundant grass lawns and lightly wooded; >80% vegetation	Rural
22	Developed, Low Intensity	Developed, Low Intensity - Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20-49 percent of total cover. These areas most commonly include single-family housing units.	R1	Common Residential - Single family dwelling with normal easements; generally one story, pitched roof structures, with driveways; Abundant grass lawns and light-moderately wooded; >70% vegetation	Rural
23	Developed, Medium Intensity	Developed, Medium Intensity - Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50-79 percent of the total cover. These areas most commonly include single-family housing units.	R2, R3	R2: Compact Residential - Single, some multiple, family dwelling with close spacing; generally <2 story, pitched roof structures; garages (via alley), no driveways; Limited lawn sizes and shade trees; <30% vegetation R3: Compact Residential - Old multi-family dwellings with close (<2 m) lateral flat roof structures; garages (via alley) and ashpits, no driveways; Limited lawn sizes, old established shade trees; <35% vegetation	Urban
24	Developed, High Intensity	Developed, High Intensity - Includes highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80 to100 percent of the total cover.	I1, I2, C1	I1: Heavy Industrial - Major chemical, steel and fabrication industries; generally 3-5 story buildings, flat roofs; Grass and tree growth extremely rare; <5% vegetation I2: Light-moderate Industrial - Rail yards, truck depots, warehouses, industrial parks, minor fabrications; generally 1-3 story buildings, flat roofs; Very limited grass, trees almost totally absent; <5% vegetation C1: Commercial - Office and apartment buildings, hotels; >10 story heights, flat roofs; Limited grass and trees; <15% vegetation	Urban
31	Barren Land (Rock/Sand/Clay)	Barren Land (Rock/Sand/Clay) - Barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15 percent of total cover.	A3	Undeveloped - Uncultivated; wasteland; Mostly wild grasses and weeds, lightly wooded; 90% vegetation	Rural
41	Deciduous Forest	Deciduous Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75 percent of the tree species shed foliage simultaneously in response to seasonal change.	A4	Undeveloped Rural - Heavily wooded; >95% vegetation	Rural
42	Evergreen Forest	Evergreen Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75 percent of the tree species maintain their leaves all year. Canopy is never without green foliage.	A4	Undeveloped Rural - Heavily wooded; >95% vegetation	Rural
43	Mixed Forest	Mixed Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75 percent of total tree cover.	A4	Undeveloped Rural - Heavily wooded; >95% vegetation	Rural
51	Dwarf Scrub	Dwarf Scrub - Alaska only areas dominated by shrubs less than 20 centimeters tall with shrub canopy typically greater than 20% of total vegetation. This type is often co-associated with grasses, sedges, herbs, and non-vascular vegetation.	A3	Undeveloped - Uncultivated; wasteland; Mostly wild grasses and weeds, lightly wooded; 90% vegetation	Rural
52	Shrub/Scrub	Shrub/Scrub - Areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions.	A3	Undeveloped - Uncultivated; wasteland; Mostly wild grasses and weeds, lightly wooded; 90% vegetation	Rural
71	Grassland/Herbaceous	Grassland/Herbaceous - Areas dominated by grammanoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.	A3	Undeveloped - Uncultivated; wasteland; Mostly wild grasses and weeds, lightly wooded; 90% vegetation	Rural
72	Sedge/Herbaceous	Sedge/Herbaceous - Alaska only areas dominated by sedges and forbs, generally greater than 80% of total vegetation. This type can occur with significant other grasses or other grass like plants, and includes sedge tundra, and sedge tussock tundra.	A3	Undeveloped - Uncultivated; wasteland; Mostly wild grasses and weeds, lightly wooded; 90% vegetation	Rural

Table 5
Land Use Designations for Auer Urban/Rural Determination
Candlestick Point – Hunters Point Shipyard
Phase II Development Plan
San Francisco, California

USGS Code	2001 USGS Land Use Type	2001 USGS Land Use Type Description	Auer Land Use Type	Auer Land Use Name	Auer Classification for Urban/Rural Determination
81	Pasture/Hay	Pasture/Hay - Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20 percent of total vegetation.	A2	Agricultural Rural - Local crops (e.g., corn, soybean); 95% vegetation	Rural
82	Cultivated Crops	Cultivated Crops - Areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20 percent of total vegetatation. This class also includes all land being actively tilled	A2	Agricultural Rural - Local crops (e.g., corn, soybean); 95% vegetation	Rural
90	Woody Wetlands	Woody Wetlands - Areas where forest or shrubland vegetation accounts for greater than 20 percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water.	A3	Undeveloped - Uncultivated; wasteland; Mostly wild grasses and weeds, lightly wooded; 90% vegetation	Rural
91	Palustrine Forested Wetland	Palustrine Forested Wetland* -Includes all tidal and non-tidal wetlands dominated by woody vegetation greater than or equal to 5 meters in height and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 0.5 perent. Total vegetation coverage is greater than 20 percent.	A3	Undeveloped - Uncultivated; wasteland; Mostly wild grasses and weeds, lightly wooded; 90% vegetation	Rural
92	Palustrine Scrub/Shrub Wetland	Palustrine Scrub/Shrub Wetland* - Includes all tidal and non-tidal wetlands dominated by woody vegetation less than 5 meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 0.5 percent. Total vegetation coverage is greater than 20 percent.	A3	Undeveloped - Uncultivated; wasteland; Mostly wild grasses and weeds, lightly wooded; 90% vegetation	Rural
95	Emergent Herbaceous Wetlands	Emergent Herbaceous Wetlands - Areas where perennial herbaceous vegetation accounts for greater than 80 percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water.	A3	Undeveloped - Uncultivated; wasteland; Mostly wild grasses and weeds, lightly wooded; 90% vegetation	Rural

Source:

United States Geological Survey (USGS) 2001 National Land Cover Dataset (NLCD) Zone 4 Land Cover Layer. 2003. http://www.mrlc.gov/
Auer, Jr., A.H. "Correlation of Land Use and Cover with Meteorological Anomalies". Journal of Applied Meteorology, 17:636-643, 1978.
United States Environmental Protection Agency (USEPA). 2005. Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose.

Table 6
Land Use Areas for Auer Analysis
Candlestick Point – Hunters Point Shipyard
Phase II Development Plan
San Francisco, California

Urban or Rural Classification	3 kilometers around Site	
	Area (m^2)	Area %
Rural	19,440,225	68.76%
Urban	8,832,854	31.24%

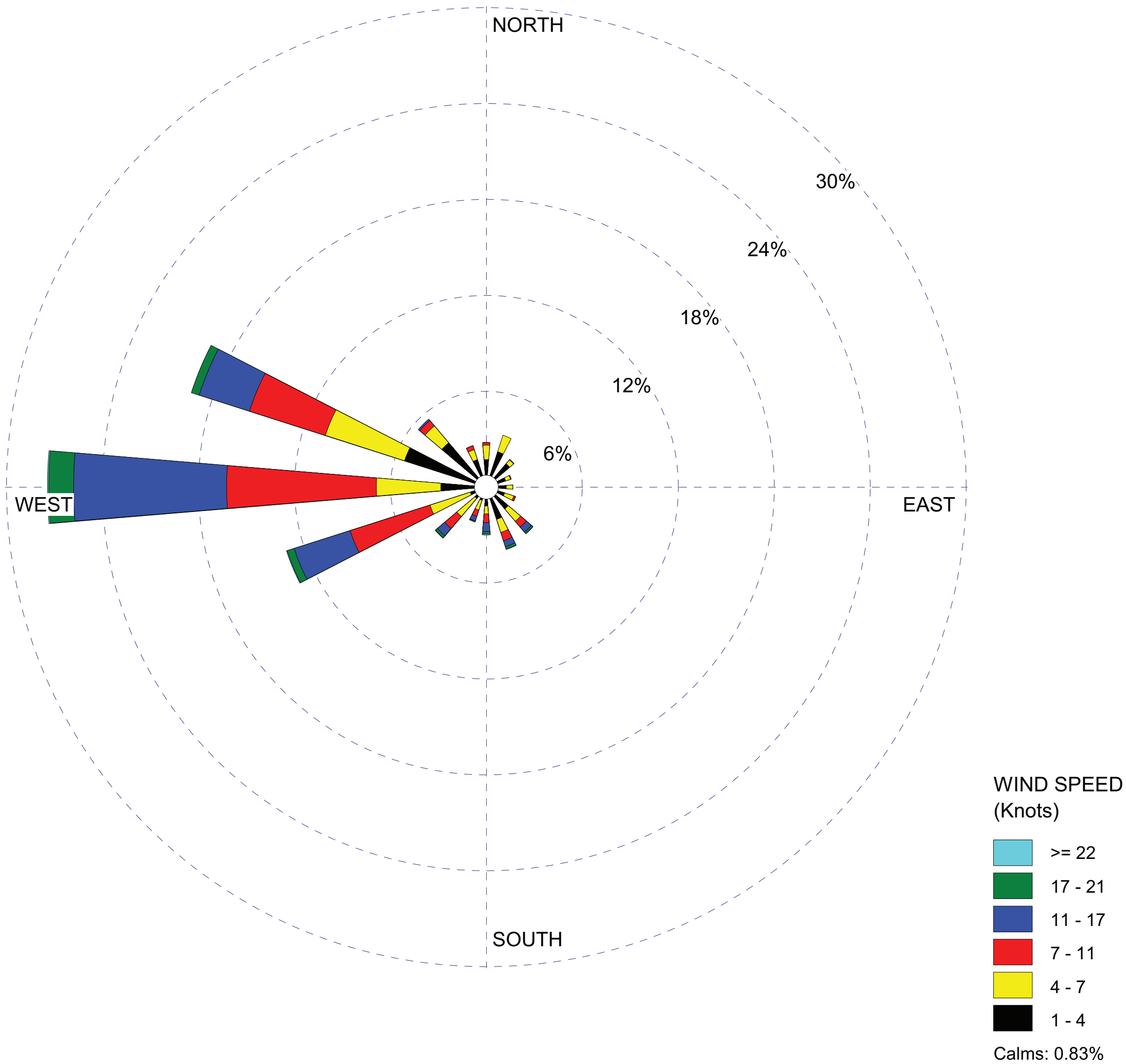
Abbreviation:
m^2: square meters

Note:
Auer land use classification based on National Land Use Cover Dataset (NLCD) (USGS 2001) as described in Table 2.

Figures

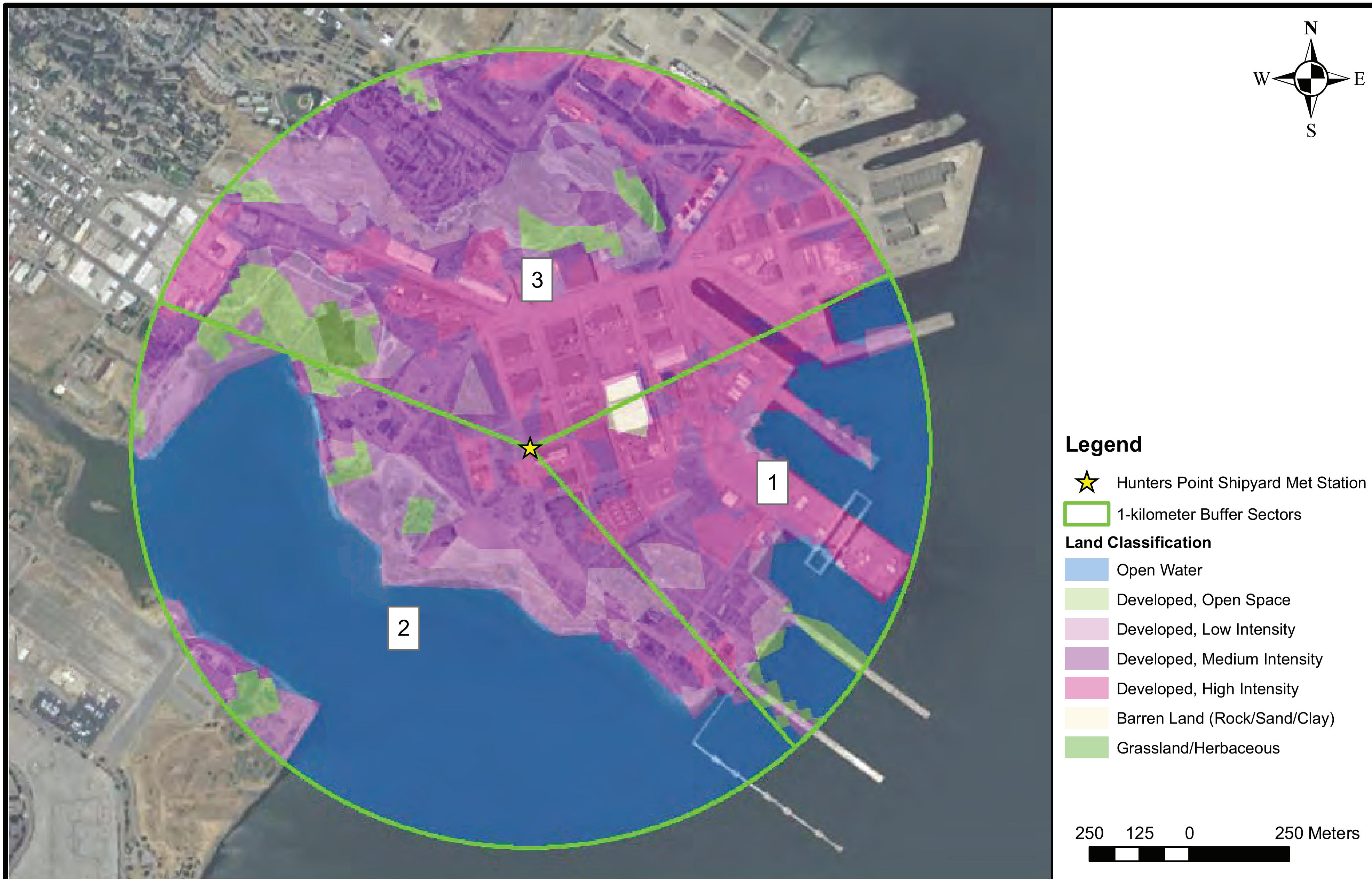
Figure 1

WIND ROSE PLOT:	DISPLAY:
Hunters Point Shipyard 2002-2003	**Wind Speed Direction (blowing from)**



COMMENTS:	DATA PERIOD:	COMPANY NAME:	
	2002-2003 Jan 1 - Dec 31 00:00 - 23:00	MODELER:	
	CALM WINDS: **0.83%**	TOTAL COUNT: **8760 hrs.**	
	AVG. WIND SPEED: **7.72 Knots**	DATE: **07/09/2009**	PROJECT NO.:

WRPLOT View - Lakes Environmental Software



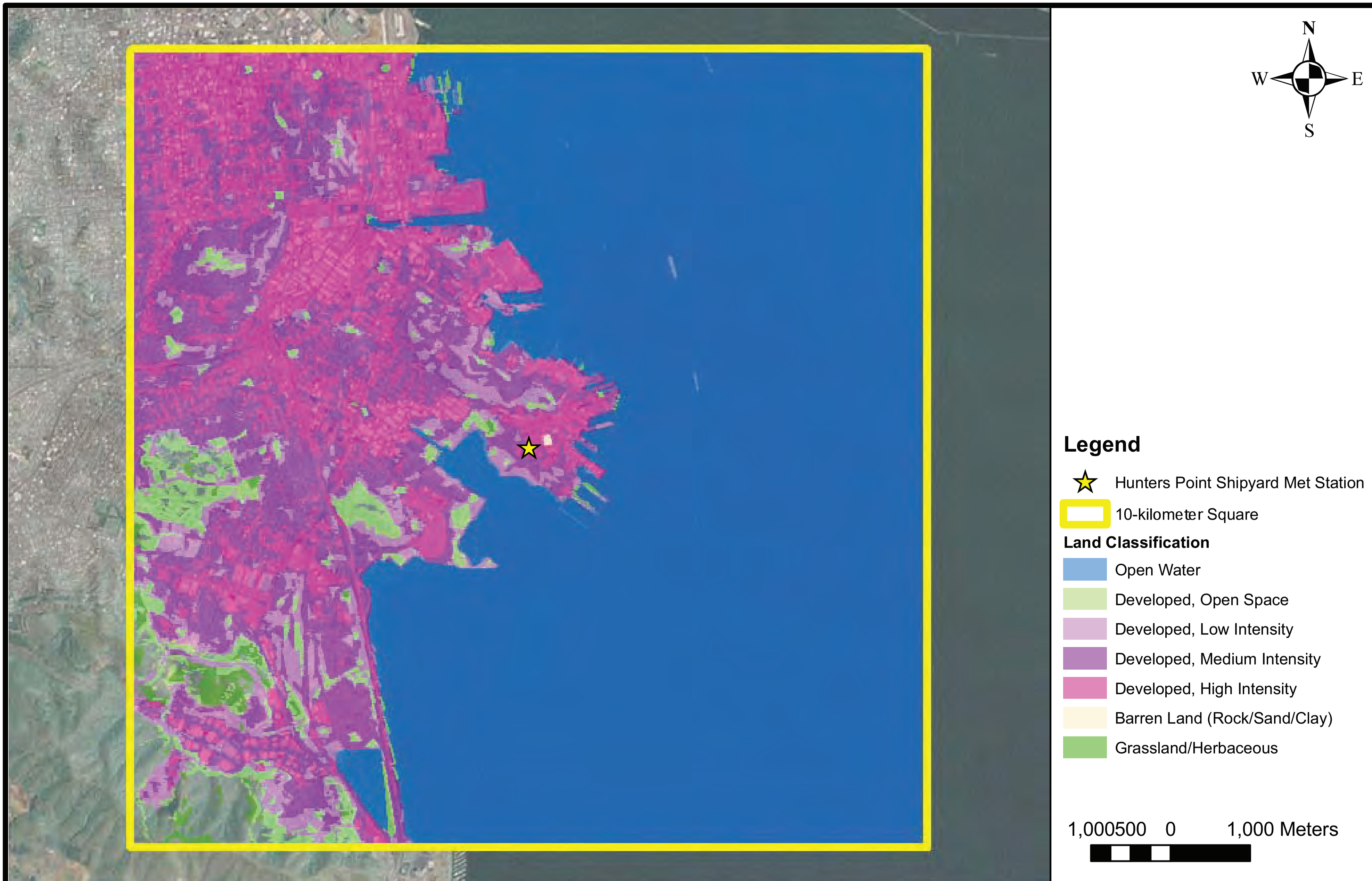
ENVIRON

6001 Shellmound St., Suite 700, Emeryville, CA 94608

Surface Roughness Domain
Candlestick Point - Hunters Point Shipyard
Phase II Development Plan - San Francisco, California

Figure **2**

Drafter: Date: Contract Number: Approved: Revised:



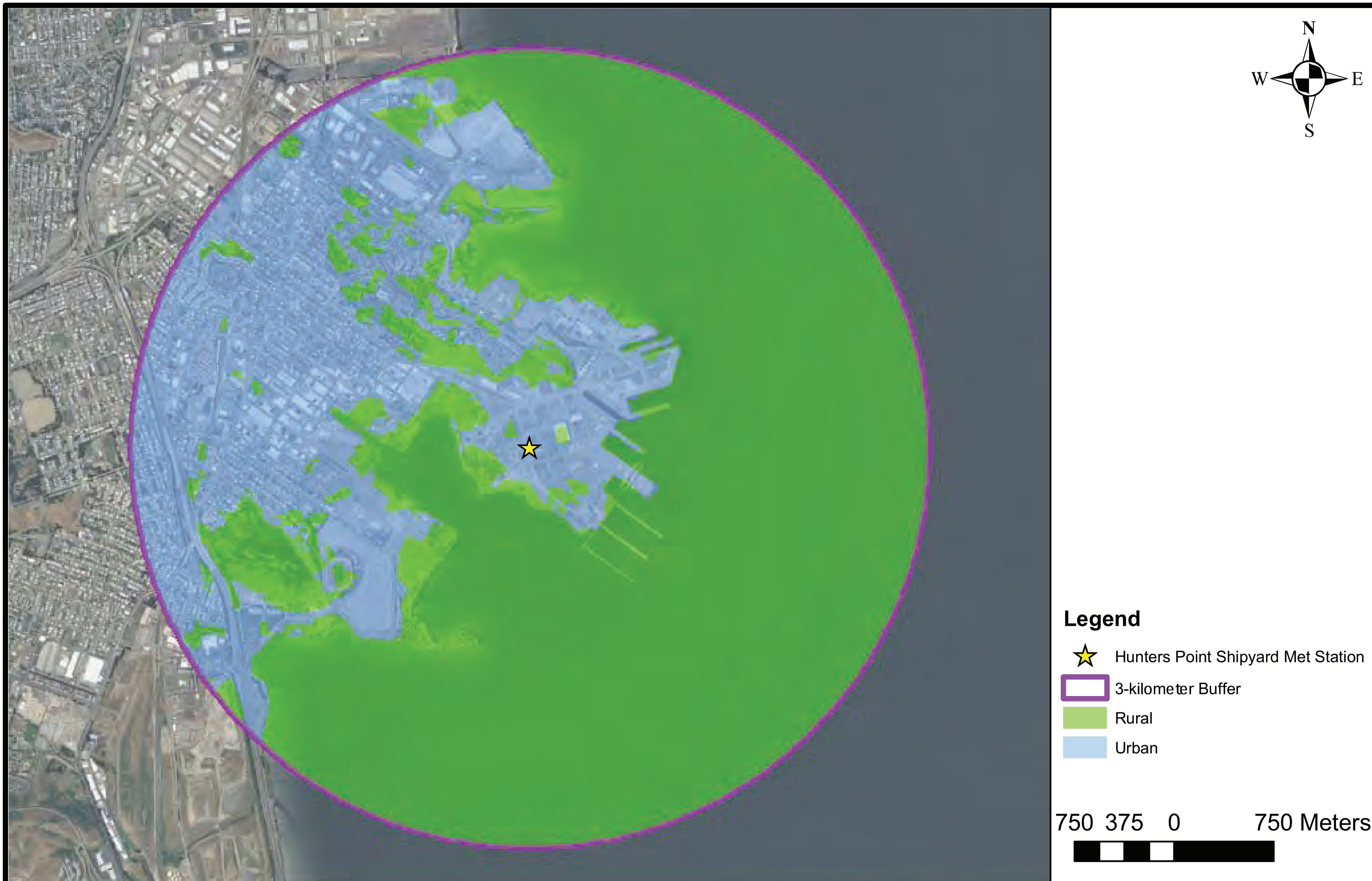
ENVIRON

6001 Shellmound St., Suite 700, Emeryville, CA 94608

Albedo and Bowen Ratio Domain
Candlestick Point - Hunters Point Shipyard
Phase II Development Plan - San Francisco, California

Figure **3**

Drafter: Date: Contract Number: Approved: Revised:



ENVIRON

6001 Shellmound St., Suite 700, Emeryville, CA 94608

Auer Land Use Analysis
Candlestick Point - Hunters Point Shipyard
Phase II Development Plan - San Francisco, California

Figure **4**

Drafter: Date: Contract Number: Approved: Revised:

Attachment VI
Technical Memorandum
Updated Project Description

Candlestick Point – Hunters Point
Shipyard Phase II Development Plan
San Francisco, California

Contents

List of Tables

List of Figures

List of Acronyms

AAQ	Ambient Air Quality
BAAQMD	Bay Area Air Quality Management District
CEQA	California Environmental Quality Act
cm	centimeter
CP	Candlestick Point
DPM	Diesel Particulate Matter
HHRA	Human Health Risk Assessment
HI	Hazard Index
HPS	Hunters Point Shipyard
MEI	Maximally Exposed Individual
MEIR	Maximally Exposed Individual Resident
MEIW	Maximally Exposed Individual Worker
$\mu g/m^3$	microgram per cubic meter
mph	miles per hour
R&D	Research and Development
SFDPH	San Francisco Department of Public Health
TAC	Toxic Air Contaminants
URBEMIS	URBan EMISsions Model
USEPA	United States Environmental Protection Agency

1 Introduction

Appendix H, Ambient Air Quality Human Health Risk Assessment consists of six attachments. Attachments I through IV present the four ambient air quality (AAQ) human health risk assessments (HHRA) prepared by ENVIRON International Corporation (ENVIRON). These include:

- Attachment I: Human Health Risk Assessment of Construction-Related Diesel Particulate Matter (DPM)
- Attachment II: Human Health Risk Assessment of Chemicals Bound to Airborne PM_{10}
- Attachment III: Analysis of Toxic Air Contaminant (TAC) Emissions from Stationary Sources in Research & Development (R&D) Areas
- Attachment IV: $PM_{2.5}$ Analysis of Traffic/Vehicular Emissions

Attachment V presents documentation of the meteorological data used in the air dispersion modeling component of the four AAQS HHRAs.

Since the HHRAs were completed, changes were made to the Project Description including the addition of roadway improvements on Ingerson and Jamestown Avenues, compaction of Candlestick Point (CP) construction schedule (completion in 2026), and slight changes to the CP phasing boundaries.

This addendum presents the screening-level emission estimates to address these changes.

2 Summary of Project Modifications

The differences between the configuration of the Project evaluated in Appendix H and that of the updated Project Description are summarized below.

2.1 Construction Schedule for Candlestick Point

As shown in Table 1, under the updated Project Description construction at CP will be expedited to be completed by 2026 rather than in 2028, as initially evaluated. This change in schedule results in condensing the construction activity initially scheduled from 2017 to 2028, to the period from 2017 to 2026. The condensed schedule will lead to higher annual equipment usage at the CP site (onsite), as indicated by the “Equipment-Month” parameter shown in Table 1. However the total DPM emissions from the onsite construction equipment over the entire construction period will remain approximately the same. The new schedule also has the possibility of increasing annual airborne soil emissions at the CP. The construction schedule at the Hunters Point Shipyard (HPS) will remain the same as previously evaluated.

2.2 Improvement of Surface Roadways

The updated Project Description includes improvements to two additional surface roadways not initially evaluated in Appendix H, Ingerson Avenue and Jamestown Avenue, which are southwest of and parallel to Gilman Avenue. Offsite construction-related DPM emissions from the implementation of the improvements and the associated potential health impacts to the offsite receptors, especially the residential receptors along these two roadways, are evaluated in this attachment. The $PM_{2.5}$ impacts from the project-related traffic on these two roadways are also evaluated in this attachment. Figure 1 shows the location of three roadways under proposed improvements and the residential areas along the roadways.

3 Methodology

ENVIRON conducted a screening-level analysis to determine what impacts, if any, the updated Project Description would have on the conclusions reached in **Attachment I** (Construction-related DPM), **Attachment II** (Chemicals Bound to Airborne PM_{10}), and **Attachment IV** ($PM_{2.5}$ Analysis of Traffic/Vehicular Emissions). The modifications reflected in the updated Project Description are not expected to affect the analyses conducted as part of **Attachment III** (Analysis of TAC Emissions from Stationary Sources in R&D Areas), as there are no expected changes to the R&D areas of HPS. Below is a discussion of the methods used to evaluate, at a screening-level, the impacts of the updated Project Description on conclusions reached in **Attachments I, II,** and **IV**.

3.1 Construction-related DPM

As mentioned above, the condensed construction schedule of CP will result in higher annual DPM emissions from the onsite construction equipment for several years but will not significantly change the total onsite DPM emissions over the entire construction period. Since excess lifetime cancer risks are calculated based on total emissions rather than annual emissions, for most locations the estimated excess lifetime cancer risks associated with onsite construction activities for the updated Project Description are not expected to differ significantly from those reported in **Attachment I**.

The estimated excess lifetime cancer risks due to offsite construction activities; however, could increase at some locations because of the proposed improvements for Ingerson and Jamestown Avenues, particularly for receptors in the immediate vicinity of these streets. The two roadways are located in a relatively flat area, southwest from and parallel to Gilman. The updated Project Description assumes that the improvements of these two roadways will each generate approximately 60% of the construction activities from the improvements of Gilman Avenue.

In order to calculate the potential impact, at a screening level, of roadway improvements on each of these streets, the estimated excess lifetime cancer risks associated with roadway improvements from Gilman were reduced to 60% and superimposed on both Ingerson and Jamestown Avenues. This is appropriate as Gilman, Ingerson and Jamestown are located in a relatively flat area and are oriented parallel to each other. The winds which affect the emissions from each street will affect them all similarly. As an example, if the roadway improvement on Gilman caused a receptor located 50 meters immediately east of Gilman to have an estimated excess lifetime cancer risk of 1 in a million (1×10^{-6}), then a receptor 50 meters immediately to the east of Ingerson or Jamestown, in the same relative location, was assigned an impact of 0.6 in a million (i.e., 60% of the Gilman contribution). Figure 2 shows the receptors with the same relative location from Ingerson, Jamestown, and Gilman, which were paired to calculate estimated excess lifetime cancer risks from the improvements of the two additional roadways.

The excess lifetime cancer risks due to onsite construction-related DPM emissions (unchanged), the excess lifetime cancer risks due to offsite DPM emissions from the roadway improvements evaluated in Appendix H, and the excess lifetime cancer risks due to additional offsite DPM emissions from the improvements of Ingerson and Jamestown are summed for each receptor to evaluate health risk impact from the construction-related DPM.

Since the calculated construction-related noncancer chronic hazard index (HI) for the previous Project configuration is very small (i.e., the estimated noncancer chronic HIs for all receptors is 0.006 or below), it was assumed that the noncancer chronic HI will be well below 0.5 for the updated Project Description.

3.2 Chemicals Bound to Airborne PM_{10}

As described in **Attachment II**, the PM_{10} emissions associated with demolition and grading activities were calculated using the following formula from URBan EMISsions Model (URBEMIS 2007) version 9.2.4:

$$PM_{10} \text{ Emissions (ton)} = EF \times A \times D$$

Where:

EF = Emission Factor (ton/acre-month)

A = Disturbed Area (acre)

D = Phase Duration (month)

As mentioned above, the condensed construction schedule of CP will probably increase the phase duration of demolition and grading activities, some of which happen between the years of 2017 to 2026. As a result, the annual PM_{10} emissions and associated health risks will increase during this period. As a screening, ENVIRON assumed that the ratio of Equipment-Month value in the updated Project Description to that used in Appendix H as presented in Table 1 is proportional to the phase duration, and thus to the emissions. Therefore, ENVIRON used the ratio to scale up the estimated excess lifetime cancer risks, noncancer chronic HI, and noncancer acute HI to obtain the estimated health risks for the updated Project Description for CP. The scaled risks values then were added to the unchanged risk values due to HPS construction to evaluate the overall potential health risk impact from the constructed-related airborne soil.

3.3 $PM_{2.5}$ Analysis of Traffic/Vehicular Emissions

As described above, the improvement on surface roadways is expected to result in higher traffic volumes on Ingerson and Jamestown Avenues. To estimate the potential impact of this change, dispersion modeling was performed for roads in the surrounding area, including the southern portion of Third Street, Gilman, Paul, Ingerson, and Jamestown. It is indicated in the United States Environmental Protection Agency (USEPA) User's Guide to CAL3QHC (whose basic algorithm is shared by CAL3QHCR, the model used in this Project) that roadways more than 1,000 meters away from receptors won't likely have a significant impact on the given receptor (USEPA 1995). Therefore constraining the modeling domain won't have an impact on the resultant $PM_{2.5}$ concentrations. Figure 3 shows the location of the travel lanes modeled for running emissions.

Averaging periods, terrain, meteorological data, and residential receptor locations around the new roadways were set up following the approach described in **Attachment IV.** The residential receptor locations are shown in Figure 4. The surface roughness was changed to 100 centimeters (cm), consistent with USEPA recommendations for dispersion modeling in urban areas (USEPA 2009).

The hourly emission factors for exhaust emissions were refined to take into account the fact that arterials (Third Street) have speed limits of 30 miles per hour (mph), while local roads (Gilman, Paul, Harney Way, Ingerson, and Jamestown) have speed limits of 25 mph, in accordance with San Francisco Department of Public Health (SFDPH) Guidance (SFDPH 2008). The emission factors were estimated on these roadways in the method described in **Attachment IV**, with the exception of travel speeds, which were updated to reflect the speed limits above. The running emission factors for the updated travel speeds are shown in Table 2. Queuing emission factors are the same as presented in **Attachment IV**.

Hourly traffic volumes remained unchanged on the roads previously analyzed. Traffic volumes on Ingerson and Jamestown were estimated in a manner consistent with the description provided in **Attachment IV**, with the exception of eastbound traffic on Ingerson, which, absent any more specific data, was assumed to be equal to westbound traffic on Ingerson. The hourly traffic volumes on the new roads, Ingerson and Jamestown, are shown in Table 3.

The road configurations are as discussed in **Attachment IV**, with the exception of the addition of Ingerson and Jamestown, whose parameters are shown in Table 4.

Queuing emissions were analyzed using the same approach followed in **Attachment IV**, with the addition of westbound queues on Ingerson and Jamestown. Northbound and southbound queues on Third Street at these intersections were already taken into account in **Attachment IV**. Queuing parameters for the two new queues are shown in Table 5, and the locations of all modeled queues are shown in Figure 5.

4 Results

4.1 Construction-related DPM

Excess lifetime cancer risks from construction-related DPM emissions for modeled receptors are presented in Figures 6 and 7. Figure 6 shows the offsite residential receptors at which the excess lifetime cancer risks corresponding to updated Project Description were calculated. The highest estimated excess lifetime cancer risk for a residential receptor is 1.6 in a million (1.6×10^{-6}). The cancer risk corresponding to the updated Project description for the previously determined maximally exposed individual resident (MEIR)-adult location (on the northwest boundary of the Hunters Point site) was not calculated due to the limitation of this screening approach (i.e., the paired receptors shown in Figure 2 do not exist in this area). However, from evaluating receptors in the same area on Figure 6, it was concluded that improvements of the Ingerson Avenue and Jamestown Avenue contributes approximately 0.001 in a million (1×10^{-9}) of excess lifetime cancer risks for the receptors in this area. Therefore the estimated excess lifetime cancer risk for the offsite MEIR–adult is approximately 1.8 in a million (1.8×10^{-6}), equal to the value calculated in Appendix H.

Figure 7 shows the offsite worker receptors at which the estimated excess lifetime cancer risks corresponding to the updated Project Description were calculated. The highest risk for the offsite worker receptors is 3.8 in a million (3.8×10^{-6}). However for the same reason mentioned above, the estimated excess lifetime cancer risk corresponding to the updated Project Description for the previously determined maximally exposed individual worker (MEIW) location (on the southeast end of the Carroll Avenue on the northwest boundary of the Hunters Point site) was not calculated. However, from evaluating receptors in the same area on Figure 7, it was concluded that improvements of the Ingerson Avenue and Jamestown Avenue contributes approximately 0.02 in a million (2×10^{-8}) of excess lifetime cancer risks for the receptors in this area. Therefore the estimated cancer risk for the offsite MEIW is 4.5 in a million (4.5×10^{-6}), equal to the value calculated in Appendix H. Additionally, as shown in Figure 6, the excess cancer risk estimated for residential receptors directly adjacent to Ingerson and Jamestown Avenues are less than 1 in a million ($<1.0 \times 10^{-6}$).

4.2 Chemicals Bound to Airborne PM_{10}

Excess lifetime cancer risks, noncancer chronic hazard indices (HIs), and noncancer acute HIs from airborne contaminated soil due to construction are presented in Tables 6 and 7. As shown in Table 6, the estimated excess lifetime cancer risks at the MEIW, MEIR-adult, and MEIR-child continue to be below 10 in a million (1.0×10^{-5}), the Bay Area Air Quality Management District (BAAQMD) California Environmental Quality Act (CEQA) thresholds of significance (BAAQMD 1999). In addition, as shown in Table 7, the noncancer chronic HIs and acute HIs at MEIW and MEIR-adult are all below the CEQA thresholds of 1.0.

4.3 $PM_{2.5}$ Analysis of Traffic/Vehicular Emissions

The results of the refined dispersion modeling are shown in Figure 8. $PM_{2.5}$ concentrations in the area surrounding Gilman, Ingerson, Jamestown, and Third Street are not expected to exceed 0.2 micrograms per cubic meter (μg/m^3), the SFDPH threshold (SFDPH 2008). The maximum estimated impact is 0.15 μg/m^3, which occurs on the northern side of Gilman, near its easternmost end. This value is lower than the one estimated in **Attachment IV**, mainly because of the modification of hourly running emission factors which takes into account speed limits in accordance with SFDPH guidance. In addition, the modified surface roughness, increased to account for the urban nature of the area around the site, was also a contributor to the reduction in the maximum expected impact. The change of the MEIR location is due to the addition of the emissions on Ingerson and Jamestown which shift the major emissions to the east side of the modeling domain.

5 Conclusion

The estimated excess lifetime cancer risks and chronic noncancer HIs for all receptors are below the BAAQMD CEQA thresholds of significance. Further, the estimated $PM_{2.5}$ concentrations from vehicular emissions for all receptors are below the SFDPH threshold. Thus, changing of the configuration of the Project evaluated in Appendix H to the updated Project Description would not change the conclusions previously reached in Appendix H.

6 References

Bay Area Air Quality Management District (BAAQMD). 1999. *BAAQMD CEQA Guidelines: Assessing the Air Quality Impacts of Projects and Plans*. December.

San Francisco Department of Public Health (SFDPH). 2008. *Assessment and Mitigation of Air Pollutant Health Effects from Intra-urban Roadways: Guidance for Land Use Planning and Environmental Review.* May 6.

United States Environmental Protection Agency (USEPA). 1995. *User's Guide to CAL3QHC Version 2.0: A Modeling Methodology for Predicting Pollutant Concentrations Near Roadway Intersections.* September.

United States Environmental Protection Agency (USEPA). 2009. *AERMOD Implementation Guide*. March.

Tables

Table 1
Construction Schedule - Candlestick Point Project Updated Project Description[1]
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Year	Equipment-Month[2]		
	Candlestick Point Project Updated Project Description	Candlestick Point Project Previously Evaluated[3]	Updated Project Description / Previously Evaluated
2017	271	249	1.09
2018	240	192	1.25
2019	225	182	1.24
2020	291	216	1.35
2021	211	195	1.08
2022	154	160	0.96
2023	214	208	1.03
2024	274	139	1.97
2025	172	160	1.08
2026	60	157	0.38
2027		55	
2028		27	

Notes:
1. The construction schedule and equipment-month information for Candlestick Point Project Variant 6 was provided by MACTEC Engineering and Consulting, Inc.
2. Equipment-month = # of months worked x # equipment producing emissions.
3. The evaluation was conducted as part of Appendix H of the Environmental Impact Report (EIR) for the proposed Candlestick Point – Hunters Point Shipyard Phase II Development Plan (Technical Report, dated September 28th, 2009) prepared by ENVIRON International Corporation.

Table 2
Summary of Emission Factors
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Hour	Running Emission Factor, Arterial Roads[1,2] (grams/vehicle-mile)				Running Emission Factor, Local Roads[1,2] (grams/vehicle-mile)			
	Exhaust[3]		Non-Exhaust[3]		Exhaust[3]		Non-Exhaust[3]	
	All Vehicles[4]	*No HD Vehicles*[5]	All Vehicles[4]	*No HD Vehicles*[5]	All Vehicles[4]	*No HD Vehicles*[5]	All Vehicles[4]	*No HD Vehicles*[5]
1	1.42E-02	*1.28E-02*	7.06E-03	*6.97E-03*	1.73E-02	*1.57E-02*	7.06E-03	*6.97E-03*
2	1.37E-02	*1.28E-02*	7.09E-03	*6.97E-03*	1.68E-02	*1.57E-02*	7.09E-03	*6.97E-03*
3	2.13E-02	*1.45E-02*	7.38E-03	*6.99E-03*	2.55E-02	*1.77E-02*	7.38E-03	*6.99E-03*
4	1.36E-02	*1.30E-02*	7.14E-03	*6.97E-03*	1.66E-02	*1.59E-02*	7.14E-03	*6.97E-03*
5	1.30E-02	*1.28E-02*	7.11E-03	*6.97E-03*	1.59E-02	*1.57E-02*	7.11E-03	*6.97E-03*
6	1.59E-02	*1.31E-02*	7.11E-03	*6.97E-03*	1.92E-02	*1.60E-02*	7.11E-03	*6.97E-03*
7	1.40E-02	*1.31E-02*	7.01E-03	*6.97E-03*	1.71E-02	*1.60E-02*	7.01E-03	*6.97E-03*
8	1.32E-02	*1.27E-02*	6.99E-03	*6.97E-03*	1.61E-02	*1.55E-02*	6.99E-03	*6.97E-03*
9	1.55E-02	*1.29E-02*	7.06E-03	*6.97E-03*	1.88E-02	*1.58E-02*	7.06E-03	*6.97E-03*
10	2.36E-02	*1.40E-02*	7.33E-03	*6.99E-03*	2.82E-02	*1.71E-02*	7.33E-03	*6.99E-03*
11	2.16E-02	*1.37E-02*	7.27E-03	*6.98E-03*	2.59E-02	*1.67E-02*	7.27E-03	*6.98E-03*
12	1.92E-02	*1.33E-02*	7.19E-03	*6.98E-03*	2.31E-02	*1.63E-02*	7.19E-03	*6.98E-03*
13	1.67E-02	*1.30E-02*	7.10E-03	*6.97E-03*	2.01E-02	*1.59E-02*	7.10E-03	*6.97E-03*
14	1.61E-02	*1.29E-02*	7.09E-03	*6.97E-03*	1.94E-02	*1.58E-02*	7.09E-03	*6.97E-03*
15	1.65E-02	*1.30E-02*	7.10E-03	*6.97E-03*	2.00E-02	*1.59E-02*	7.10E-03	*6.97E-03*
16	1.71E-02	*1.31E-02*	7.11E-03	*6.97E-03*	2.06E-02	*1.60E-02*	7.11E-03	*6.97E-03*
17	1.59E-02	*1.30E-02*	7.08E-03	*6.97E-03*	1.93E-02	*1.59E-02*	7.08E-03	*6.97E-03*
18	1.41E-02	*1.28E-02*	7.02E-03	*6.97E-03*	1.71E-02	*1.57E-02*	7.02E-03	*6.97E-03*
19	1.38E-02	*1.27E-02*	7.01E-03	*6.97E-03*	1.68E-02	*1.55E-02*	7.01E-03	*6.97E-03*
20	1.36E-02	*1.27E-02*	7.00E-03	*6.97E-03*	1.65E-02	*1.55E-02*	7.00E-03	*6.97E-03*
21	1.34E-02	*1.26E-02*	7.01E-03	*6.97E-03*	1.64E-02	*1.55E-02*	7.01E-03	*6.97E-03*
22	1.28E-02	*1.26E-02*	6.99E-03	*6.97E-03*	1.56E-02	*1.54E-02*	6.99E-03	*6.97E-03*
23	1.29E-02	*1.26E-02*	7.00E-03	*6.97E-03*	1.58E-02	*1.55E-02*	7.00E-03	*6.97E-03*
24	1.28E-02	*1.26E-02*	7.00E-03	*6.97E-03*	1.56E-02	*1.54E-02*	7.00E-03	*6.97E-03*

Notes:

1. The emission factors for each vehicle class were extracted from EMFAC2007 and were weighted by default hourly fraction of trip in EMFAC2007 to yield composite hourly emission factors. Detailed discussion of the methodology is presented in Appendix H, Attachment IV, Section 4.2. Arterial roads, including Third Street, have speed limits of 30 miles per hour (mph). Local roads, including Gilman, Jamestown, and Ingerson, have speed limits of 25 mph.
2. Arterial roads, including Third Street, have speed limits of 30 mph. Local roads, including Gilman, Jamestown, and Ingerson, have speed limits of 25 mph.
3. Exhaust refers to running emissions from vehicle exhaust; non-exhaust refers to running emissions from tire and brake wear.
4. The emission factors for all vehicles are used for road segments with no truck restrictions.
5. The emission factors for all vehicles, excluding heavy-duty vehicles, are used for road segments with truck restrictions which forbid trucks over 14,000 pounds. Those emission factors are shown in *italics.*

Abbreviations:

HD: heavy duty vehicle, and refers to vehicles with a gross vehicle rating of 10,001 pounds or more.
mph : miles per hour

Table 3
Summary of Traffic Volumes on New Roads by Modeled Road Segment
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Hour	Fraction of Trip/Day, All Vehicles[1]	Fraction of Trip/Day, *No HD Vehicles*[2]	Ingerson Segments 10 to --[3]		Jamestown Segments 11 to 29	
			Eastbound	Westbound	Eastbound	Westbound
1	0.0080	*0.0084*	11	11	30	29
2	0.0040	*0.0041*	5	5	15	14
3	0.0020	*0.0015*	2	2	6	5
4	0.0016	*0.0017*	2	2	6	6
5	0.0027	*0.0028*	4	4	10	10
6	0.0044	*0.0045*	6	6	16	16
7	0.0174	*0.0191*	24	24	69	66
8	0.0512	*0.0567*	42	42	169	170
9	0.0545	*0.0563*	72	72	203	195
10	0.0625	*0.0480*	61	61	173	166
11	0.0617	*0.0512*	65	65	185	177
12	0.0795	*0.0723*	92	92	261	250
13	0.0837	*0.0831*	151	106	352	288
14	0.0688	*0.0692*	88	88	249	239
15	0.0744	*0.0738*	94	94	266	255
16	0.0792	*0.0779*	100	100	281	270
17	0.0732	*0.0743*	95	95	268	257
18	0.0730	*0.0786*	101	101	284	272
19	0.0587	*0.0638*	82	82	230	221
20	0.0466	*0.0509*	65	65	183	176
21	0.0312	*0.0340*	44	44	123	118
22	0.0267	*0.0295*	38	38	106	102
23	0.0190	*0.0208*	27	27	75	72
24	0.0160	*0.0175*	22	22	63	61

Notes:

1. Hourly fraction of trips per day calculated from EMFAC total trips per hour for San Francisco County in 2030 were used to convert AM peak hour and PM peak hour traffic volumes into hourly traffic count. AM and PM peak hour traffic volumes were extracted from the Traffic Report. Detailed discussion of the methodology is presented in Appendix H, Attachment IV, Section 4.2.

2. The fractions of trips per day, excluding heavy-duty vehicles, are used for segments with truck restrictions which forbid trucks over 14,000 pounds. Those segments with truck restrictions are shown in*italics.*

3. The intersection at the easternmost end of Ingerson was not evaluated in the Traffic Report; therefore, it does not have an assigned number.

Abbreviations:
HD: heavy duty vehicle, and refers to vehicles with a gross vehicle rating of 10,001 pounds or more.

Table 4
CAL3QHCR Source Parameters for New Roads, Running Emissions
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Segment[1]	Link	Type	$UTMx_{start}$ (meters)	$UTMy_{start}$ (meters)	$UTMx_{end}$ (meters)	$UTMy_{end}$ (meters)	Relative Elevation[2] (meters)	Mixing Zone Width[3] (meters)
10 to -- Eastbound	Link_163	Above ground	553,213	4,175,015	553,237	4,175,003	0	9.50
	Link_164	Above ground	553,237	4,175,003	553,661	4,174,706	0	9.50
	Link_165	Above ground	553,661	4,174,706	553,672	4,174,696	0	9.50
	Link_166	Above ground	553,672	4,174,696	553,932	4,174,505	0	9.50
10 to -- Westbound	Link_167	Above ground	553,239	4,175,007	553,214	4,175,019	0	9.50
	Link_168	Above ground	553,664	4,174,709	553,239	4,175,007	0	9.50
	Link_169	Above ground	553,675	4,174,699	553,664	4,174,709	0	9.50
	Link_170	Above ground	553,935	4,174,508	553,675	4,174,699	0	9.50
11 to 29 Eastbound	Link_171	Above ground	553,182	4,174,936	553,430	4,174,766	0	9.50
	Link_172	Above ground	553,430	4,174,766	553,452	4,174,749	0	9.50
	Link_173	Above ground	553,452	4,174,749	553,528	4,174,697	0	9.50
	Link_174	Above ground	553,528	4,174,697	553,573	4,174,670	0	9.50
	Link_175	Above ground	553,573	4,174,670	553,632	4,174,639	0	9.50
	Link_176	Above ground	553,632	4,174,639	553,662	4,174,616	0	9.50
	Link_177	Above ground	553,662	4,174,616	553,685	4,174,592	0	9.50
	Link_178	Above ground	553,685	4,174,592	553,712	4,174,559	0	9.50
	Link_179	Above ground	553,712	4,174,559	553,745	4,174,516	0	9.50
	Link_180	Above ground	553,745	4,174,516	553,773	4,174,477	0	9.50
	Link_181	Above ground	553,773	4,174,477	553,809	4,174,429	0	9.50
	Link_182	Above ground	553,809	4,174,429	553,841	4,174,380	0	9.50
	Link_183	Above ground	553,841	4,174,380	553,889	4,174,301	0	9.50
	Link_184	Above ground	553,889	4,174,301	553,912	4,174,257	0	9.50
	Link_185	Above ground	553,912	4,174,257	553,929	4,174,208	0	9.50
	Link_186	Above ground	553,929	4,174,208	553,940	4,174,158	0	9.50
	Link_187	Above ground	553,940	4,174,158	553,946	4,174,122	0	9.50
	Link_188	Above ground	553,946	4,174,122	553,956	4,174,079	0	9.50
	Link_189	Above ground	553,956	4,174,079	553,972	4,174,051	0	9.50
	Link_190	Above ground	553,972	4,174,051	554,057	4,173,967	0	9.50

Table 4
CAL3QHCR Source Parameters for New Roads, Running Emissions
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Segment[1]	Link	Type	$UTMx_{start}$ (meters)	$UTMy_{start}$ (meters)	$UTMx_{end}$ (meters)	$UTMy_{end}$ (meters)	Relative Elevation[2] (meters)	Mixing Zone Width[3] (meters)
11 to 29 Westbound	Link_191	Above ground	553,432	4,174,770	553,185	4,174,941	0	9.50
	Link_192	Above ground	553,456	4,174,754	553,432	4,174,770	0	9.50
	Link_193	Above ground	553,531	4,174,702	553,456	4,174,754	0	9.50
	Link_194	Above ground	553,578	4,174,678	553,531	4,174,702	0	9.50
	Link_195	Above ground	553,637	4,174,646	553,578	4,174,678	0	9.50
	Link_196	Above ground	553,669	4,174,624	553,637	4,174,646	0	9.50
	Link_197	Above ground	553,690	4,174,600	553,669	4,174,624	0	9.50
	Link_198	Above ground	553,717	4,174,566	553,690	4,174,600	0	9.50
	Link_199	Above ground	553,749	4,174,523	553,717	4,174,566	0	9.50
	Link_200	Above ground	553,780	4,174,482	553,749	4,174,523	0	9.50
	Link_201	Above ground	553,816	4,174,434	553,780	4,174,482	0	9.50
	Link_202	Above ground	553,848	4,174,385	553,816	4,174,434	0	9.50
	Link_203	Above ground	553,897	4,174,303	553,848	4,174,385	0	9.50
	Link_204	Above ground	553,921	4,174,257	553,897	4,174,303	0	9.50
	Link_205	Above ground	553,937	4,174,209	553,921	4,174,257	0	9.50
	Link_206	Above ground	553,948	4,174,158	553,937	4,174,209	0	9.50
	Link_207	Above ground	553,953	4,174,122	553,948	4,174,158	0	9.50
	Link_208	Above ground	553,966	4,174,081	553,953	4,174,122	0	9.50
	Link_209	Above ground	553,982	4,174,056	553,966	4,174,081	0	9.50
	Link_210	Above ground	554,023	4,174,013	553,982	4,174,056	0	9.50

Notes:
1. Segments are identified by the bounding intersections, using the intersection numbering developed in Figure 26A of the Traffic Report, and by the direction of traffic flow.
2. CAL3QHCR limits relative elevations to a range of -10 meters to +10 meters. Here, the elevations are fairly flat. Therefore, the site is assigned an elevation of 0 meters.
3. As defined in CAL3QHCR, mixing zone width for a given free flow link is calculated by adding 6 meters to the width of the road. The width of the road is obtained by visual observation of high-resolution aeiral photograph.

Abbreviations:
CAL3QHCR: a steady-state Gaussian dispersion model
UTMx: X coordinate in Universal Transverse Mercator coordinate system, zone 10N
UTMy: Y coordinate in Universal Transverse Mercator coordinate system, zone 10N

Sources:
CHS Consulting Group et al. 2009. Bayview Waterfront Project Transportation Study: Preliminary Draft 1 Report.

Table 5
CAL3QHCR Source Parameters for New Roads, Queuing Emissions
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Segment[1]	Link	Type	$UTMx_{start}$ (meters)	$UTMy_{start}$ (meters)	$UTMx_{end}$ (meters)	$UTMy_{end}$ (meters)	Relative Elevation[2] (meters)	Mixing Zone Width[3] (meters)
10 to -- Westbound	Ingerson WB	Above ground	553305.3	4174963.0	553214.8	4175025.5	0	3.50
11 to 29 Westbound	Jamestown WB	Above ground	553276.6	4174877.6	553185.4	4174940.8	0	3.50

<u>Notes:</u>

1. Segments are identified by the bounding intersections, using the intersection numbering developed in Figure 26A of the Traffic Report, and by the direction of traffic flow.

2. CAL3QHCR limits relative elevations to a range of -10 meters to +10 meters. Here, the elevations are fairly flat. Therefore, the site is assigned an elevation of 0 meters.
3. As defined in CAL3QHCR, mixing zone width for a given queue link is equal to the width of the road. The width of the road is obtained by visual observation of high-resolution aeiral photograph.

<u>Abbreviations:</u>
CAL3QHCR: a steady-state Gaussian dispersion model
UTMx: X coordinate in Universal Transverse Mercator coordinate system, zone 10N
UTMy: Y coordinate in Universal Transverse Mercator coordinate system, zone 10N

<u>Sources:</u>
CHS Consulting Group et al. 2009. Bayview Waterfront Project Transportation Study: Preliminary Draft 1 Report.

Table 6
Summary of Estimated Excess Lifetime Cancer Risks at the Offsite Maximally Exposed Individual (MEI)
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Project Area	Offsite Worker[2]	Offsite Resident[2]	
		Adult	Child
Candlestick Point - Hunters Point Shipyard Phase II Development Plan	2E-08	2E-08	3E-08

Notes:
1. The construction schedule and equipment-month information for the updated project description was provided by MACTEC Engineering and Consulting, Inc.
2. The estimated excess lifetime cancer risks were calculated by scaling individual hazard indices (HIs) associated with the Candlestick Point demolition and grading activities previously estimated by the ratio of equipment-month presented in Table 1.

Table 7
Summary of Noncancer Hazard Indices (HIs) at the Offsite Maximally Exposed Individual (MEI)[1]
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Project Area	HI Category	Offsite Worker	Offsite Resident	
			Adult	Child
Candlestick Point - Hunters Point Shipyard Phase II Development	Chronic HI	0.01	0.009	--
	Acute HI	0.4	0.3	--

Notes:

1. The construction schedule and equipment-month information for the updated project description was provided by MACTEC Engineering and Consulting, Inc.
2. The chronic and acute HIs were calculated by scaling individual hazard indices (HIs) associated with the Candlestick Point demolition and grading activities previously estimated by the ratio of equipment-month presented in Table 1.

Figures

ENVIRON

6001 Shellmound St., Suite 700, Emeryville, CA 94608

Road Improvements - Project Update
Candlestick Point - Hunters Point Shipyard Phase II
Development Plan
San Francisco, California

Figure

1

Drafter: MH Date: 10/16/2009 Contract Number: 0320816A Approved: Revised:

ENVIRON

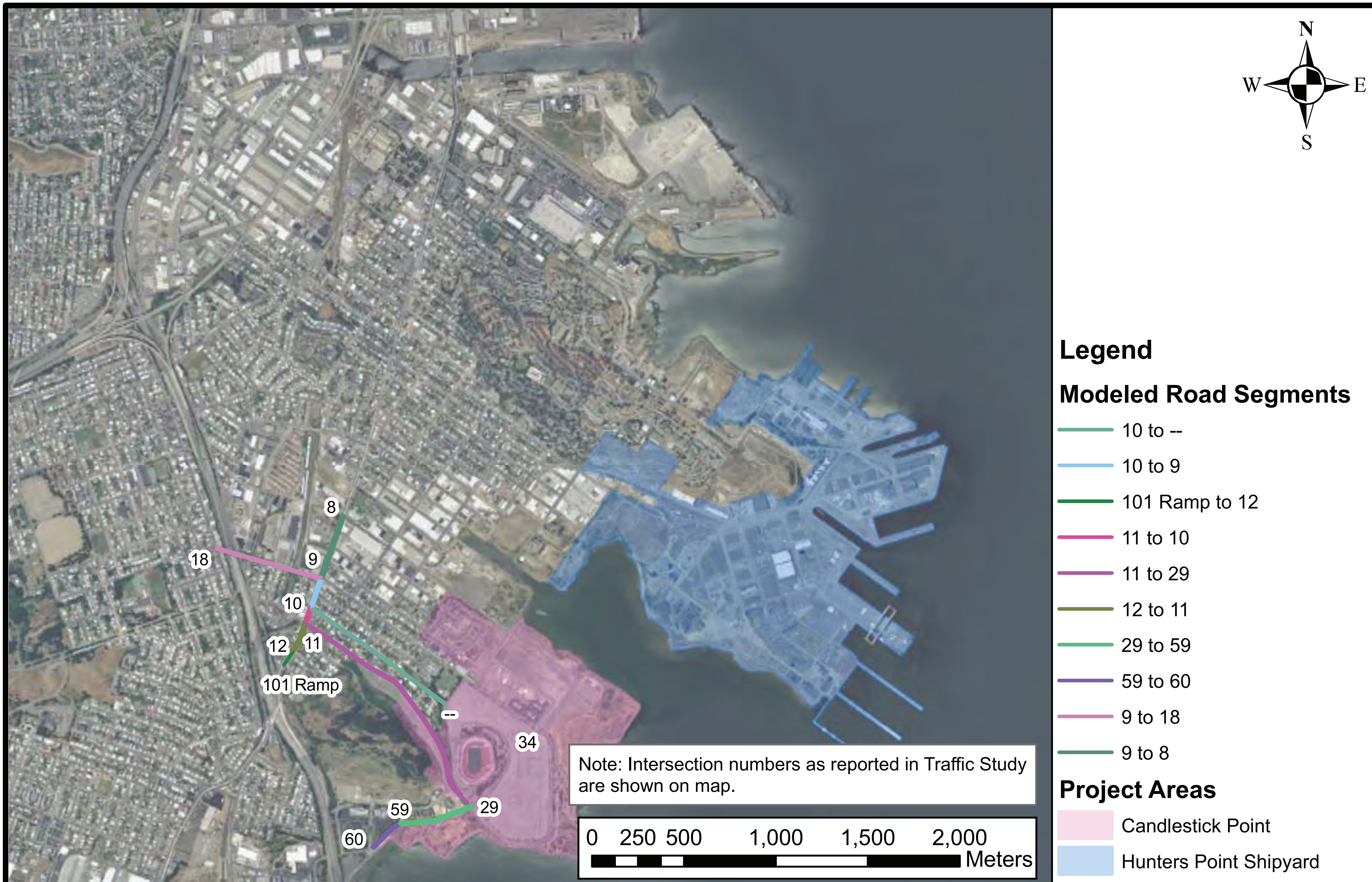
6001 Shellmound St., Suite 700, Emeryville, CA 94608

Example Paired Receptors for Calculating Cancer Risks
Candlestick Point - Hunters Point Shipyard Phase II
Development Plan
San Francisco, California

Figure

2

Drafter: MH | Date: 10/16/2009 | Contract Number: 0320816A | Approved: | Revised:



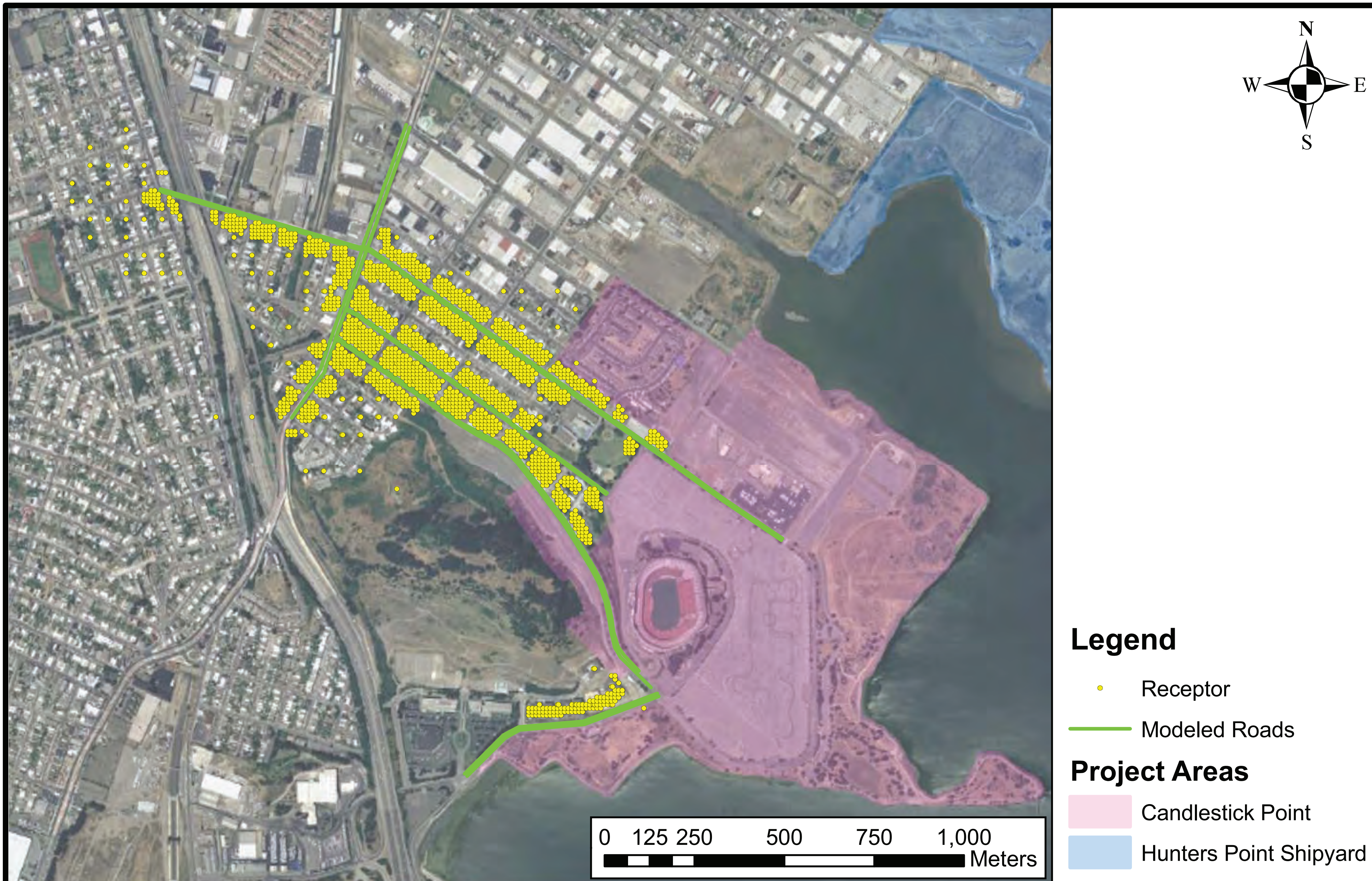
ENVIRON

6001 Shellmound St., Suite 700, Emeryville, CA 94608

Location of Travel Lanes Modeled
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Figure **3**

Drafter: KD | Date:10/27/2009 | Contract Number: 03-20816A | Approved: | Revised:



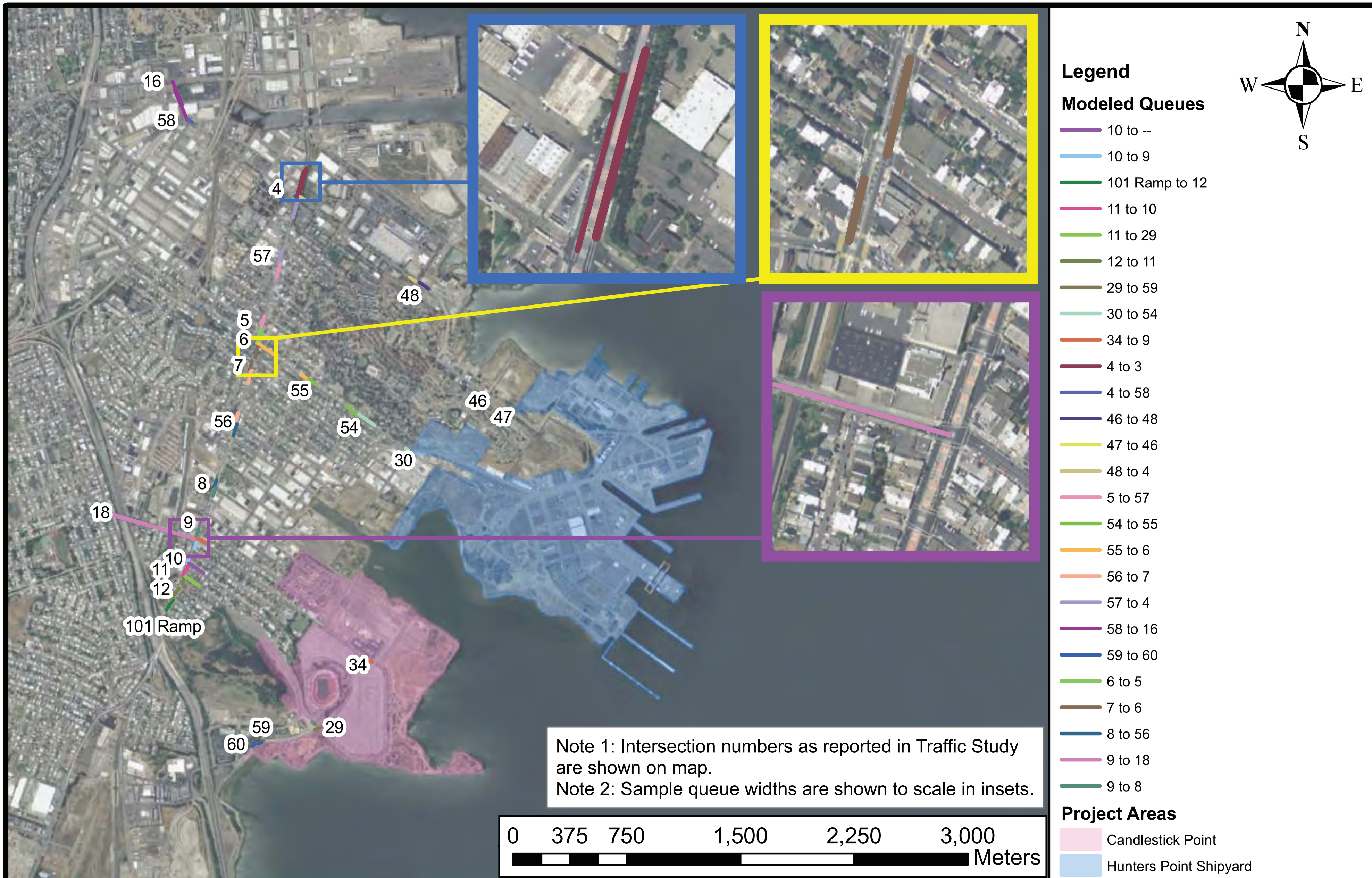
ENVIRON

6001 Shellmound St., Suite 700, Emeryville, CA 94608

Location of Modeled Residential Receptors
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Figure **4**

Drafter: KD Date:10/27/2009 Contract Number: 03-20816A Approved: Revised:



ENVIRON

6001 Shellmound St., Suite 700, Emeryville, CA 94608

Location of Modeled Queues
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Figure **5**

Drafter: KD	Date:10/28/2009	Contract Number: 03-20816A	Approved:	Revised:

ENVIRON

6001 Shellmound St., Suite 700, Emeryville, CA 94608

Excess Lifetime Cancer Risks - Offsite Residential Receptors
Candlestick Point - Hunters Point Shipyard Phase II
Development Plan
San Francisco, California

Figure

6

Drafter: MH   Date: 10/16/2009 Contract Number: 0320816A   Approved: Revised:

ENVIRON

6001 Shellmound St., Suite 700, Emeryville, CA 94608

Excess Lifetime Cancer Risks - Offsite Worker Receptors
Candlestick Point - Hunters Point Shipyard Phase II
Development Plan
San Francisco, California

Figure

7

Drafter: MH | Date: 10/16/2009 | Contract Number: 0320816A | Approved: | Revised:

ENVIRON

6001 Shellmound St., Suite 700, Emeryville, CA 94608

Estimated Concentrations of PM2.5
Candlestick Point - Hunters Point Shipyard Phase II Development Plan
San Francisco, California

Drafter: KD Date:10/27/2009 Contract Number: 03-20816A Approved: Revised:

Figure
8

Appendix I1 Wilson Ihrig San Francisco 49ers Stadium Operational Noise Study, October 15, 2009

WILSON, IHRIG & ASSOCIATES, INC.
ACOUSTICAL AND VIBRATION CONSULTANTS
OAKLAND, CA NEW YORK, NY

5776 BROADWAY
OAKLAND, CA
U.S.A. 94618-1531
Tel: (510) 658-6719
Fax: (510) 652-4441
E-mail: info@wiai.com
Web: www.wiai.com

BAYVIEW WATERFRONT DEIR

SAN FRANCISCO 49ers STADIUM

OPERATIONAL NOISE STUDY

15 October 2009

Prepared By:

Wilson, Ihrig & Associates
5776 Broadway
Oakland, CA 94618

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 Executive Summary

Wilson, Ihrig & Associates (WIA) has conducted a noise study and mitigation evaluation for the Bayview Waterfront EIR Project. The study is limited to operational noise impacts from the San Francisco 49ers stadium proposed to be constructed in the Hunter's Point neighborhood of San Francisco to replace the Candlestick Park stadium now used for 49ers NFL football games. The impact evaluation presented herein includes assessment of noise from two types of events, which are unrelated: football games and large venue popular music concerts. As a result of this study, it was determined that there is a potential for significant noise impacts from both types of events. Potential noise mitigation has been evaluated to determine if these impacts could be sufficiently reduced to a level that is less than significant.

2.0 Introduction

This report presents the results and findings of a noise study conducted by WIA for a proposed San Francisco 49ers stadium (Stadium) option of the Bayview Waterfront Development Project (Project). This option of the Project proposes to construct a new stadium in the Hunter's Point neighborhood for the San Francisco 49ers National Football League (NFL) team. The current location for the 49ers football games is Candlestick Park located approximately 1.25 miles from the proposed site for the new stadium. On certain occasions, the Stadium may also be used for music concerts.

In the study reported herein, WIA evaluated potential operational noise impacts associated with the proposed siting of the Stadium which would be used for football games and could be used for occasional music concerts. The results of the study indicated potentially significant noise impacts. Investigated were various possible noise mitigation options to lessen impacts to the surrounding community for both types of events.

This noise study is being performed to support the Draft Environmental Impact Report (DEIR) for the Project prepared by PBS&J for the City of San Francisco, the Lead Agency. The noise study addresses operational noise impacts associated with 49ers National Football League (NFL) football games of which there are approximately eight (8) every year and the noise impacts associated with music concerts held within the Stadium. The study does not evaluate noise impacts that may occur for other types of events that might be conducted in the proposed Stadium.

The purpose of this noise study is to identify potential noise impacts and noise mitigation for the Stadium.

The steps taken to determine impacts and mitigation were:

- Identify potentially significant sources of environmental noise for the Stadium associated with football games and music concerts
- Evaluate the need for mitigation based on individual source noise emission, multiple source emission, and proximity to adjacent sensitive land uses (e.g., residences)
- Determine if there are appropriate noise mitigation measures and strategies that would lessen impacts

The potentially significant sources of Stadium noise were determined by reviewing the Project description, Stadium configuration plans and the proximity of the site to sensitive receptors, discussions with PBS&J concerning the operational plans for the Stadium, and WIA experience with other similar sports facilities.

There are two sources of noise during football games in the Stadium that could produce audible noise in the surrounding community:

- The spectators at the game
- Amplified speech and music broadcast over the Stadium's sound system.

Both of these sources will be intermittent. Consequently noise intensity and its duration are important with regard to determining impact.

There are two sources of noise during music concerts held in the Stadium that could produce audible noise in the surrounding community:

- The concert audience
- Amplified music broadcast over a concert sound system.

Both of these sources will be intermittent. Consequently noise intensity and its duration are important with regard to determining impact.

WIA reviewed the proposed Stadium site layout, the surrounding topography, and the location of noise sensitive receptors (residences) in the area. Based on its previous experience with large sports facilities and sound system equipment with the guidance of the acoustical consulting firm and sound system designer Rosen, Goldberg, Der and Lewitz (RGDL), WIA developed input parameters to be used in the community noise prediction computer model SoundPLAN®.

Using field measured noise data from its in-house database and other sources, WIA developed reference noise levels for the audience. The Stadium's "house" sound system would be used during football games whereas a band or other musical performer would normally provide their own sound system for a concert. The house sound system will be a fixed public address (PA) system. The concert sound system is a portable system typically set up at field level and in the vicinity of the performer's stage.

For the house sound system, WIA used the Stadium sound system specifications to develop a maximum sound power level output for this source. For the concert sound system, WIA used a typical configuration of loudspeakers for this type of event. The typical details for these two types of sound systems (e.g., type, number of speakers, size, sound radiation patterns) were provided by Joel Lewitz of RGDL. The sound emission characteristics of the sound systems were used in the SoundPLAN® models to project noise levels in the community and evaluate whether noise impacts would potentially occur. The SoundPLAN® noise projection results were used to determine the possible need for mitigation and the preliminary details of such mitigation.

Contained herein are the findings of the study based on WIA's noise analysis and mitigation evaluation. Possible mitigation has been evaluated and preliminary design details were analyzed to determine specific noise reduction benefits. The mitigation presented here will be reviewed by the City of San Francisco for reasonableness and feasibility of implementation. Depending on the result of these reviews, certain mitigation or aspects thereof may be developed further, modified by additional analysis, or even eliminated from further consideration based on conclusions regarding feasibility, and/or cost effectiveness.

3.0 Description of Facility

The site for the proposed 49ers Stadium is shown in Figure 3-1 as is the proximity of nearby land use that might be affected by Project noise. This site is adjacent to San Francisco Bay (on the east) and bounded directly to the north by land proposed for development of R&D facilities. Beyond the R&D development is land proposed for residences. For the purpose of modeling noise source locations in this study, the site and Stadium details contained in project drawings (Ref. 1) were used.

3.1 General Details

The proposed Stadium option would provide a new 69,000-seat NFL stadium for the San Francisco 49ers. The Stadium footprint is on 17.4 acres. The Stadium proper would include seating, ramps and stairs, office and administrative facilities, food service and retail areas, and access facilities for stadium visitors, players and staff. The top row seating would be at an elevation of approximately 156 feet above the playing field. The parking area surrounding the Stadium would serve stadium-related events.

3.2 Operational Details

The Stadium would primarily be used for football games. It also may be used occasionally for popular music concerts. The following is discussion of the general Stadium details and the sound system details relevant to the SoundPLAN® noise prediction models.

3.2.1 Football Games

It is planned that the 49ers Stadium will be used for the team's home football games on weekends and Monday nights, and also during the NFL playoffs should the team advance to that stage. There are expected to be approximately eight 49ers home games at the Stadium during the normal football season.

The following narrative on the Stadium sound system is excerpted from the Project Description.

***Overview of Systems** – All of the electronic systems considered in this outline are related to game operations or fan entertainment. The specific football operations issues listed are based in information from 49'ers game and stadium operations staff. The systems are best considered as parts of an overall whole, rather than independently operating entities.*

<u>Audio Systems – Main Seating Bowl</u>

***Bowl Loudspeaker Options** – The main seating bowl system is requested to be a point source, or "single cluster" loudspeaker type. Due to the asymmetrical seating bowl geometry and the lack of structure in the end zone center lines, a side line cluster system, such as that installed at Soldier Field may be the most appropriate solution. The seating bowl loudspeaker system is to achieve:*

- *Frequency response of 60 to 8,500 Hz minimum*
- *Uniformity of loudness - +/- 3 dBA; +/- 3 dB at 4000 Hz*
- *Ratio of first/direct arrival sound to reverberant or indirect sound - +6 dB.*
- *Maximum continuous loudness of 105 dBA*

3.2.2 Music Concerts

It is proposed that the Stadium may be used occasionally as a venue for popular music concerts performed in front of a large audience. In such a venue (e.g., football stadium), the musicians perform on a large, elevated stage situated on the stadium field. The sound system used by the performers would be one that is specifically designed for touring bands. "Tour" type sound systems generally have the following basic elements.

The sound system would consist of four line arrays at the front of house (FOH) composed of twelve full-size elements such as JBL VerTec VT4889 above four full-size arrayable subwoofers integrated into each full-range speaker array such as JBL VerTec VT4880. Two towers with delayed signals are added at the 50-yard line to fulfill the back of the Stadium audio needs. Each tower has a pair of eight (8) box arrays, an example of which are JBL VT 4889 full-size line array elements. The polar or directivity pattern of the source is included based either on the manufacturer's published data or the pattern for a typical loudspeakers array used in a concert of this magnitude. To calibrate the sound system source strength inside the stadium, the level was set at 105 dBA at the "mixing position," which is the typical level observed during a concert.

The typical stage configuration during concerts would likely have the stage in the end zone for large events or at the 50-yard line for smaller shows. The noise impacts associated with large events were analyzed since this represents a worst-case condition. Although the stage could be located at either end of the field (north or south), for the purpose of this study it was assumed the stage is in the northern end field pointing south. In this way most of the sound would be projected towards the Bay and away from residences.

Noise levels from a music concert will fluctuate greatly depending on the type of music being performed (e.g., rock, pop, hip-hop, etc.) and on the performers' preferred style of loudness. The latter affects the sound power settings used for the event. The loudness is also related to the size of the venue and to some degree the size of the audience. To address the variable range of music genre possible, recorded music samples were used to obtain sound spectra for rock and hip-hop music as two different styles of music that might use the Stadium as a concert venue. Other styles of music would generally be less percussive and therefore presumably have less of an impact on the surrounding community.

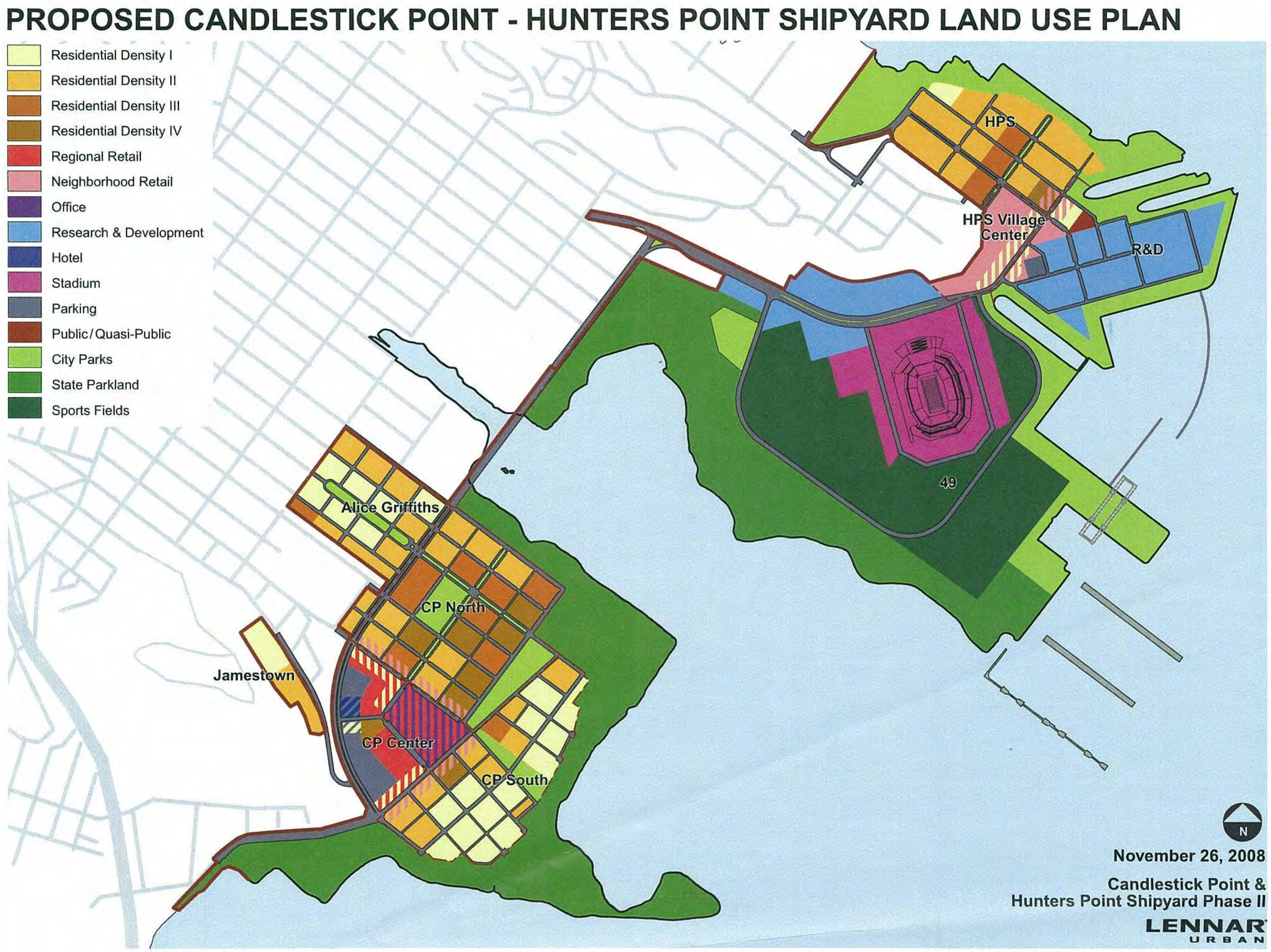


Figure 3-1 Site Plan for Stadium and Proposed Local Surrounding Land Use

4.0 Noise Sensitive Receptors and Noise Criteria

Figure 3-1 indicates the land use designations for areas in the near vicinity of the proposed Stadium building site. Land use in the immediate area of the proposed Stadium site is proposed as part of the Project to be a mixture of R&D, commercial and residential. The residential land, as shown in **Error! Reference source not found.** has the highest degree of sensitivity to noise.

Unlike most community noise, which is typically dominated by transportation sources and occurs throughout the day, the noise during football games associated with sources inside the Stadium although possibly much louder in the immediate vicinity of the Stadium than other noise sources, only affect the environment occasionally.

The primary sources within the Stadium are cheering fans and the Stadium's sound system. In terms of typical community noise sources, these sources of noise are infrequent (i.e., occurring only on days that football games are held). The noise that occurs during a game is also limited in its duration. A typical game lasts for about three hours, although the time the ball is in play is only one hour.

Therefore it is necessary to select appropriate noise criteria, which address the unique nature of the Stadium noise. To arrive at appropriate noise impact criteria we consider the Initial Study Checklist and the associated local standards of the community.

4.1 Initial Study Checklist

There are two or three topics in the Initial Study Checklist that could cause a potentially significant noise impact to occur when the Stadium is used either for an NFL football game or a popular music concert.

- Exposure of persons to or generation of noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies.
- Substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project.
- Project may be located within an airport land use plan area (SFIA). Project may expose people residing in immediate area to excessive noise levels.

4.2 Local Noise Criteria

The criteria cited in Environmental Protection Element of the City and County of San Francisco General Plan and the criteria cited in San Francisco Police Code are reviewed to determine which could be applicable to a noise impact evaluation of the Stadium.

4.2.1 Local General Plan

The Environmental Protection Element of the General Plan contains a Transportation Noise (TN) section. Objective 10 of the TN section is to *Minimize The Impact Of Noise On Affected Areas.* Although typically used to evaluate proposed new residential developments, the "Land Use

Compatibility Chart for Community Noise" contained under Objective 11 (***Promote Land Uses That Are Compatible With Various Transportation Noise Levels***) of the TN section, it is proposed that the guidelines the Chart provides can be used to evaluate projected increases in noise and their impact on existing residence based on current ambient levels of community noise.

- For residential developments, an L_{dn} of 60 or less is considered satisfactory with no special noise insulation requirements.
- Where the L_{dn} is between 60 and 70, new construction would be undertaken only after a detailed analysis.
- Where the L_{dn} is over 65, new construction is generally discouraged.

From these general guidelines, we are inclined to conclude that where existing ambient levels in the residential community exceed 65 L_{dn}, increases in community noise, even temporary or periodic increases, could be potentially significant.

4.2.2 San Francisco Noise Ordinance

Article 29 of the San Francisco Police Code regulates the creation of noise in the community by defining noise, how it is measured, and establishing when a noise level is in violation of the Police Code. Some of Article 29 pertains to transportation and construction noise sources. There are three sections of Article 29 that appear to be relevant to the proposed Stadium project. Note that the language of the Code has been paraphrased below and what appears to be relevant to the Project was included.

- Sec. 2901. Definitions

  To address general community noise sources, "ambient" means the lowest sound level repeating itself during a minimum ten-minute period as measured with a type 1, precision sound level meter, using slow response and A-weighting. For the purpose of this chapter, in no case shall the ambient be considered to be less than Forty-five dBA for exterior noise.

  To address music from entertainment venues, "low frequency ambient" means the lowest sound level repeating itself during a ten-minute period as measured with a sound level meter, using slow response and C-weighting. For the purpose of this chapter, in no case shall the local ambient be considered to be less than Fifty-five dBC for exterior noise.

- Sec. 2909 Noise Limits

  (b) Commercial and Industrial Noise Limits

  No person shall produce or allow to be produced by any machine, or device, music or entertainment or a combination of same, on commercial or industrial property a noise level more than eight dBA above the local ambient at any point outside the property plane. With respect to noise generated by a licensed Place of Entertainment, in addition to the dBA criteria a secondary low frequency dBC criterion shall apply to the definition above. No noise or music associated with a licensed Place of Entertainment shall exceed the low frequency ambient noise level defined by Section 2901 (f) by more than eight dBC.

- Sec. 2910 Variances

  The Directors of Public Health, Public Works, Building Inspection, or the Entertainment Commission, or the Chief of Police may grant variances to noise regulations, over which they have jurisdiction pursuant to Section 2916. All administrative decisions granting or denying variances are appealable to the San Francisco Board of Appeals.

Although not explicitly stated, it would appear that the ambient noise levels defined by Section 2901 would be consistent with what is called the L_{90} (level exceeded 90% of the time) or the background noise level, since the operative words are the “lowest repeating sound level.” If this is in fact the intent of Article 29 and it appears that it is then the noise limits are L_{90} + 8 dBA for general community noise and L_{90} + 8 dBC for low frequency noise such as might be produced by amplified music.

The Article 29 noise limits are quite restrictive, in particular for events that are infrequent, generate transient noises and last for a limited duration. Article 29 noise limits have more relevance to noises that are permanent and continuous. The noise produced during a football game is very transient in nature. Cumulatively the noises would last for less than 1 hour and occur eight times a year. The very transient nature of football game noises are such that each noise event typically lasts for 1 minute or less except of course during the halftime show when the a music program is performed. The halftime show may last for approximately 20 minutes.

In the case of a music concert, the noise producing portion may cumulatively last approximately 2 to 3 hours and occur once or twice a year. However, unlike football game noise (crowd cheering and PA announcements), music concert noises would typically last for periods of 10 minutes each followed by short pauses. This would typically repeat for an hour until the performers took a break.

Section 2910 allows for variances from the noise regulations. It would appear that in the case of the Stadium the Entertainment Commission would have jurisdiction. Section 2910 seems to indicate that under certain circumstances discretion is applied to enforce the noise limits.

Although they are exempted, common community noise sources such as automobiles, buses and trucks routinely generate levels that exceed the Article 29 noise limits. There are also yearly events that occur in San Francisco, which produce noise levels in excess of Article 29 noise limits, examples of which are the Blue Angels flying showing the occurs during Fleet Week and there are fireworks on the 4th of July.

Under the circumstances and with all due consideration, applying the Article 29 noise limits as thresholds for significant impacts would appear to be inconsistent with the intent of CEQA. However, the noise projections for a football game and for a music concert are compared to Article 29 noise limits and discussed.

4.2.3 L_{max} Criterion

It is common to apply a limit to the maximum noise level (L_{max}) when noise is transient or even continuous but of short duration. The maximum noise level that would interfere with normal speech indoors is commonly used as a criterion. Noise levels that exceed 60 dBA would generally be considered to cause interference with normal speech or interference with listing to television, whereas noise levels that are less than 55 dBA would generally not interfere. The amount of sound reduction typically obtained from residential structures with windows closed ranges from 15 to 20 dBA. Consequently, an exterior noise level that did not exceed 75 dBA would not be expected to substantially interfere with normal speech indoors. Exterior levels that exceeded 75 dBA might be expected to interfere with speech indoors or comfortably listening to television. We propose that a reasonable outdoor L_{max} criterion is 75 dBA.

4.2.4 Audibility of Game Sounds at Greater Distances from the Stadium

It may be possible for individuals in the noise study area at times and under the right weather conditions to hear sounds from NFL football games and music concerts even though the noise levels associated with these sounds do not necessarily exceed local standards such as Article 29. Sometimes this may occur at distances removed from the Stadium (e.g., greater than 1 mile) and in particular in neighborhoods where there is low background ambient noise.

Audibility of Stadium sounds might be cause for concern among certain individuals in the community bothered by such sounds. However, in the case of the proposed Stadium, this is not expected to cause a significant noise impact, because Candlestick Park currently exists and is used for the 49ers games. Presumably under the right weather conditions current 49ers game sounds from Candlestick Park can be heard over a wide area. Consequently this phenomenon is already part of the existing ambient condition.

4.3 Proposed Significance Thresholds for Noise Impacts

WIA proposes the following steps in determining whether a significant noise impact is projected to occur:

a) Evaluate the change in L_{dn} on a typical football day due to operational noise. Minor changes of less than 1 dBA would be considered less than significant regardless of the existing ambient. Greater changes of more than 1 dBA could be considered potentially significant if the existing ambient L_{dn} exceeds 65 or the change in the L_{dn} would exceed 65.

b) Evaluate whether projected maximum operational noise levels (L_{max}) exceed 75 dBA.

4.4 Noise Sensitive Receptors Potentially Affected by the Project

The proposed Stadium site is on the land that was the former Hunters Point Shipyard (HPS). The land is now vacant except for a couple of large, unoccupied buildings. There are currently four residential neighborhoods to the north and west of the HPS site. Most of the residences in these neighborhoods are single-family homes, but there are apartments as well.

WIA conducted long-term ambient noise measurements at six locations in these neighborhoods. The locations of these measurements are indicated as N1 through N6 on the aerial photo in **Error! Reference source not found.**. As discussed further below, there are additional noise sensitive receptor locations which WIA has modeled as part of this analysis in order to address the range of community environments affected. All ten noise sensitive receptors studied are shown on the aerial photo in Figure 4-2 where R1 through R6 represent the same locations as N1 through N6. The long-term ambient noise measurements were conducted first by recording A-weighted community noise levels in January 2009 and then C-weighted community noise levels in July 2009.

The topography of the area surrounding the Stadium site is somewhat complex. Directly to the north there is a bluff that forms the end of a ridge extending to the northwest almost to Third Street. The bluff is currently being developed as residential land by Lennar (Phase I). The ridge shields the residential portion of the Hunters Point neighborhood from the Stadium site. To the southwest is Candlestick Point and above that to the west is the Bayview Heights neighborhood which elevated above the surrounding terrain. To the northwest of the Stadium site the land is generally flat and rising to the Silver Terrace neighborhood.

The noise study area, for the Stadium option of the Project, extended out to approximately 1½ miles away from the site. The reason for having such a large study area was to include receivers that while not normally affected by Project noise associated with the Stadium, under certain metrological conditions might experience higher levels of noise than usual. Such conditions occur only infrequently.

4.4.1 Hunters Point Neighborhood

There are existing residences relatively near the Stadium site and there also new residential areas proposed for the Project. Lennar Corporation is also currently developing land under the Hunters Point Shipyard Phase I (Phase I) redevelopment plan, which will include residences just to the north of the Project site. The closest existing residential land to the proposed Stadium site is located just north of Donahue Street.

Receptor location N3 (located near the corner of Donahue Street and Kirkwood Avenue) is generally characteristic of the quieter portions of this neighborhood. However this may change depending on traffic patterns once the Phase I Lennar development is completed. The ambient noise in this part of the Hunters Point neighborhood was measured to be L_{dn} 58 to 62 (Saturday through Monday). The noise levels on the Saturday (1/10/09) when measurements were obtained may have been elevated somewhat by construction grading work occurring on the Lennar property directly across Donahue Street. The normal ambient noise is due to a combination of motor vehicles on local and distant streets.

Receptor location N4 (located on Kirkwood Avenue near its intersection with Ingalls Street) has slightly more traffic than does N3. The ambient noise in this part of the Hunters Point neighborhood was measured to be L_{dn} 62 to 65 (Saturday through Monday) with higher levels on Saturday than on the other two days. The ambient noise is due to a combination of noise from motor vehicles on local traffic streets, but primarily on Hunters Point Boulevard.

Receptor location N5 (located near the intersection of Hunters Point Boulevard and Hawes Street) has more traffic than does N3. The ambient noise in this part of the Hunters Point neighborhood was measured to be L_{dn} 62 to 65 (Saturday through Monday) with higher levels on Saturday than on the other two days. The ambient noise is due to a combination of noise from motor vehicles on local traffic streets, but primarily on Hunters Point Boulevard.

In addition to these receptor locations, two other locations were included in the study. Receptor location R7 (at what used to be the intersection of Jerrold Avenue and Coleman Street) is in the area currently being developed by Lennar as Phase I. This is at the closest residential land in this area. Receptor location R8 (on what used to be Robinson Street near Horne Avenue) is representative of the new residential land proposed as part of the Project. No ambient measurements were obtained for these receptors, since they are yet to be developed. However, the ambient conditions will be somewhat like those at N3 and N4 with an L_{dn} probably between 58 and 63 depending on local traffic conditions.

4.4.2 Bayview Neighborhood

This neighborhood is bounded by US101 on the west, Cesar Chavez Street on the north, Gilman Avenue on the south and the Hunters Point neighborhood on the east. It is primarily a residential neighborhood, but also with commercial land in particular along Third Street. Third Street runs through the center of this neighborhood and is a major noise source in addition to US101. The closest homes to the Stadium site in this neighborhood are approximately 3,965 feet away.

Receptor Location N1 (located on Carroll Avenue Walker Drive) is characteristic of the generally noisier portion of this neighborhood, since it is along a truck route. The ambient noise in this part of the Bayview neighborhood was measured to be L_{dn} 63 to 67 (Saturday through Monday) with higher levels on Saturday and Monday than on Sunday. The ambient noise is primarily to traffic on Carroll Avenue.

Receptor location N2 (located on Revere Avenue near Ingalls Street) is characteristic of the somewhat quieter portions of this neighborhood. The ambient noise in this part of the Bayview neighborhood was measured to be L_{dn} 63 to 65 (Saturday through Monday) with higher levels on Monday than on the other two days. The ambient noise is due to a combination of noise from motor vehicles on local traffic streets, but primarily on Ingalls Street.

Additional receiver locations were used to project operational noise levels for the Stadium. They include R9 (located on Palou Avenue near Lane Street) and R10 (located on Bayview Circle near Newhall Street). No ambient measurements were obtained for these receptors. However, it is reasonable to assume that the ambient conditions at R9 will be somewhat like those at N2, with an L_{dn} probably between 63 and 65 depending on local traffic conditions. The ambient conditions at N10 will be somewhat like those at N4, with an L_{dn} probably between 58 and 62 depending on local traffic conditions.

4.4.3 Bayview Heights Neighborhood

This neighborhood is bounded by Gilman Avenue, the San Francisco Bay and US101. It is primarily a residential neighborhood, but also includes Candlestick Park. The closest homes to the Stadium site in this neighborhood are approximately 6,400 feet away. Receptor Location N6 (located at the corner of Jamestown Avenue and Hawes Street) is characteristic of the generally quieter portion of this neighborhood, since it is shielded from US101 and is removed somewhat from Third Street.

The ambient noise in this part of the Bayview Heights neighborhood was measured to be L_{dn} 59 to 60 (Saturday through Monday). The ambient noise is due to a combination of noise from motor vehicles on Gilman Street and some local traffic on Jamestown Avenue. However, on football game days, Jamestown is a major access route to Candlestick Park.

4.4.4 Silver Terrace Neighborhood

Somewhat beyond the study area is the neighborhood of Silver Terrace, which is bounded on the west by US101 and Industrial Street on the north. Silver Avenue bisects the neighborhood. This neighborhood is approximately 2 miles from the Stadium site and therefore was considered to be sufficiently far enough away as to not be significantly impacted.

4.4.5 Nearby Non-residential Land Uses

There are R&D facilities proposed directly adjacent to the Stadium site. These uses would normally be occupied during the daytime work hours on weekdays, but not on the weekend or at night when football games would be held. Consequently, these future facilities were not considered to be noise sensitive for the purpose of this study. There are also existing light industry and warehouse land use to the west and northwest of the Stadium site. This type of receptor is not generally considered to be noise sensitive.

4.5 Ambient Noise Survey

WIA first conducted A-weighted, ambient noise measurements over the course of three days in January 2009. Long-term ambient noise data were obtained between Saturday and Monday, January 10 to 12. **Error! Reference source not found.** indicates the location of the long-term ambient noise measurement locations. WIA also conducted another set of the ambient noise measurements in July 2009 by logging C-weighted levels at the same locations used in January 2009. Both sets of noise data were obtained using Larson Davis digital, sound level meter, logging instruments at six locations. The loggers were mounted to utility poles approximately 12 ft above the ground.

4.5.1 A-weighted Ambient Noise Levels

Hourly data were recorded for the energy average (L_{eq}) and statistical noise levels (L_n, where n=90, 50, 10, and 1) also known as the level exceeded n% of the time. The full hourly data for each of the six measurement locations for the three days are contained in Appendix A. Table 4-1 contains a summary of the L_{dn} measurements by location for each full day of the survey.

Table 4-1 Existing Day-Night Noise Levels (Ldn)

Location ID	Description	Saturday 10 Jan 2009	Sunday 11 Jan 2009	Monday 12 Jan 2009
N1	Carroll Avenue north of Walker Drive	67	63	67
N2	Revere Avenue between Ingalls Street and Jennings Street	64	63	65
N3	Donahue Street between Kirkwood Avenue and Jerrold Avenue	62	58	59
N4	Kiska Road between Reardon Road and Ingalls Street	65	65	66
N5	Hawes Street near Hunters Point Boulevard	65	62	64
N6	Jamestown Avenue at Hawes Street	60	59	60

Table 4-2 contains a summary of the range of A-weighted L_{90} levels), at times when a football game might occur: afternoon (3pm to 6pm) on the weekend and evening on Monday (6pm to 9pm).

Table 4-2 Existing A-weighted Background Noise Levels (L_{90})

Location ID	Description	Saturday[1] 10 Jan 2009	Sunday[1] 11 Jan 2009	Monday[2] 12 Jan 2009
N1	Carroll Avenue north of Walker Drive	45 to 46	45 to 49	43 to 47
N2	Revere Avenue between Ingalls Street and Jennings Street	48 to 49	47 to 50	45 to 49
N3	Donahue Street between Kirkwood Avenue and Jerrold Avenue	42 to 45	43 to 45	41 to 43
N4	Kiska Road between Reardon Road and Ingalls Street	45 to 48	42 to 43	44 to 45
N5	Hawes Street near Hunters Point Boulevard	47 to 50	44 to 46	43 to 48
N6	Jamestown Avenue at Hawes Street	47 to 50	49 to 50	46 to 48

1 Afternoon 3pm to 6pm
2 Evening 6pm to 9pm

4.5.2 C-Weighted Ambient Noise Levels

Hourly data were recorded for the energy average (L_{eq}) and statistical noise levels (L_n, where n=90, 50, 10, and 1) also known as the level exceeded n% of the time. Table 4-3 contains a summary of the C-weighted L_{90} levels at night during the time a concert might occur (7pm to midnight).

Table 4-3 Existing C-weighted Background Noise Levels (L_{90}) at Night

Location ID	Description	Range	Median
N1	Carroll Avenue north of Walker Drive	58 to 63	60
N2	Revere Avenue between Ingalls Street and Jennings Street	55 to 62	58
N3	Donahue Street between Kirkwood Avenue and Jerrold Avenue	53 to 60	56
N4	Kiska Road between Reardon Road and Ingalls Street	55 to 64	59
N5	Hawes Street near Hunters Point Boulevard	56 to 64	60
N6	Jamestown Avenue at Hawes Street	--	--

1 Location of Long-term Ambient Noise Measurement

Location of All Noise Study Receptors

4.6 General Conclusion on Existing Ambient Noise

The existing ambient noise measurement data indicate variable conditions within the noise study area, as would be expected, with some areas which are quieter than others. From Table 4-1 it can be seen that the measured L_{dn} ranges from 58 to 67, with the highest level measured at N1, which is due to a higher level of truck traffic there than elsewhere. Noise levels on the weekend, as would be expected were lower (from 1 to 4 dBA) on Sunday than on Saturday and Monday's noise levels were generally similar to Saturday's.

The ambient noise conditions in the study area can be characterized as being generally noisy with L_{dn} values that, except in two locations (N3 and N6) approach or are greater then than 65. An L_{dn} of 65 can be considered the threshold of unacceptable for new residential development. It was observed that N3 and N6 had less traffic than the other locations measured, which would explain why these locations are quieter than the others.

Background A-weighted noise levels at the six measurement locations indicate a range of 42 to 50 dBA taking into account all locations. At quieter locations (N3 and N4), a median L_{90} is about 44 dBA. At the rest of the locations (N1, N2, N5 and N6) a median L_{90} is about 48 dBA.

Background C-weighted noise levels at night range from 53 to 63 taking into account all six locations. For quieter locations (e.g., N3) the median L90 is about 56 dBC. For the other locations, the median L_{90} is about 59.

5.0 Project Noise Sources and Prediction Model for Football Games

During football games, the noise sources that will likely have the most potential to affect the stadium surroundings will be: a) noise from the crowd and b) amplified speech, music and/or sound effects from the sound system. The intensity of the crowd noise is not controllable nor would that be desirable and will vary depending on the number of people and their reactions to what is happening on the field. Further there are no feasible physical changes other than proximity to receptors that can be made to lessen crowd noise with an open stadium design. In general, the Stadium sound system noise sources is the easier of the two noise sources to control. This can be accomplished through the selection of the loudspeakers and their orientation.

5.1 Crowd Noise

WIA modeled the noise from the audience in the Stadium as an area source with uniform sound power distribution. The model assumes the exposed seating areas contain a total of approximately 65,000 seats (i.e., all seats except the enclosed suites).[1] Figure 5-1 illustrates the extent of the crowd area based on the outline of the seating sections angled from the top seating row down to the field level.

The noise spectrum (i.e., frequency content) is based on 1/3 octave band data that WIA obtained from measurements for another stadium project. WIA has adjusted the 1/3 octave band data to represent the total sound power for a full capacity crowd at the 49ers Stadium. The underlying metric for the sound power derivation is the L_1 (levels exceeded only 1% of the original measurement period). Refer to Figure 5-2 which shows the reference spectrum. While use of the L_1 is more conservative than other metrics such as an L_{eq} or a set duration, WIA believes this is more appropriate as a starting point for this study. The crowd noise projections are thus representative of anticipated relative maximum noise levels. However as the duration of event noise levels is also important with respect to community noise standards and proposed impact criteria, WIA also made projections that account for anticipated duration of event noise levels for a typical game as described in Section 6.

[1] Based on the number of seats listed in "Areas and Seat Counts etc 11-20-2006.xls" for the Lower, Mid, and Upper Bowl general seating sections (57,834 seats) adjusted to included club seats in the Red Zone, Main, and Mezzanine sections for a total of approximately 65,000 seats. Assumes approximately 5.38 ft^2 (0.5 m^2) per seat.

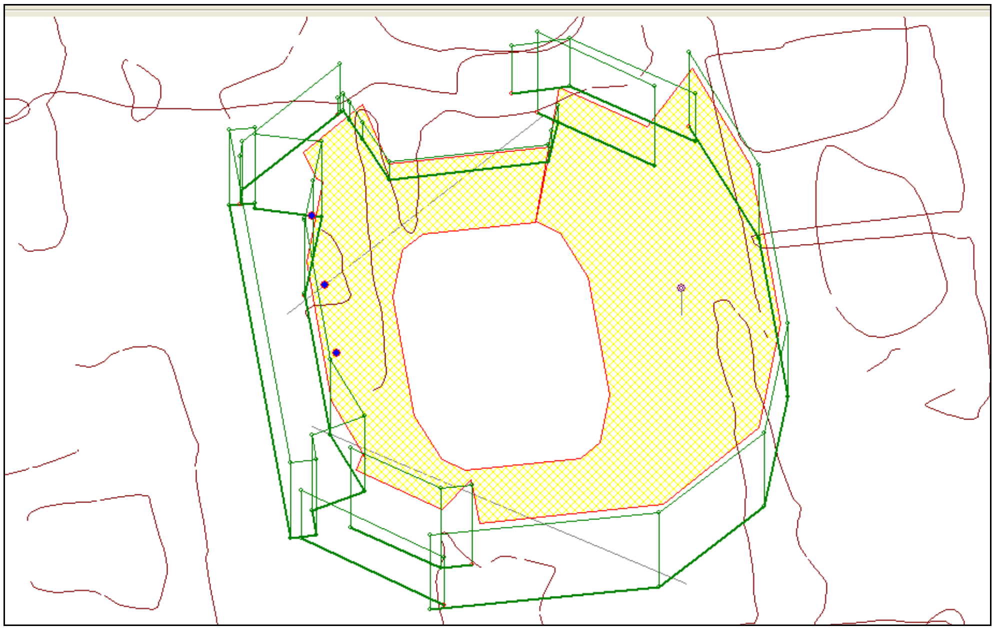


Figure 5-1 Computer Model Representation of Crowd Noise Area Source

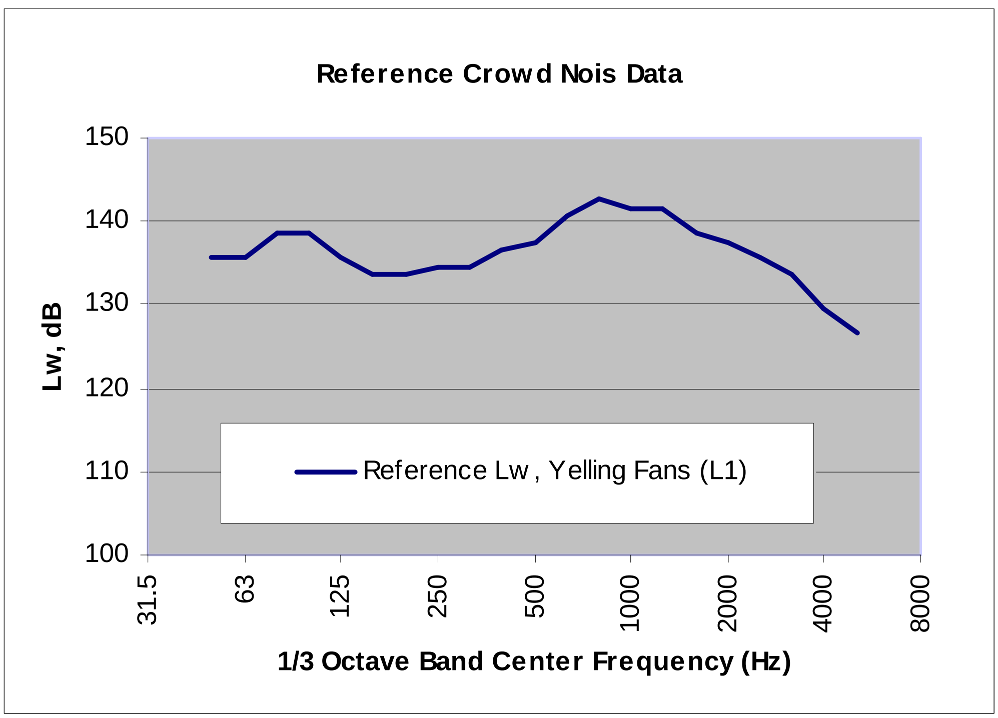


Figure 5-2 49ers Crowd Noise Reference Sound Power Levels

5.2 Stadium Sound System Noise

The Stadium will have a sound system which WIA anticipates would be similar to that which is currently installed at Soldier Field in Chicago. Consequently a similar sound system design concept served as the basis for developing the Stadium model. Figure 5-3 shows part of the sound system at Soldier Field.

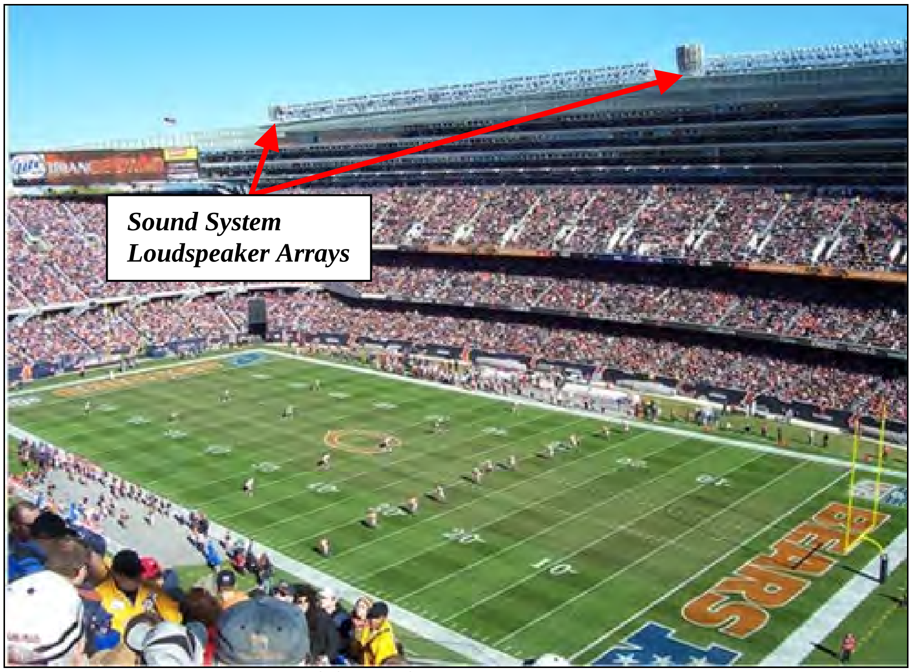


Photo Source: http://www.stadiumsofnfl.com/nfc/images/soldmain08.jpg

Figure 5-3 Soldier Field in Chicago, Illinois

The Stadium sound system would likely use JBL VLA or similar type series arrays with a sideline (as opposed to end-zone) cluster configuration for the following reasons:

1. The configuration of the suites along one sideline is a good place to locate the side cluster, especially since there are no loudspeaker mounting opportunities on the opposite side.

2. The difference between an end-zone cluster and side line cluster is that in the side cluster the three arrays would be "distributed" with the center array on the roof of the suites at the 50 yard line covering all the seats on the opposite side between the 10 yard lines. The other two clusters will also be on opposite ends of the roof at the 10 yard lines covering the remaining seats from the 10 yard lines around through the end zones.

Figure 5-4 and Figure 5-5 illustrate the general concept configuration in plan and section, respectively. The greatest potential noise impact would likely be from three large arrays on the roof of the suites pointing across the field out toward the opposite seats. As shown in the section view, the center array assumes a throw on axis of about 504 ft from the roof top to the seating plane.

Each of the three arrays is assumed to have a horizontal coverage of about 60 degrees and a vertical coverage of about 30 degrees. These are the 6 dB down points of the loudspeaker array coverage. The horizontal coverage is determined by the type of device used in the array, in this case JBL VLA601H. The vertical coverage is controlled by the number of individual components in the array (it will be probably be about six, as shown), and by the "splay" of the array (the angle between components).

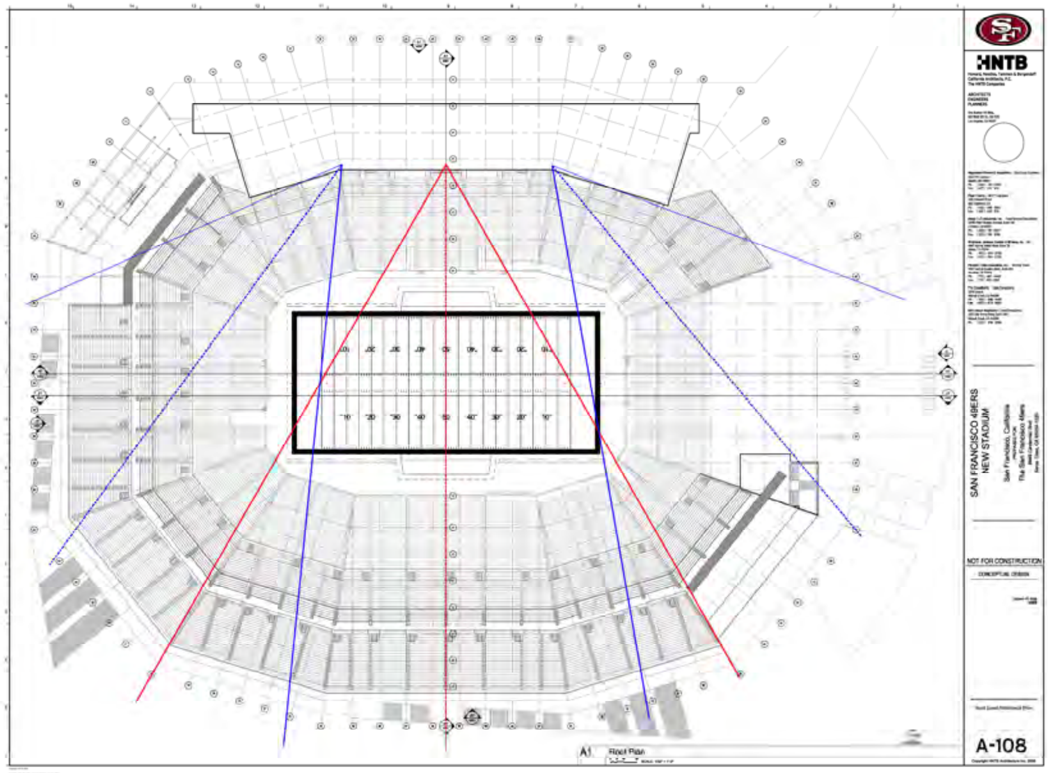


Figure 5-4 Plan View of Sideline Cluster Sound System Configuration Concept

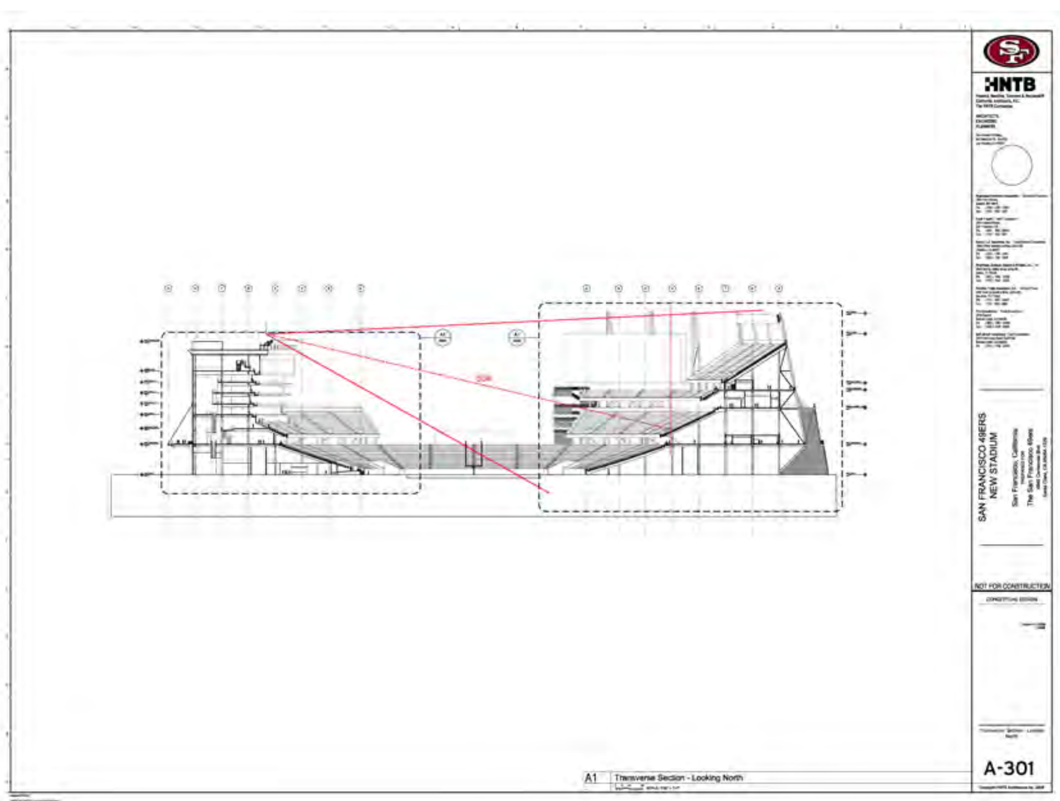


Figure 5-5 Section View of Sideline Cluster Sound System Configuration Concept

Figure 5-6 shows the location of the three line array clusters with respect to the Stadium in the computer model. In modeling the sound system noise source, WIA has assumed:

- The sound system achieves a sound pressure level of 105 dBA at the seats,
- Sound power levels based on pink noise (equal sound power per 1/3-octave band)[2],
- Point source attenuation for each cluster positioned at a height of 169 ft (51.5 m),
- 6-box line array built using EASE[3] software to create 500 Hz and 1 kHz directivity polar plots in horizontal and vertical directions,
- 500 Hz directivity pattern assigned to octave bands 500 Hz and below and 1 kHz directivity pattern assigned to octave bands 1 kHz and above.

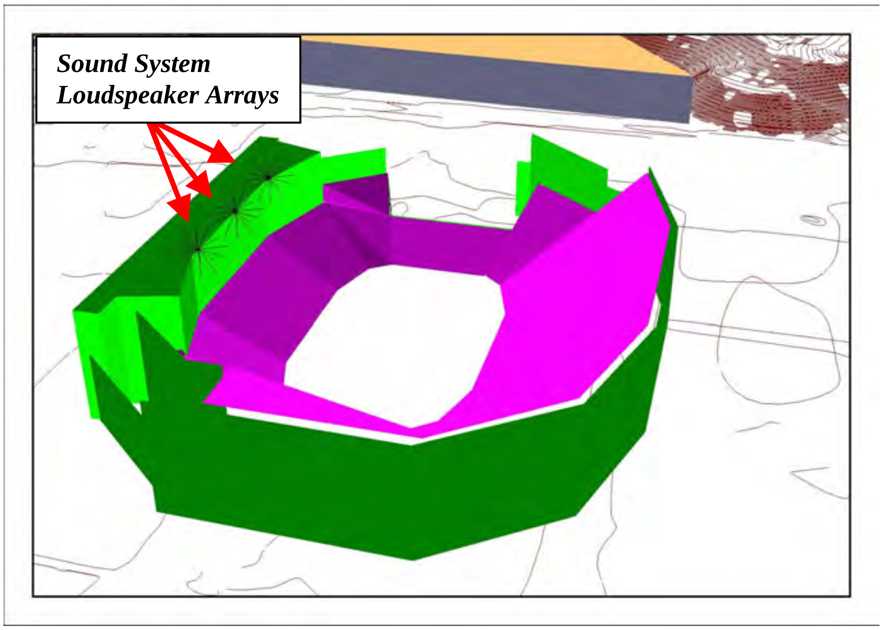


Figure 5-6 Computer Model of Stadium Sound System

The system will likely include other loudspeaker components (not currently in the model), such as small distributed loudspeakers covering under balcony seating opposite the suites which do not have line of sight to the clusters. The seats on the suites side of the field would be covered by distributed loudspeakers mounted on and under the suites. This study does not include any distributed loudspeakers since these would be small and pointing down toward the zones of coverage. Since these loudspeakers would be close to the seats and pointing towards them, the sound energy would be well contained within the seating bowl. Representing the maximum sound power with just the line arrays is therefore a conservative assumption.

5.3 Noise Projection Computer Model for Football Game

WIA developed a 3-D computer noise model using SoundPLAN® to project Stadium operational noise levels to the surrounding community for football games.

Figure 5-6 shows the model in plan view and the location of the Stadium with respect to the ten model receivers. Figure 5-7 shows the model in perspective view illustrating the site topography.

[2] The pink noise assumption is somewhat conservative and may warrant further refinement.

[3] Enhanced Acoustic Simulator for Engineers (EASE), version 4.2,using JBL_VLA_V1p5.dll.

For the purpose of this study which involves sound propagation over large distances, WIA evaluated results using the ISO 9613-2 1996 methodology which is a widely used industry standard and generally considered to be fairly reliable. The model accounts for geometrical spreading losses, air absorption, ground effects and acoustical shielding from buildings or topography that may block line-of-sight conditions between noise sources and receivers.

Model Receivers

All model receivers are 5 ft above the local terrain elevation. As indicated above, receivers R1 through R6 are located at the 6 long-term noise measurement locations (N1 through N6). As described above in Section 4, the additional study receivers include:

Two receivers east of long-term measurement location N3:

- R7 is on Coleman Street, representative of the new residential development, (it as at the closest point extending out from the long axis of the stadium).
- R8 is at the closest point in the proposed Project HPS Residential Density III area (next to the HPS Village Retail Center).

Two receivers in the Bayview Neighborhood:

- R9 is on Palou Avenue and Lane Street
- R10 is on Bayview Circle near Newhall Street

Stadium Shell

The model represents the outer shell of the Stadium as noise walls with different heights, depending on the highest elevation of the stadium structure (e.g., suite tower roof, top row of seating, top of scoreboard). Noise generated from within the Stadium will project out over the stadium structure. As shown on the conceptual design drawings, the main concourse (36.5 ft high) is open on the north end, leaving less acoustical shielding in that direction.

Topography/Terrain/Attenuation

The site terrain data are based on an import of the CitySF_Topo drawings scaled to metric units (a SoundPLAN® convention). The entire project area assumes a ground absorption of 0.30 (0 = hard; 1 = soft) assuming the majority of it will be developed land, except for State Park Land (0.50) and water (0.00).

Building data are based on an import of the x-Korve-topo layer and conversion to building objects in SoundPLAN®. Buildings directly east of Location N3 have been deleted due to current redevelopment occurring there. Building 199959 (east of N3) will not be in the future scenario and has been replaced with one 100 ft tall and the same size as the proposed R&D area shown on the building's elevation plan view drawing provided by PBS&J. The purpose of this step was to study potential acoustical shielding effects this may have on nearby receivers.

Meteorological Effects

For all calculations, the model assumes average conditions for the area: 71.5% humidity, 29.36 in Hg, and 56.6 ºF [4]. For evaluating potential worst case wind conditions (i.e., receiver downwind of noise source), WIA assumed a maximum expected wind speed and potential worst case direction for each receiver. Though very infrequent since the general prevailing winds blow from west to east, high winds may achieve 24 mph occasionally in the direction of the neighborhoods. Section 6 below

[4] www.wunderground.com

further discusses the noise levels associated with the worst case wind conditions for each receiver and likelihood that such conditions would occur.

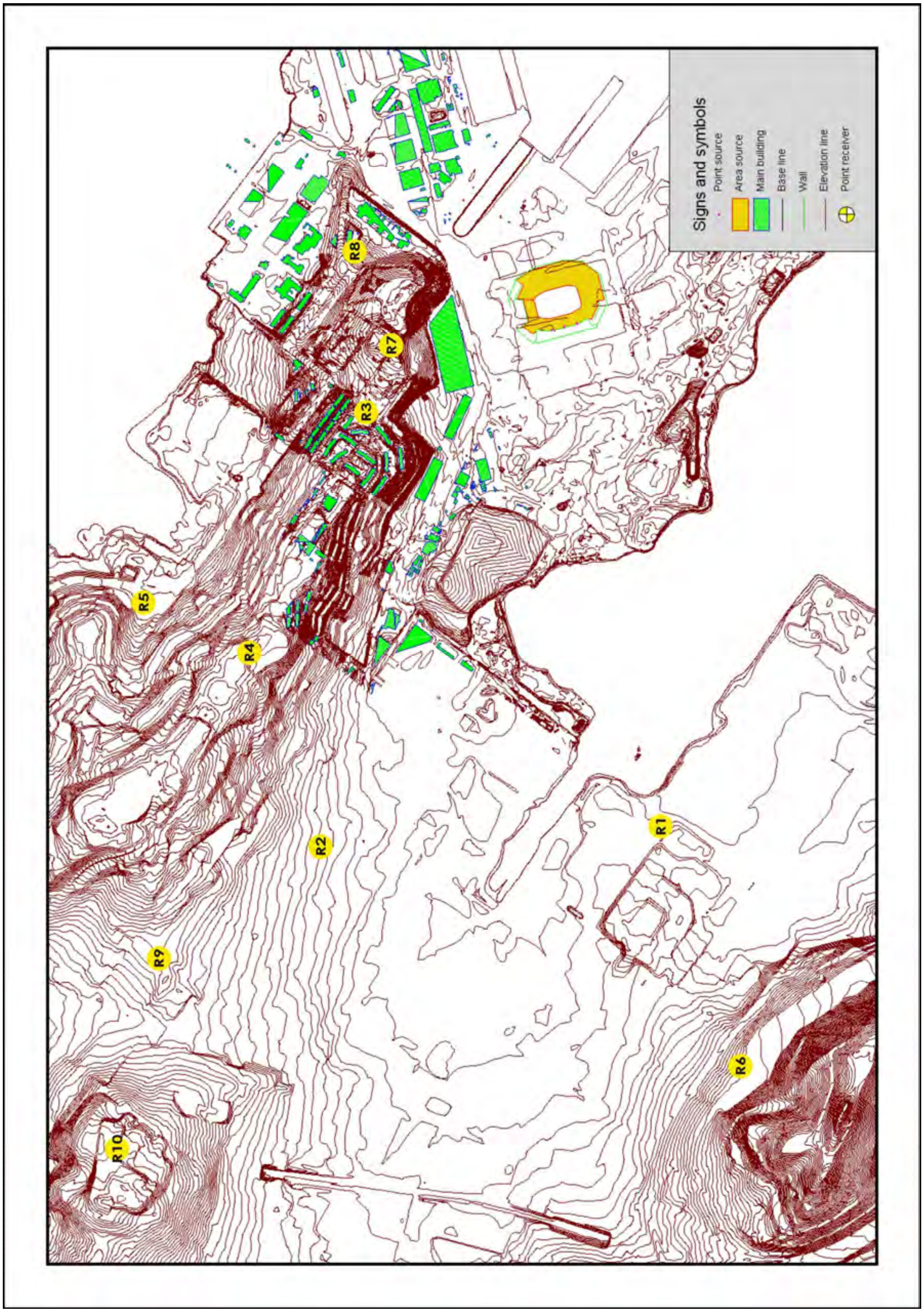


Figure 5-7 3-D Computer Noise Model (Plan View)

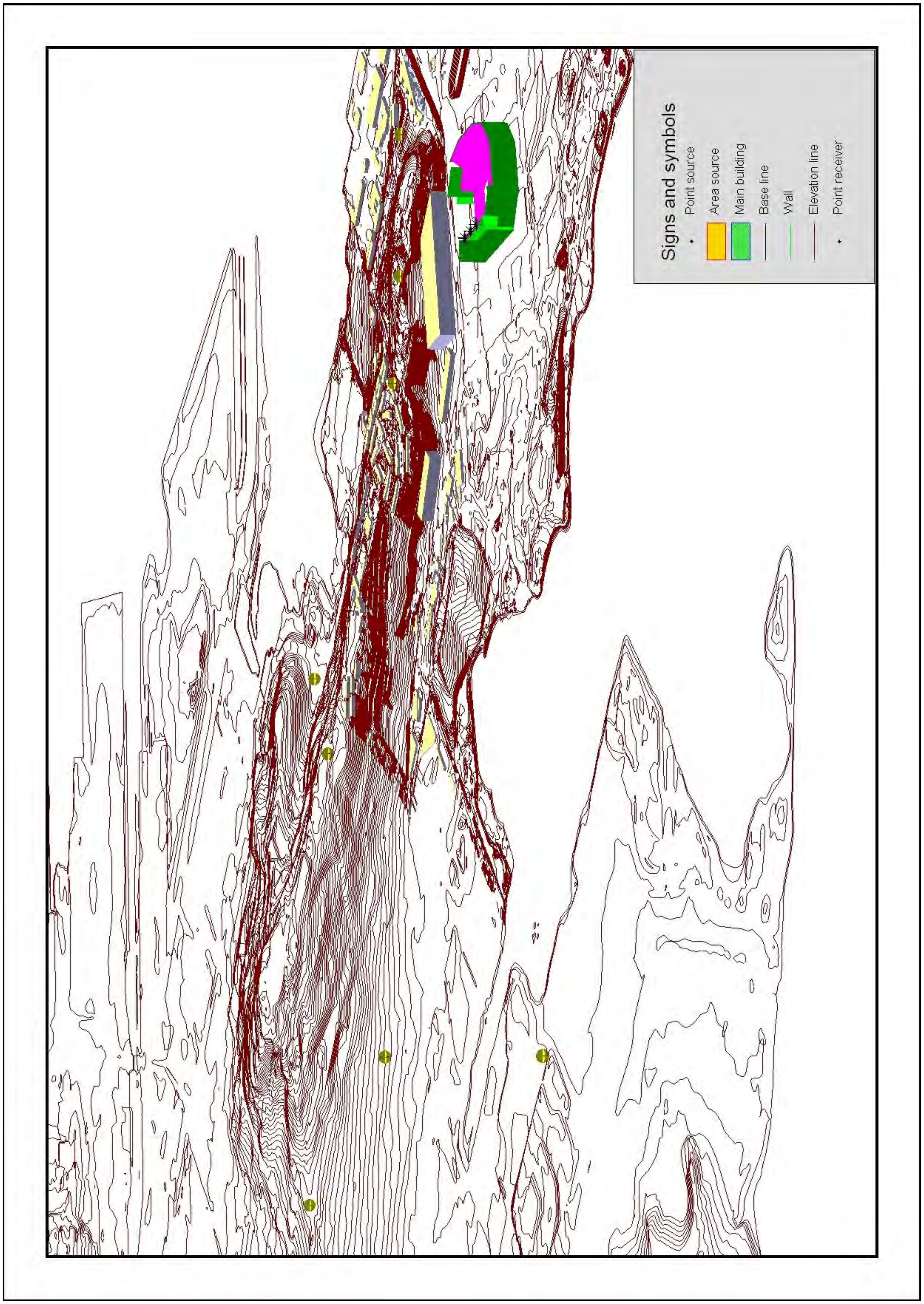


Figure 5-8 3-D Computer Noise Model (Perspective View)

6.0 Project Noise Sources and Prediction Model for Music Concerts

During music concerts, there is primarily only one noise source that needs to be considered and that is the performer's sound system. The audience will produce some noise, but it is reasonable to assume that it will be of a lesser intensity than the crowd noise at a football game. In general, the performer's sound system can be controlled to some degree. This can be accomplished through the selection of the loudspeakers and their orientation.

6.1 Music Concert Sound System

The performer's sound system would be similar to that which is typically seen at many large outdoor music concerts.

Figure 6-1 illustrates what such a sound system could look like.

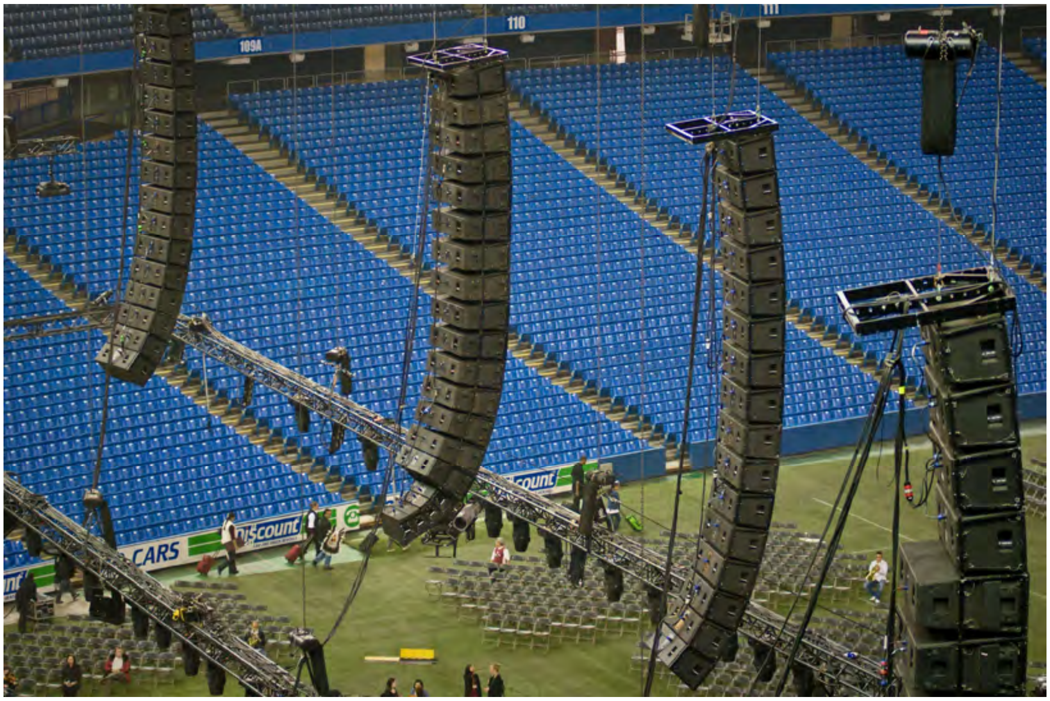


Figure 6-1 Example of Sound System for Touring Concerts

The performer's sound system would likely use JBL or similar type line series arrays composed of full-size components:

1. At the performance stage there would be four line arrays serving as FOH and composed of twelve full-size elements such as JBL VerTec VT4880 above four full-size arrayable subwoofers integrated into each full-range speaker array such as JBL VerTec VT4880.

2. Two towers with delayed signals would be positioned at the 50-yard line to fulfill the back of the Stadium audio needs. Each tower has a pair of eight box arrays, an example of which is a JBL Vertec 4889 full-size array with multiple elements.

Figure 6-2 shows the location of the line arrays with respect to the Stadium in the computer model. In modeling the performer's sound system as a noise source, WIA has assumed:

- Stage layout for large venue is either at north end of field or at 50-yard line,
- Towers (end field and delay) are directed south towards Bay,
- The sound system achieves a sound pressure level of 105 dBA at the mixing panel on the field in front of the stage,
- Sound power levels were based on three different samples of music including one rock sample and two hip-hop samples,
- Point source attenuation for each cluster positioned at a height of 36.5 ft (11.1 m),
- 16-box line array (Vertec VT4880) built using JBL Calculator[5] to create angle and coverage of array and EASE[6] software to create directivity polar plots in horizontal and vertical directions for 100 Hz to 2 kHz,
- For Vertec VT 4880 line arrays 100 Hz directivity pattern assigned to octave bands form 25 to 200 Hz, 500 Hz directivity pattern assigned to octave bands from 250 to 8000 Hz, and 1 kHz directivity pattern assigned to octave bands 1 kHz and above,
- Four arrayable subwoofers (Vertec VT 4889) built using JBL Calculator to create angle and coverage of array and EASE software to create directivity polar plots in horizontal and vertical directions for 25 to 160 Hz,
- For Vertec VT 4889 subwoofer line arrays 100 Hz directivity pattern assigned to octave bands form 25 to 160 Hz.

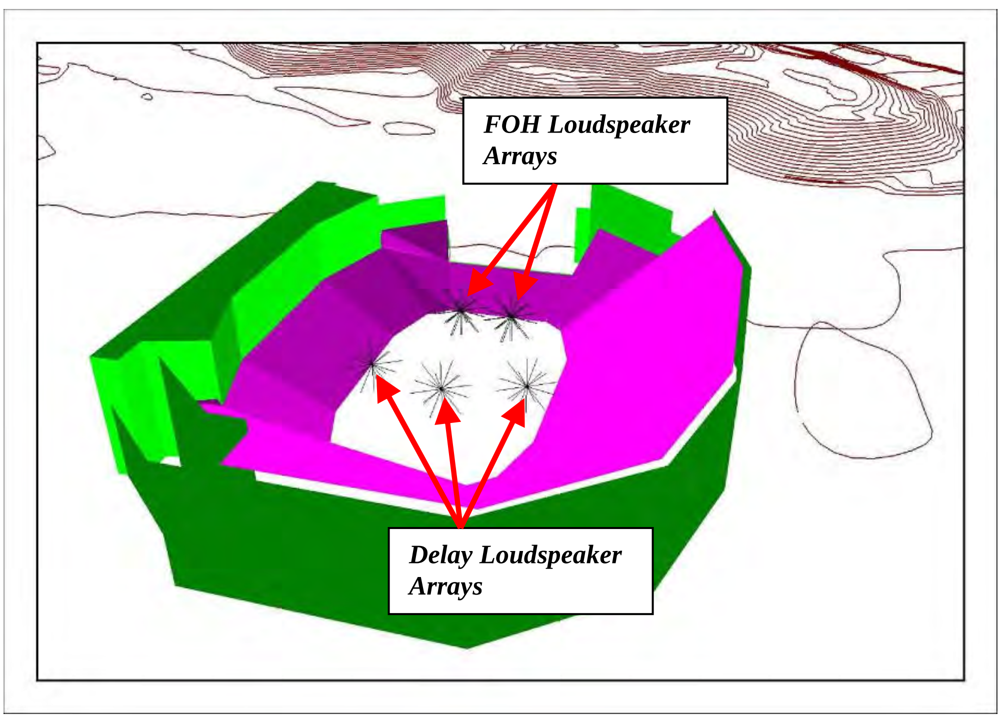


Figure 6-2 Computer Model of Concert Sound Systems

[5] JBL Vertec Line Array Calculator Version 2.10
[6] Enhanced Acoustic Simulator for Engineers (EASE)

The sound pressure levels at the mixing console for each of the three music samples are shown in Figure 6-3.

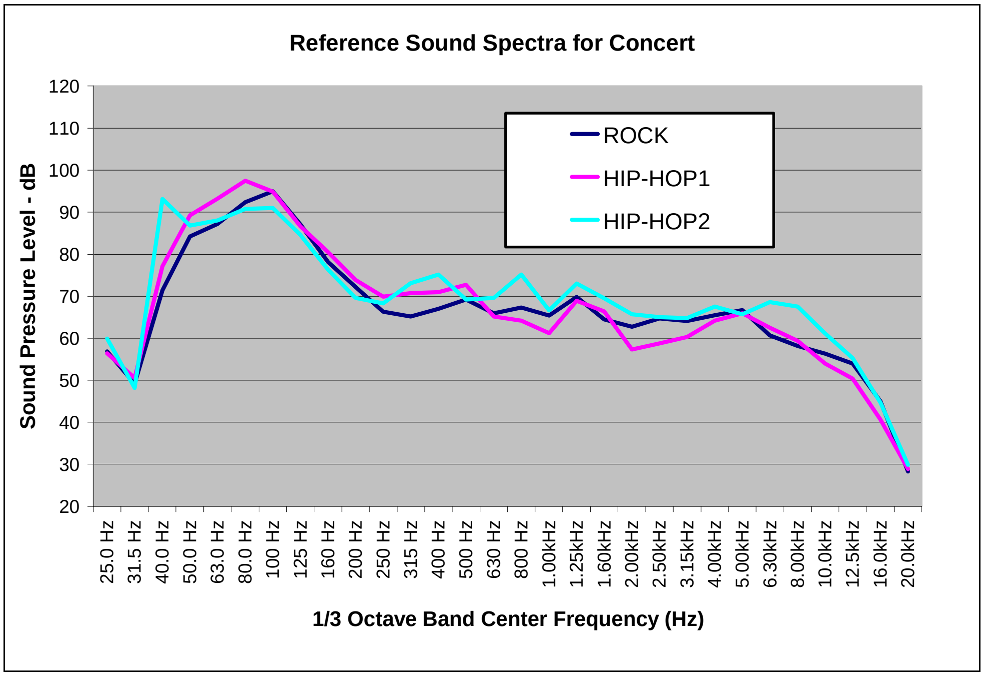


Figure 6-3 Concert Music Sound Pressure Levels

6.2 Noise Projection Computer Model for Concert

The same computer model used for football game noise projections was used to project concert noise outside the Stadium, except for the different sound system being used as described above. Consequently, Figure 5-7 shows the basic geometry of the noise projection model as modeled in SoundPLAN®.

7.0 Potential Noise Impacts

7.1 Football Games

WIA has evaluated the potential noise impacts associated with both the crowd and sound system for a typical full capacity football game. As is standard practice, the noise analyses conducted by WIA to determine noise impact levels assume noise sensitive receptors that are located five feet above the ground and at the setback or nearest building façade to the noise source.

Projections assume a typical game is on the order of three hours with crowd and/or PA noise sustained at typical maximum levels for an aggregate 45 minutes over the three hour period. This is a conservative assumption in that crowd noise probably is less than 45 minutes and not necessarily would occur at maximum levels. Furthermore, it is also assumed that crowd noise consists of people cheering continuously during this 45 minute aggregate. The assumption was also made that all of the football fans in the stadium are cheering at maximum level they are capable of when they do cheer. These are also conservative assumptions.

For the two noise sources (fans cheering and PA), WIA presents the projections for maximum noise levels (L_{max}), and the day night level (L_{dn}) for a game day with the conservative assumptions of level and duration of sound. The game day L_{dn} calculations are based on a noise energy summation of the existing ambient hourly L_{eq} noise levels at each location (i.e., measured or assumed from measured data) and the projected game noise levels at that location. The L_{dn} calculations assume typical games would be during evening hours and game operational noise would <u>not</u> occur between 10 p.m. and 7 a.m. which could substantially affect the L_{dn}. Doubleheaders, game delays, or other potential reasons for game operations occurring past 10 p.m. would increase the potential for noise impacts.

7.1.1 Impacts Associated with Individual Noise Sources at Football Games

It should be noted that the noise levels projected in detail herein are for a "no wind" condition. The presence of a wind blowing to the south or east would greatly reduce the noise levels occurring in the local residential community. Consequently, the operational impact analysis is based on a conservative assumption.

7.1.1.1 Football Crowd Noise

WIA evaluated the impact of noise from fans cheering in the Stadium during a "no wind" condition. This is a conservative assumption in that often the local wind is either blowing to the south or east away from the residential community and towards the Bay. Based on the analysis results shown in Table 7-1, WIA would expect noise levels to exceed the proposed impact criteria at receivers R3 and R7 based on the conservative conditions assumed. It should be noted that except for the wind condition the L_{max} levels would be expected to occur and possibly often, however the changes in L_{dn} levels are based on duration and level may not occur with regularity.

At R3, which is representative of the existing residential portion of the Hunters Point neighborhood closest to the stadium, crowd noise would be less than the 75 dBA L_{max} criterion during a game. There is the potential for an impact based on L_{dn} although the projected game day L_{dn} is less than 65. The potential increase is 2 to3 dBA which could be considered significant.

Higher noise levels are predicted at R7 which is representative of the new residential development closest to the stadium and closer to the stadium than R3 but not part of the Project. At R7, maximum crowd noise would approach but not exceed the 75 dBA L_{max} criterion. The L_{dn} may increase by 4 to 7 dBA assuming ambient noise data measured at R3 (N3) is representative of this location.

Table 7-1 Predicted Crowd Only Noise Levels (No Wind Condition)

Model Receiver	Distance[1] ft	L_{max} [2] dBA	Game Day Ldn[3]	L_{dn} Increase over existing[4]	Proposed Criteria Exceeded
R1	5,060	60	63 to 67	<1 dBA	None
R2	5,330	63	63 to 65	<1 dBA	None
R3	1,650	73	61 to 64	**2 to 3 dBA**	Increase in Ldn
R4	3,820	64	65 to 66	<1 dBA	None
R5	4,490	60	62 to 65	<1 dBA	None
R6	7,250	57	59 to 60	<1 dBA	None
R7	1,150	**79**	**65 to 66**	**4 to 7 dBA**	75 dBA L_{max}, 65 Ldn
R8	1,675	68	59 to 63	1 dBA	None
R9	6,880	55	63 to 65	<1 dBA	None
R10	8,600	56	65 to 66	<1 dBA	None

1. Approximate distance to center of stadium.
2. L_{max} is based on L_1 reference spectrum (Figure 5-1) and represents anticipated typical maximum noise levels.
3. Based on noise energy summation of measured or assumed ambient plus predicted game noise levels.
4. Relative to representative ambient data.

7.1.1.2 Stadium PA System Noise

The noise projections for the proposed PA system are shown in Table 7-2. The greatest potential for noise impacts due to PA sound would occur at locations R3, R7, and R8.

At R3, which is representative of the existing residential portion of the Hunters Point neighborhood closest to the stadium, PA noise levels would be roughly similar to crowd noise levels – less than the 75 dBA L_{max} criterion during a game. There is also the potential for an L_{dn} impact since although the projected game day L_{dn} is less than 65, the potential increase is 2 to3 dBA which could be considered significant.

At R7 which is representative of the new residential development closest to the stadium but not part of the Project, PA noise levels would be greater than the crowd noise levels alone. Typical maximum PA noise levels would be on the order of 82 dBA and exceed the 75 dBA L_{max} criterion. The L_{dn} may increase by 6 to 8 dBA assuming ambient noise data measured at R3 (N3) is representative of this location.

R8, the receiver representative of the new residential portion of the Project closest to the stadium, would experience a potential noise impact from PA noise even though crowd noise would be within the criteria. This is largely due to the loudspeaker coverage provided by the line arrays on the north end of the stadium which project out to the northeast. At R8, the projected L_{max} level is 78 dBA, which exceeds the 75 dBA L_{max} criterion. The L_{dn} would potentially increase by 4 to 6 dBA to 64 to 66 L_{dn} assuming ambient noise data similar to R3.

For most distant receivers the PA only noise levels are lower than the crowd only noise levels. This is apparent at locations R1 and R2 and other distant receivers west of the stadium. The directivity and orientation of the PA strongly influence the lower noise levels evident at receivers positioned away from the direction of the loudspeakers which face toward the east.

The PA noise projections are based on the nominal maximum design conditions and assume a continuous RMS signal. It is reasonable to expect that there may be isolated incidents where PA noise levels could be higher than the projections if PA sound levels are increased to overcome extreme bursts of crowd noise.

Table 7-2 Predicted PA Only Noise Levels (No Wind Condition)

Model Receiver	Distance[1] ft	L_{max} [2] dBA	Game Day Ldn[3]	L_{dn} Increase over existing[4]	Proposed Criteria Exceeded
R1	5,060	55	63 to 67	<1 dBA	None
R2	5,330	55	63 to 65	<1 dBA	None
R3	1,650	73	61 to 64	**2 to 3 dBA**	Increase in Ldn
R4	3,820	61	65 to 66	<1 dBA	None
R5	4,490	57	62 to 65	<1 dBA	None
R6	7,250	48	59 to 60	<1 dBA	None
R7	1,150	**82**	**67 to 68**	**6 to 8 dBA**	75 dBA L_{max}, 65 Ldn
R8	1,675	**78**	**64 to 66**	**4 to 6 dBA**	75 dBA L_{max}, 65 Ldn
R9	6,880	48	63 to 65	<1 dBA	None
R10	8,600	48	65 to 66	<1 dBA	None

1. Approximate distance to center of stadium.
2. L_{max} is based on L_1 reference spectrum (Figure 5-1) and represents anticipated typical maximum noise levels.
3. Based on noise energy summation of measured or assumed ambient plus predicted game noise levels.
4. Relative to representative ambient data.

7.1.2 Impacts Associated with Combined Noise Sources at Football Games

Table 6-3 present the results of combined crowd noise and PA system noise. As expected the noise levels slightly increase due to the energy summation of these simultaneous noise sources though this depends on the dominant noise source at each receiver. The greatest potential for noise impacts occurs at R3, R7, and R8.

At R3 which is representative of the existing residential portion of the Hunters Point neighborhood closest to the stadium, combined noise sources would generate typical maximum noise levels on the order of 76 dBA which is less than the 75 dBA L_{max} criterion. There is also the potential for an L_{dn} impact at this location since game days would potentially increase the existing L_{dn} by 3 to 4 dBA to 62 to 65 L_{dn}.

At R7 which is representative of the new residential development closest to the stadium but not part of the Project, combined noise sources would generate typical maximum noise levels on the order of 83 dBA exceeding the 75 dBA L_{max} criterion. The L_{dn} may increase by as much as 7 to 9 dBA to approximately 69 L_{dn} assuming ambient noise data measured at R3 (N3) is representative of this location.

R8, the receiver representative of new residential part of the Project closest to the stadium, would experience a potential noise impact from PA only noise. L_{max} level would be 78 dBA, which exceeds the 75 dBA L_{max} criterion. The L_{dn} would potentially increase by 4 to 6 dBA to 64 to 66 L_{dn} assuming ambient noise data similar to R3.

The general conclusion regarding potential noise impacts is that they would occur locally near the stadium but not farther out as would be expected. The influence distance appears to be on the order of approximately 2,000 to 2,500 ft. Beyond this distance it is not likely that game operational levels would exceed the proposed impact criteria.

Table 7-3 Predicted Crowd and PA Combined Noise Levels (No Wind Condition)

Model Receiver	Distance[1] ft	L_{max} [2] dBA	Game Day Ldn[3]	L_{dn} Increase over existing[4]	Proposed Criteria Exceeded
R1	5,060	61	63 to 67	<1 dBA	None
R2	5,330	64	63 to 65	<1 dBA	None
R3	1,650	**76**	62 to 65	**3 to 4 dBA**	75dBA L_{max}, Increase in Ldn
R4	3,820	66	65 to 66	<1 dBA	None
R5	4,490	62	62 to 65	<1 dBA	None
R6	7,250	58	59 to 60	<1 dBA	None
R7	1,150	**83**	**69**	**7 to 9 dBA**	75 dBA L_{max}, 65 Ldn
R8	1,675	**78**	**64 to 66**	**4 to 6 dBA**	75 dBA L_{max}, 65 Ldn
R9	6,880	55	63 to 65	<1 dBA	None
R10	8,600	57	65 to 66	<1 dBA	None

1. Approximate distance to center of stadium.
2. L_{max} is based on L_1 reference spectrum (Figure 5-1) and represents anticipated typical maximum noise levels.
3. Based on noise energy summation of measured or assumed ambient plus predicted game noise levels.
4. Relative to representative ambient data.

7.1.3 Meteorological Effects on Football Game Noise

Wind effects can increase noise levels downwind of a noise source, while reducing noise levels upwind. Generally speaking, the prevailing winds for the Project study area originate from the west, northwest, or west-northwest directions. These directions would actually be acoustically favorable for neighborhood receivers and have the potential to reduce noise levels from the Stadium[7]. However, as indicated in the Project wind assessment report, there are notable changes during winter months and winds become milder and less dominated by west-northwesterly winds. Therefore, WIA believes the above noise predictions for "no wind" present the typical worst-noise conditions for NFL games during fall and winter months.

A small percentage of the time wind conditions may occur such that the receivers are downwind of the stadium and its noise sources thus creating the potential for an increase in game noise levels over the baseline "no wind" condition. Based on preliminary analysis, WIA would expect the potential for an increase in typical maximum game noise levels of up to 3 to 5 dBA for model receivers. To calculate the potential increase, WIA assumed the downwind condition for each receiver and a wind velocity of 24 mph[8] as typical. A downwind condition however, would be a very seldom occurring and therefore unlikely condition on the order of only 6 to 7 % of the time during game season months[9]. In the event that such downwind conditions do occur, there is the possibility that

[7] Reference 8 discusses the Project Area wind climate. The dominant wind condition is associated with summer months.
[8] 24 mph is worst case based on review of wind rose plots contained in Reference 8 and would not necessarily occur in all receiver directions.
[9] Based on review of wind rose plots contained in Reference 8 for daytime winter data.

operational noise levels may exceed the proposed impact criteria at additional homes which would otherwise not experience any exceedance (i.e., locations which would otherwise be marginally in accordance with the proposed impact criteria but are near receivers already showing an exceedance). However, the overall picture does not change substantially since game noise levels would still be expected to be within the proposed impact criteria at the more distant receivers.

Most often the wind is blowing to the south or east. In this case, the noise from the Stadium during a football game would be significantly reduced in the surrounding community. This affect has been observed at the current home of the 49ers at Candlestick Park.

Temperature inversions occur when the normal temperature gradient (lower temperature with increasing height above the ground) becomes inverted due to certain atmospheric conditions. This can cause sound waves to temporarily travel faster at higher altitudes which may result in increased noise levels at distant receivers. Temperature inversions are fairly complex phenomena and modeling their potential effects is beyond the current scope of this study. Further, for the Project study area, while it is possible that temperature inversions do occur, wind conditions associated with the area are likely to disrupt an inversion condition and thus minimize its effect.

7.1.4 Potential for Audibility of Football Game Noise

Although audibility would <u>not</u> have the potential for causing a significant impact, we discuss the potential for audibility at distances greater than 3,300 ft when there is low background ambient noise. In this discussion the potential for audibility refers to the ability to easily detect game operational noise in the presence of ambient sources of community noise. For the purpose of this study the potential for game noise to be easily detectable exists where the A-weighted game noise level is equal or greater than the A-weighted community noise level. Technically, delectability is based on specific frequency bands (i.e., comparison of 1/3-octave band Stadium noise levels and corresponding 1/3-octave band ambient noise levels). However, low frequencies can mask higher frequencies and this analysis assumes that in general the ambient noise would be dominated by low frequencies while the (potentially audible) crowd and PA noise would be dominated by mid to high frequencies.

The potential for crowd and PA noise to be easily detectable both outdoors is shown in Table 6-4 and the likelihood of this condition can be determined by comparing anticipated game noise levels to the ambient statistical noise descriptors. For example, crowd noise that is less than the L_{90} would be masked (not easily detectable) at least 90% of the time. On the other hand, crowd noise that exceeds the ambient L_{10} would be easily detectable at least 90% of the time. However, the amount of time would be limited by the duration the crowd noise occurs. If the crowd noise L25 exceeds the ambient L_{10}, then, crowd noise would be easily detectable for approximately 23% of the time (or 13.5 minutes for a given hour). Review of Table 7-4 indicates that at times game noise would potential be audible at distances on the order of 1.6 miles.

The calculations for indoors also shown in Table 7-4 assume a 15 dBA nominal exterior-to-interior noise reduction provided by the building shell which is considered typical for single family homes without special acoustical mitigation. Compared with an assumed low-level ambient background noise level of 45 dBA, maximum game noise levels would potentially be audible at times at Receivers R1, R2, R4, and R5.

Table 7-4 Potential for Audibility of Game Noise at Distant Receivers Outdoors

Model Receiver	Distance ft	Exterior Ambient $L_{10,}$ dBA	Exterior Ambient $L_{50,}$ dBA	Exterior Ambient $L_{90,}$ dBA	Exterior Game L_{max} (L_{25})	Detectable Outdoors?	Interior Game L_{max}, dBA	Detectable Indoors?
R1	5,060	52 to 55	44 to 48	42 to 45	61 (55)	At least 22.5% of the time	46	Yes
R2	5,330	60 to 64	48 to 53	45 to 47	64 (58)	At least 12.5% of the time	49	Yes
R4	3,820	60 to 63	48 to 52	44 to 46	66 (60)	At least 12.5% of the time	51	Yes
R5	4,490	61 to 63	47 to 50	43 to 44	62 (56)	At least 12.5% of the time	47	Yes
R6	7,250	58 to 62	49 to 50	45 to 46	58 (52)	At least 12.5% of the time	43	No
R9	6,880	60 to 64	48 to 53	45 to 47	55 (49)	At least 2.5% of the time	40	No
R10	8,600	60 to 63	48 to 52	44 to 46	57 (51)	At least 2.5% of the time	42	No

1. Range represents lowest ambient for afternoon or evening hours.
2. Compared with an assumed indoor ambient background noise level of 45 dBA.

7.2 Noise Impacts from Music Concerts

The projected noise levels for a concert (rock music) are presented in Table 7-5. Note that the L_{max} levels in terms of dBC are presented only for informational purposes. It can be seen that the as with a football game exceedance of the proposed criteria are projected for receptors R3 and R7. The noise levels associated with the music concert are due to the concert's sound system.

Because the concert's sound system would be located closer to the ground than the stadiums sound system it is projected the sound levels outside the stadium are somewhat less for the music concert compared with the football game. The general conclusion regarding potential noise impacts is that they would occur locally near the stadium but not farther out as would be expected. The influence distance appears to be on the order of approximately 2,000 ft. Beyond this distance it is not likely that music concert noise levels would exceed the proposed impact criteria.

Table 7-5 Predicted Concert Sound System Noise Levels (Rock Music)

Model Receiver	Distance ft	L_{max} dBA	L_{max} dBC	Concert Ldn	Ldn Increase over existing	Proposed Criteria Exceeded
R1	5,060	57	78	63 to 67	< 1 dBA	None
R2	5,330	63	83	64 to 65	<1 to 1 dBA	None
R3	1,650	72	92	63 to 65	**3 to 5 dBA**	Increase in Ldn
R4	3,820	64	84	65 to 67	< 1 to 1 dBA	None
R5	4,490	63	82	62 to 65	< 1 dBA	None
R6	7,250	56	76	59 to 60	< 1 dBA	None
R7	1,150	75	95	**65 to 67**	**5 to 7 dBA**	65 Ldn, Increase in Ldn
R8	1,675	63	83	59 to 63	1 dBA	None
R9	6,880	56	76	63 to 65	< 1 dBA	None
R10	8,600	58	78	65 to 66	< 1 dBA	None

8.0 Potential Noise Mitigation

8.1 Football Game Noise Mitigation

Potentially significant noise impacts have been identified for residential areas that are relatively close to the proposed Stadium. The following is a list of potential mitigation measures that could be used to reduce noise impacts associated with the Stadium:

- Improving the external noise insulation of individual residences that would be impacted
- Shielding the back of the PA speakers
- Constructing a partial canopy to reduce crowd noise
- Limiting the level of allowable sound within the Stadium associated with the PA system

8.2 Music Concert Noise Mitigation

Potentially significant noise impacts have also been identified for residential areas during a music concert in the Stadium. The following is a list of potential mitigation measures that could be used to reduce noise impacts during a concert:

- Improving the external noise insulation of individual residences that would be impacted
- Limiting the level of allowable sound within the Stadium during a concert

9.0 Summary and Conclusions

WIA has evaluated the potential for significant noise impacts for the proposed 49ers Stadium. Both football game and a music concert noise were model and noise levels projected for the community. Significant impacts are projected to occur up to a distance of approximately 2,000 ft and possibly somewhat further for both football games and music concerts. Potential noise mitigation for football games includes residential noise insulation improvements, shielding of PA loudspeakers, a partial canopy at the top of the east side of the Stadium or limiting the level of sound associated with the PA sound system. Potential noise mitigation for music concerts includes residential noise insulation improvements, and limiting the sound level produced by the concert's sound system.

10.0 References

1. “Audio-Video (incl scoreboards) narrative.doc” received 6 January 2009.
2. “Areas and Seat Counts etc 11-20-2006.xls” received 6 January 2009.
3. 0_Blueprints - Plans_101606.pdf received 6 January 2009.
4. City SF_Topo Drawings received from PBS&J
5. x-Korve-Topo received 12 January 2009.
6. Candlestick Point and Hunters Point Shipyard, Phase II, Proposed Land Use Drawings, Lennar Urban, 26 November 2008.
7. SoundPLAN® version 6.5 and related documentation
8. CPP Inc. Final Report, Preliminary Pedestrian Wind Assessment, Candlestick Point and Hunters Point Developments, San Francisco, California. Dated June 2007.
9. Kinsler, Frey, Coppens, and Sanders, Fundamentals of Acoustics, 4th Ed., John Wiley & Sons, Inc., 2000.

APPENDIX

Ambient Noise Data

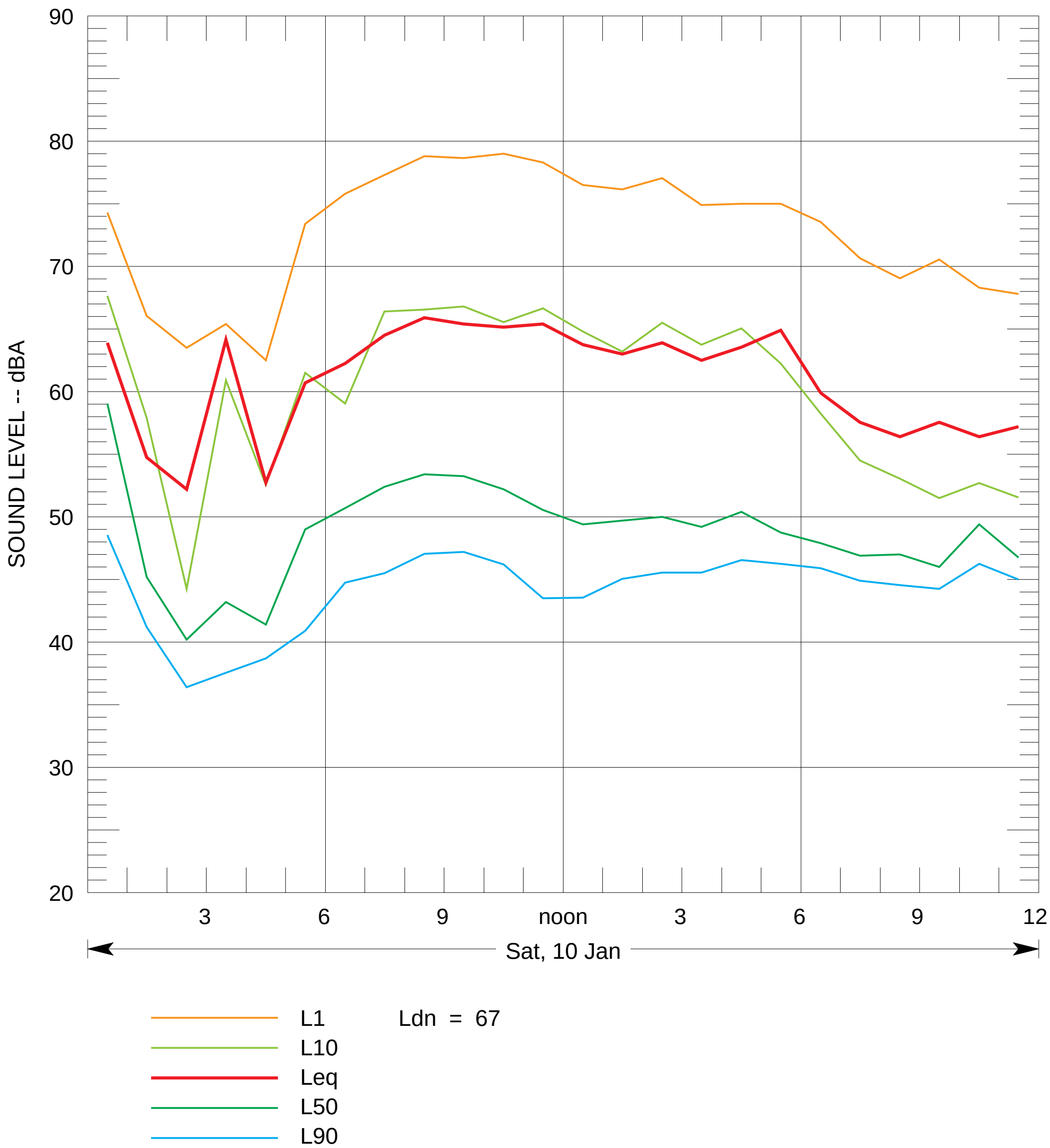


Figure A-1 Ambient Noise Levels Measured at Location N1
Carroll Avenue north of Walker Drive
Saturday, 10 January 2009

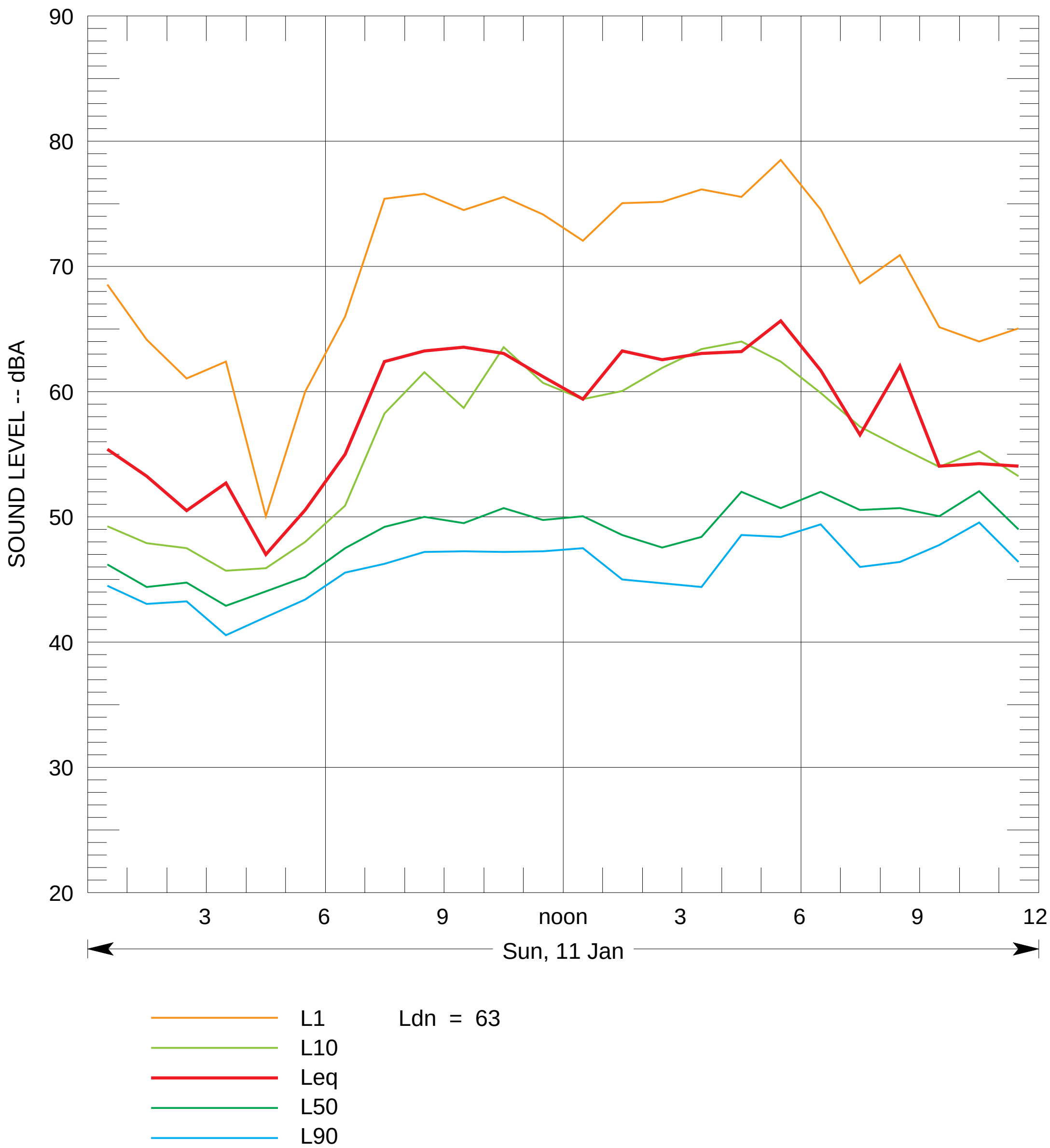


Figure A-2 Ambient Noise Levels Measured at Location N1
Carroll Avenue north of Walker Drive
Sunday, 11 January 2009

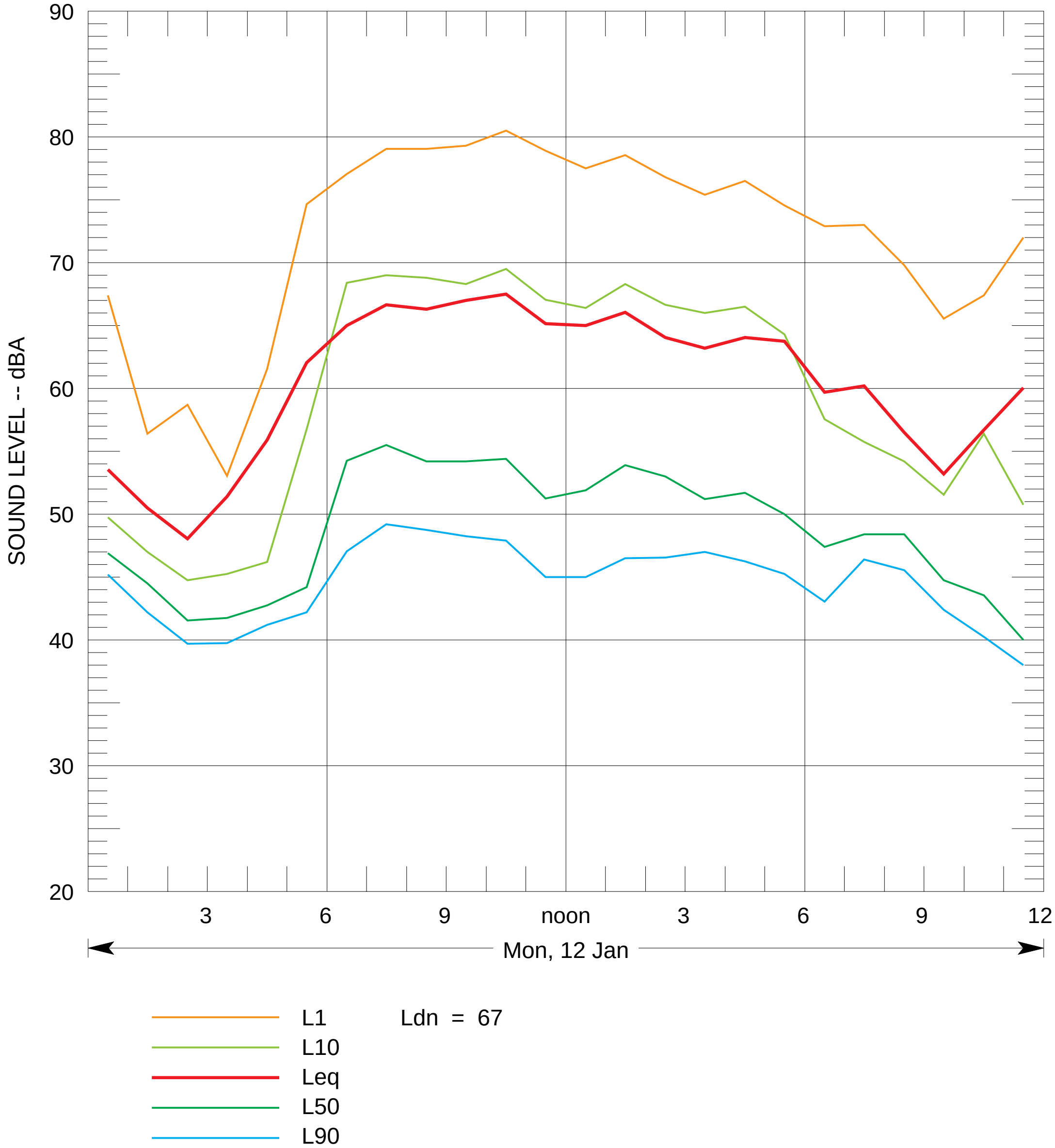


Figure A-3 Ambient Noise Levels Measured at Location N1
Carroll Avenue north of Walker Drive
Monday, 12 January 2009

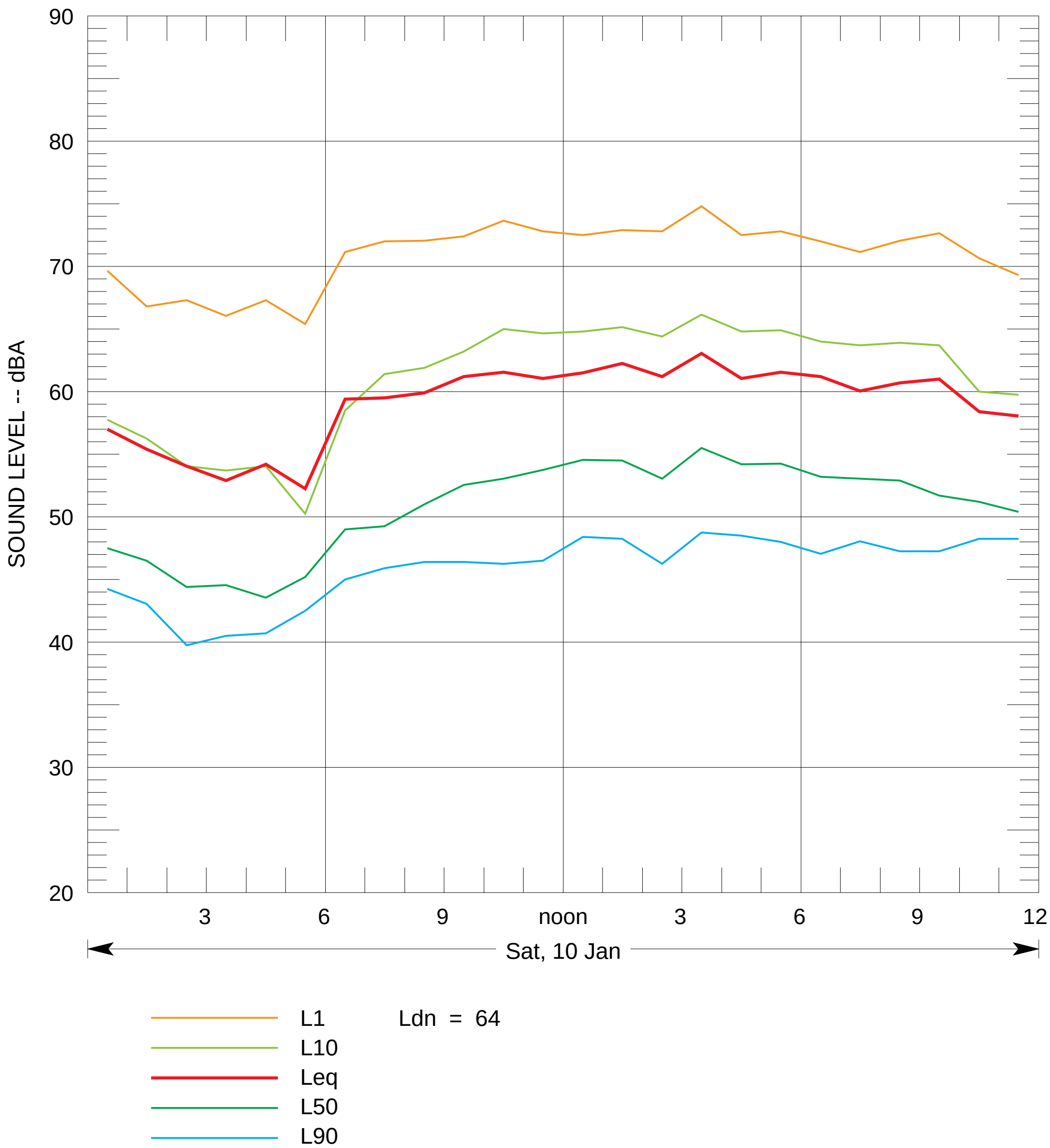


Figure A-4 Ambient Noise Levels Measured at Location N2
Revere Avenue between Ingalls Street & Jennings Street
Saturday, 10 January 2009

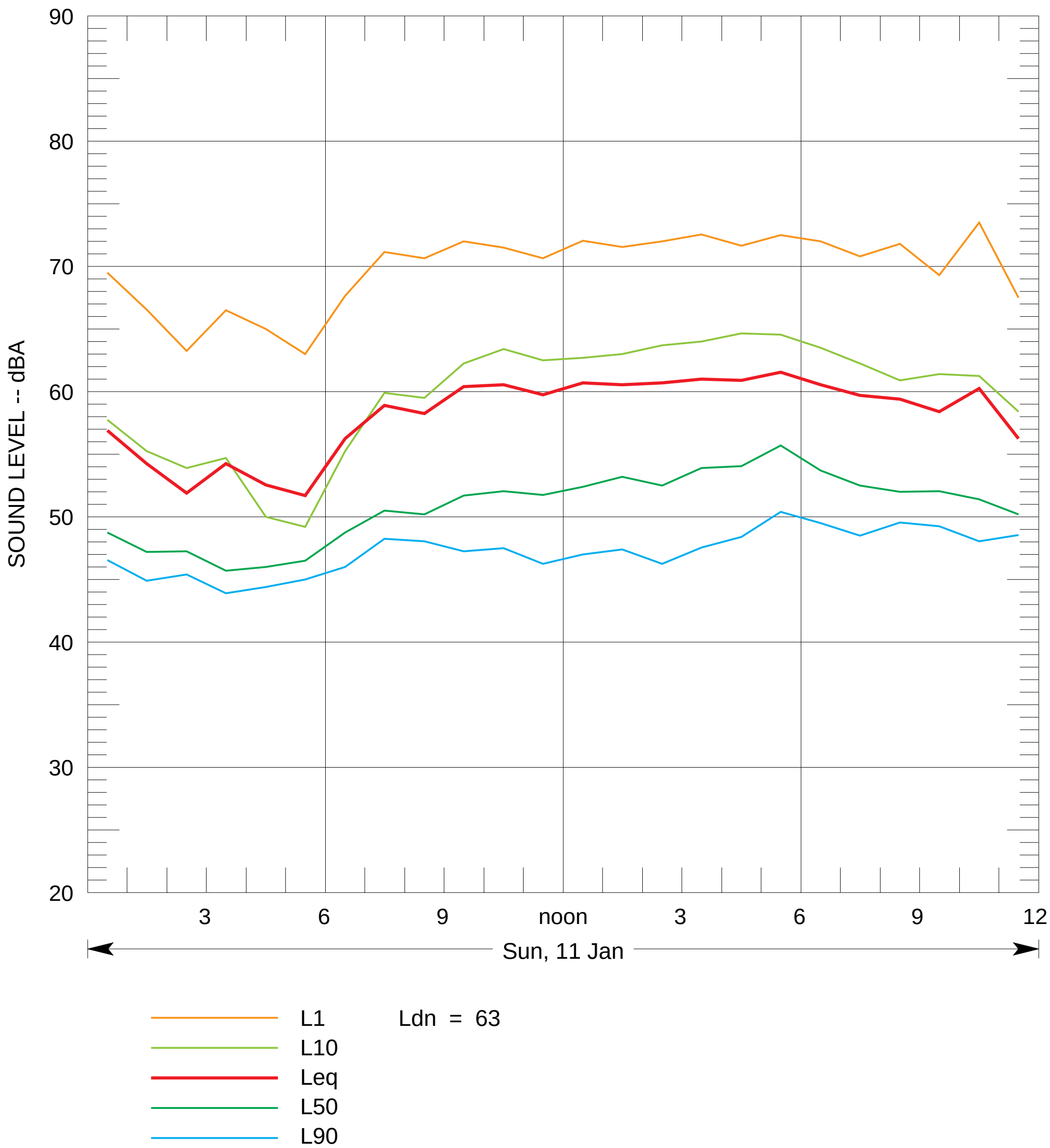


Figure A-5 Ambient Noise Levels Measured at Location N2
Revere Avenue between Ingalls Street & Jennings Street
Sunday, 11 January 2009

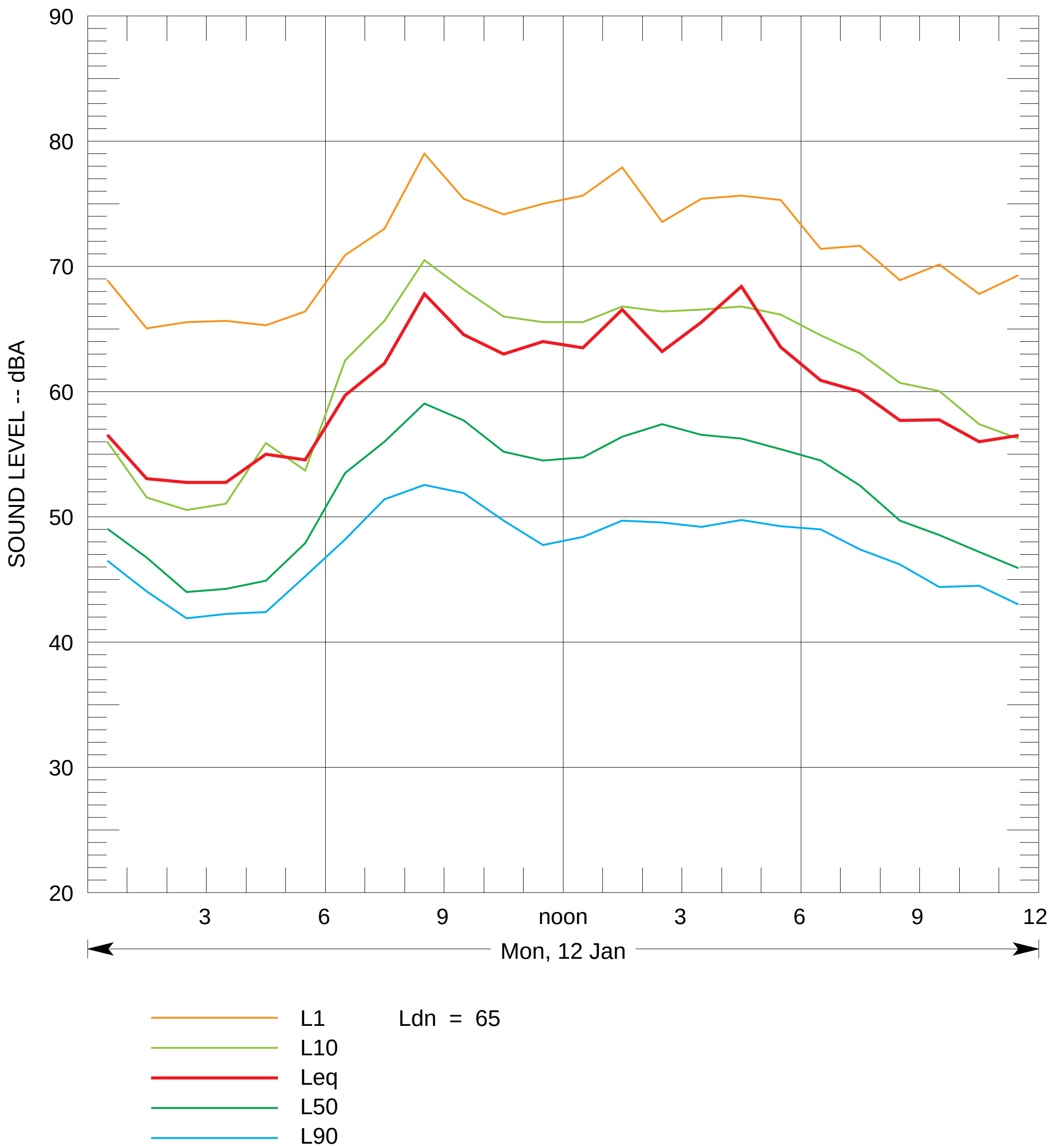


Figure A-6 Ambient Noise Levels Measured at Location N2
Revere Avenue between Ingalls Street & Jennings Street
Monday, 12 January 2009

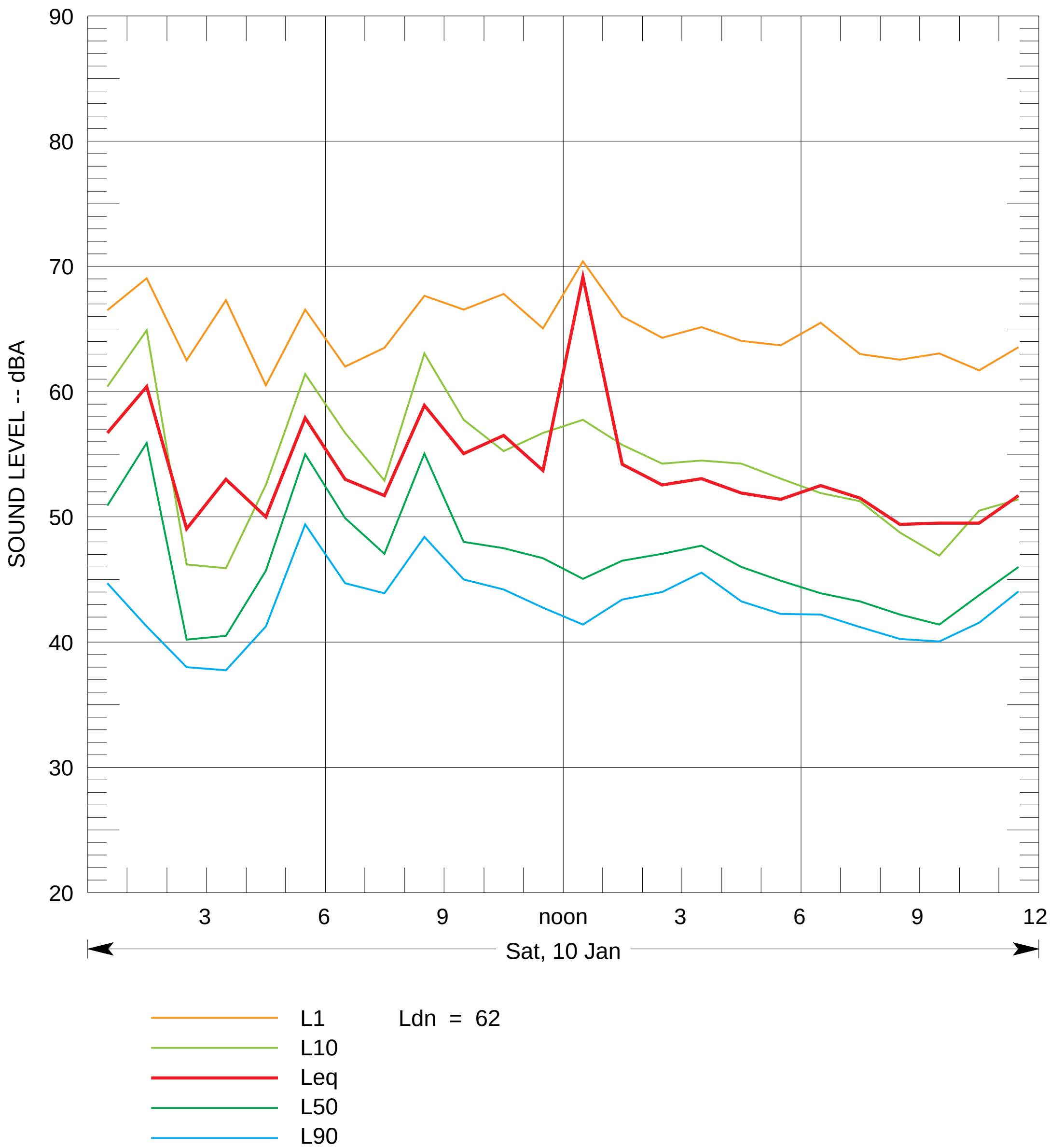


Figure A-7 Ambient Noise Levels Measured at Location N3
Donahue Street between Kirkwood Avenue & Jerrold Avenue
Saturday, 10 January 2009

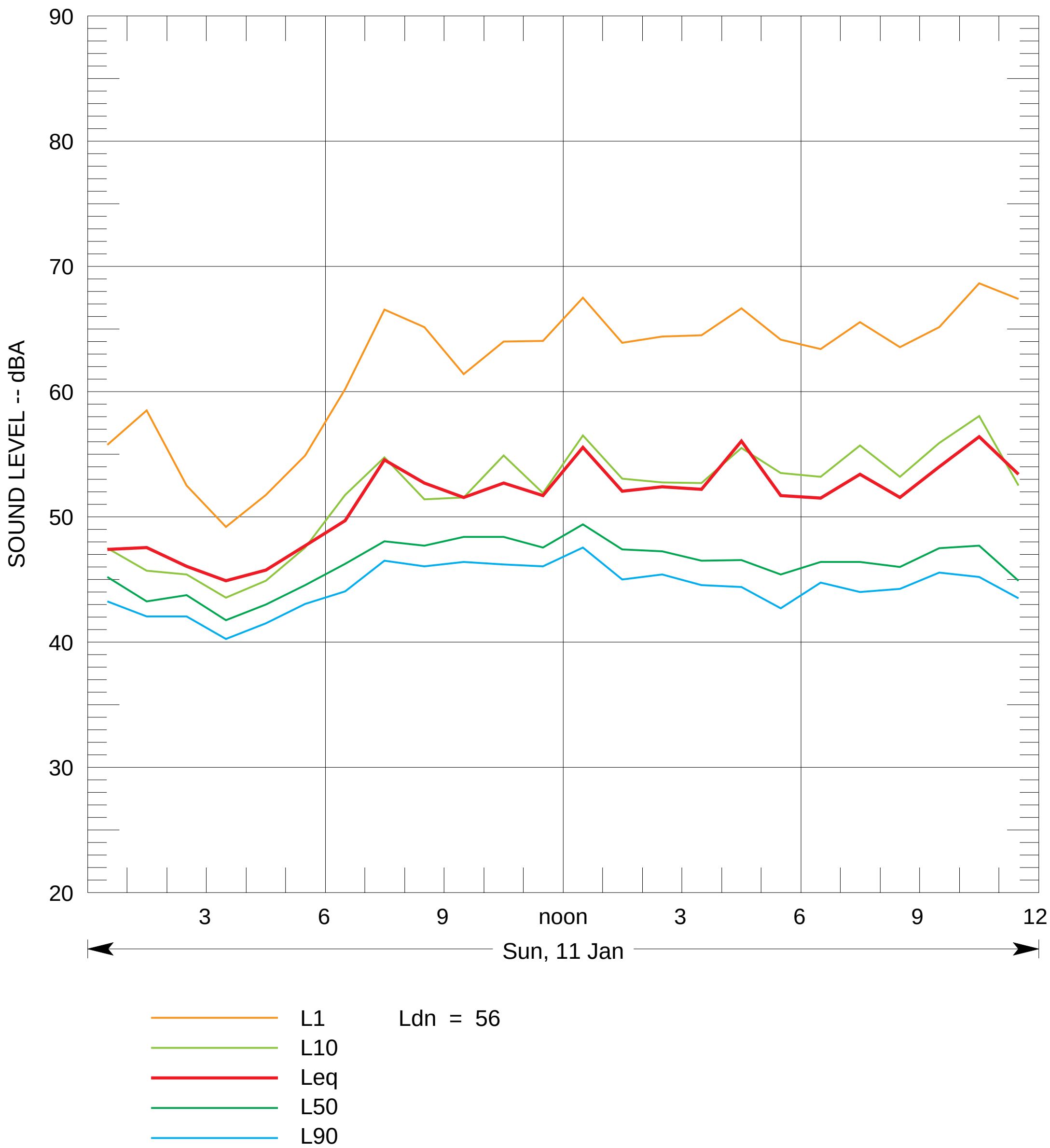


Figure A-8 Ambient Noise Levels Measured at Location N3
Donahue Street between Kirkwood Avenue & Jerrold Avenue
Sunday, 11 January 2009

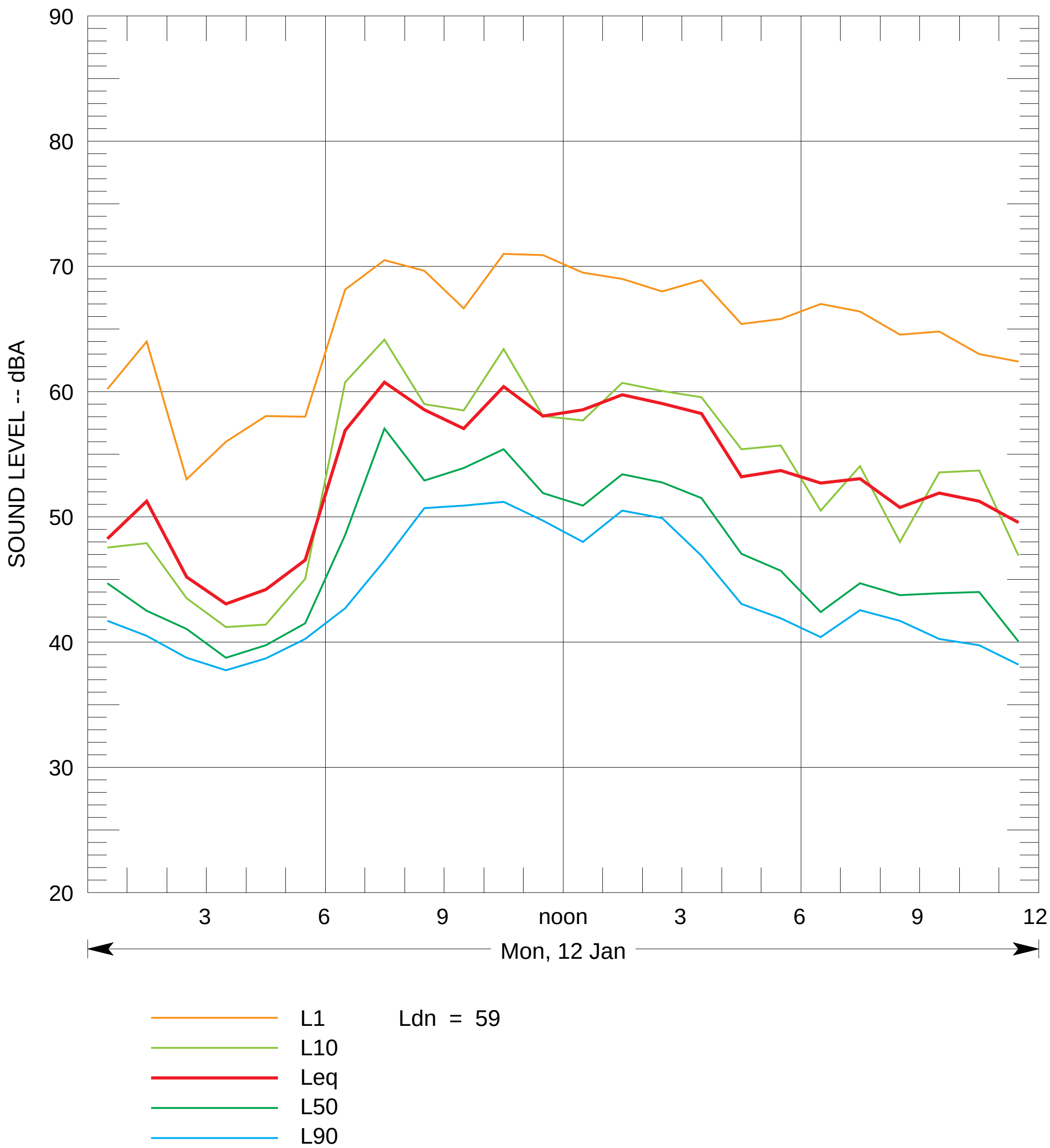


Figure A-9 Ambient Noise Levels Measured at Location N3
Donahue Street between Kirkwood Avenue & Jerrold Avenue
Monday, 12 January 2009

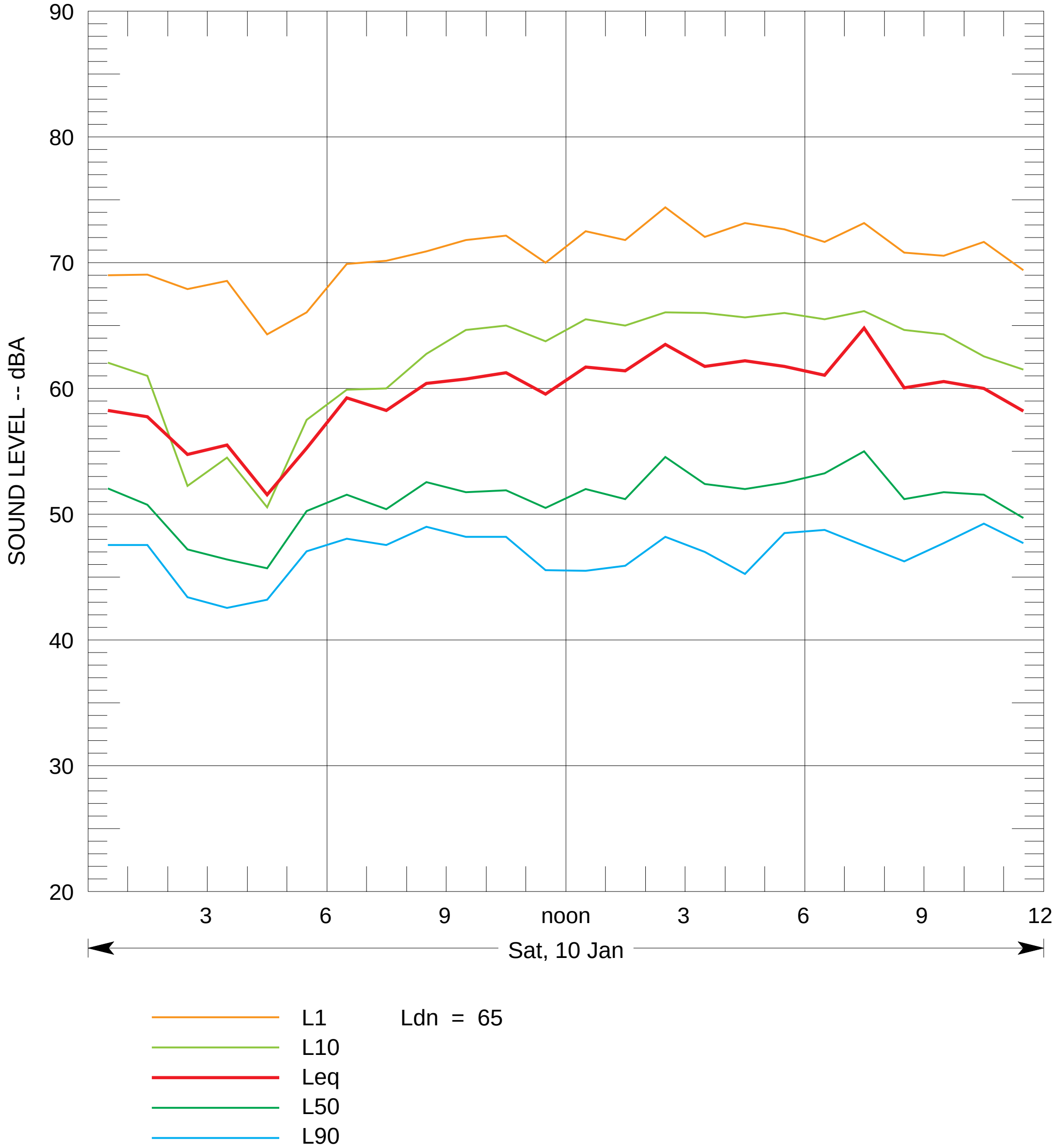


Figure A-10 Ambient Noise Levels Measured at Location N4
Kiska Road between Reardon Road & Ingalls Street
Saturday, 10 January 2009

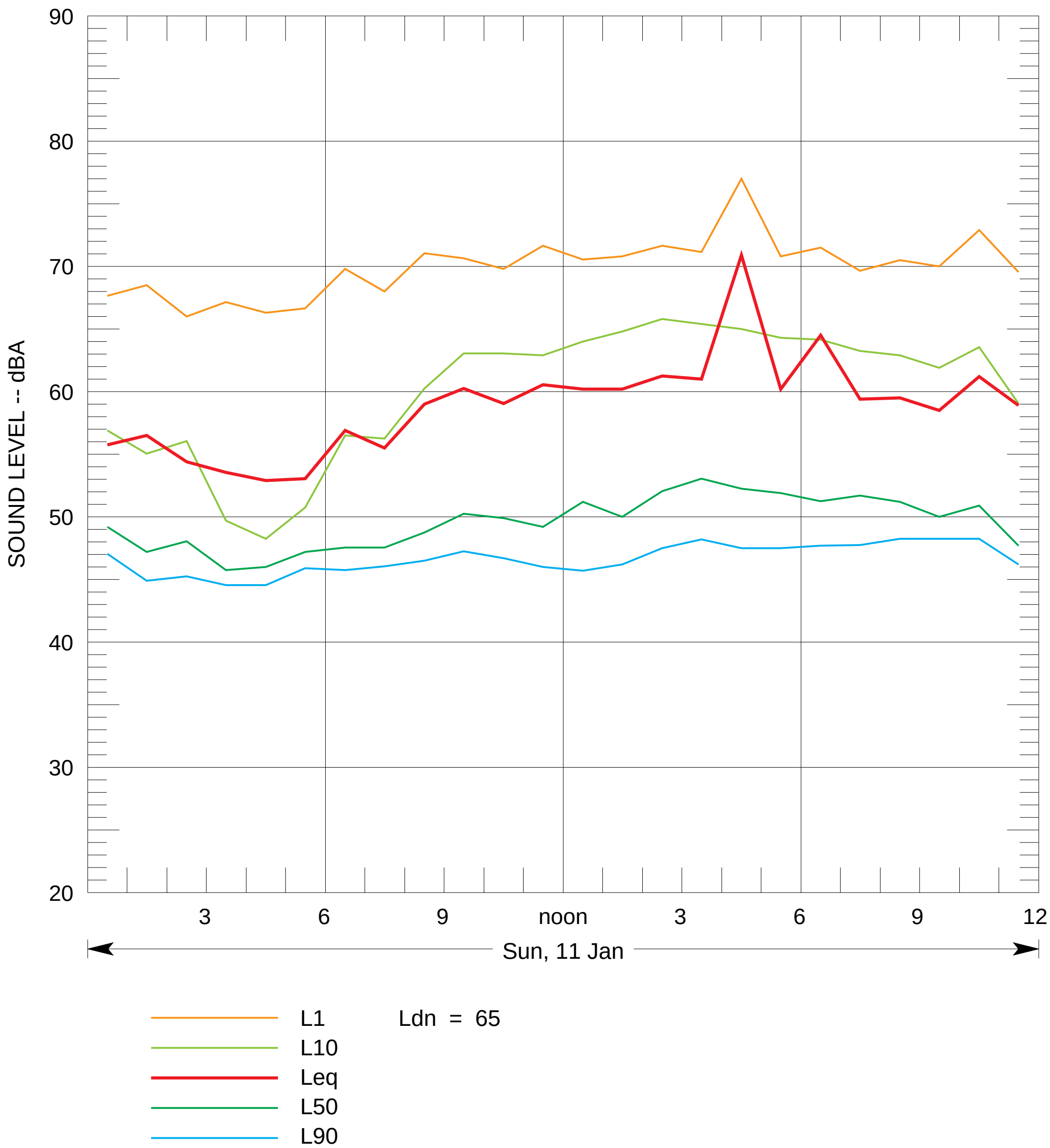


Figure A-11 Ambient Noise Levels Measured at Location N4
Kiska Road between Reardon Road & Ingalls Street
Sunday, 11 January 2009

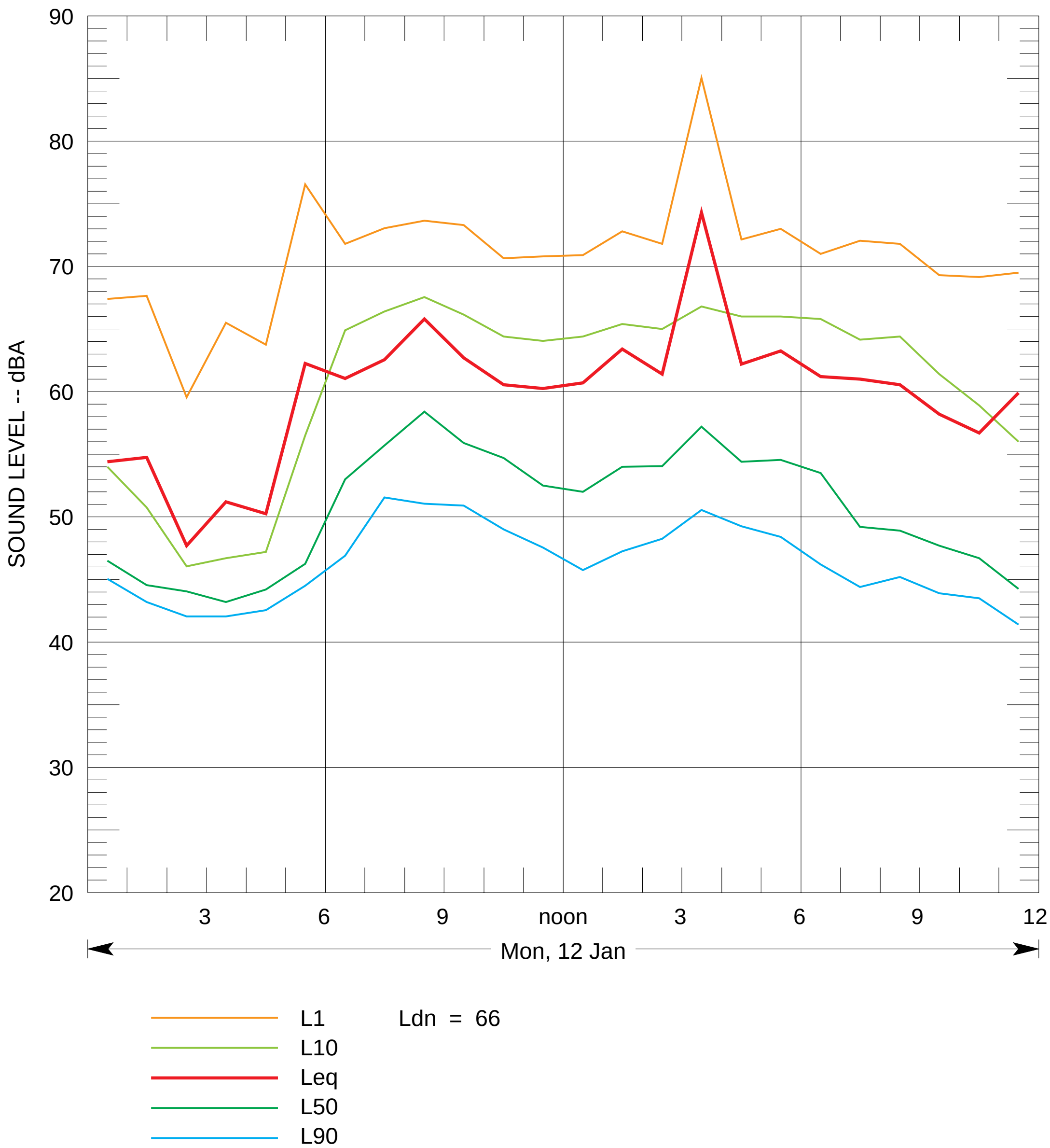


Figure A-12 Ambient Noise Levels Measured at Location N4
Kiska Road between Reardon Road & Ingalls Street
Monday, 12 January 2009

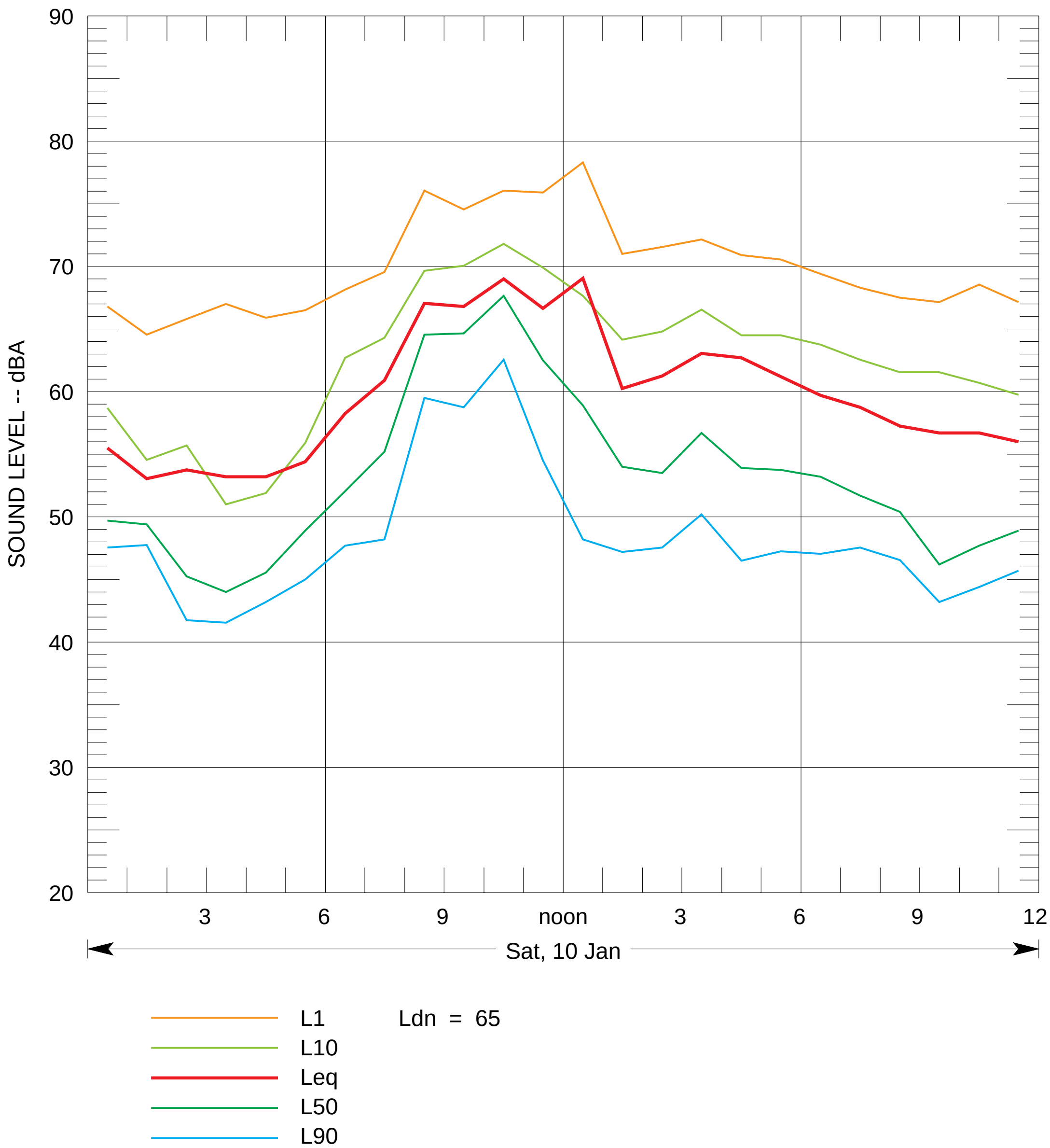


Figure A-13 Ambient Noise Levels Measured at Location N5
Hawes Street near Hunters Point Boulevard
Saturday, 10 January 2009

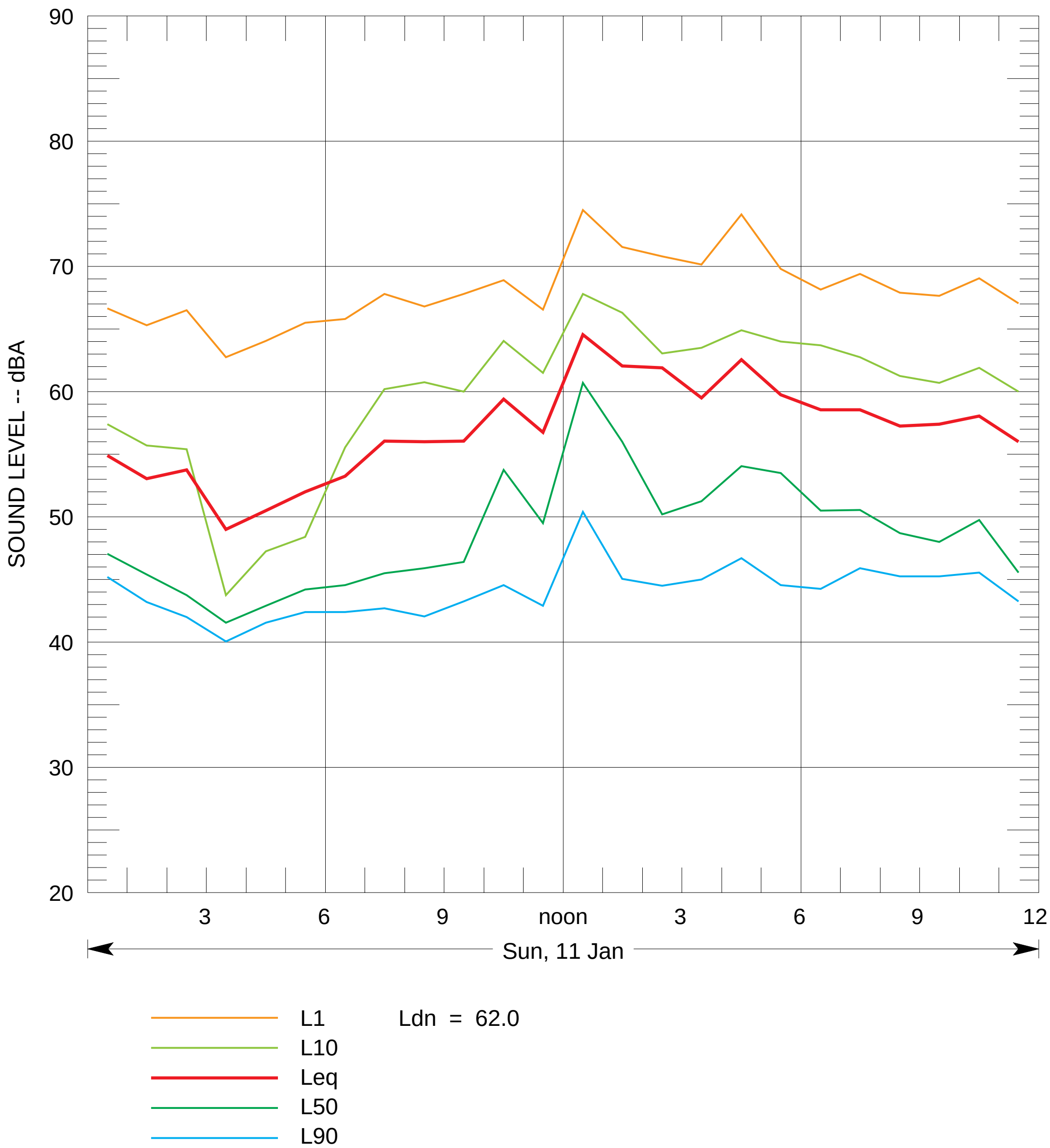


Figure A-14 Ambient Noise Levels Measured at Location N5
Hawes Street near Hunters Point Boulevard
Sunday, 11 January 2009

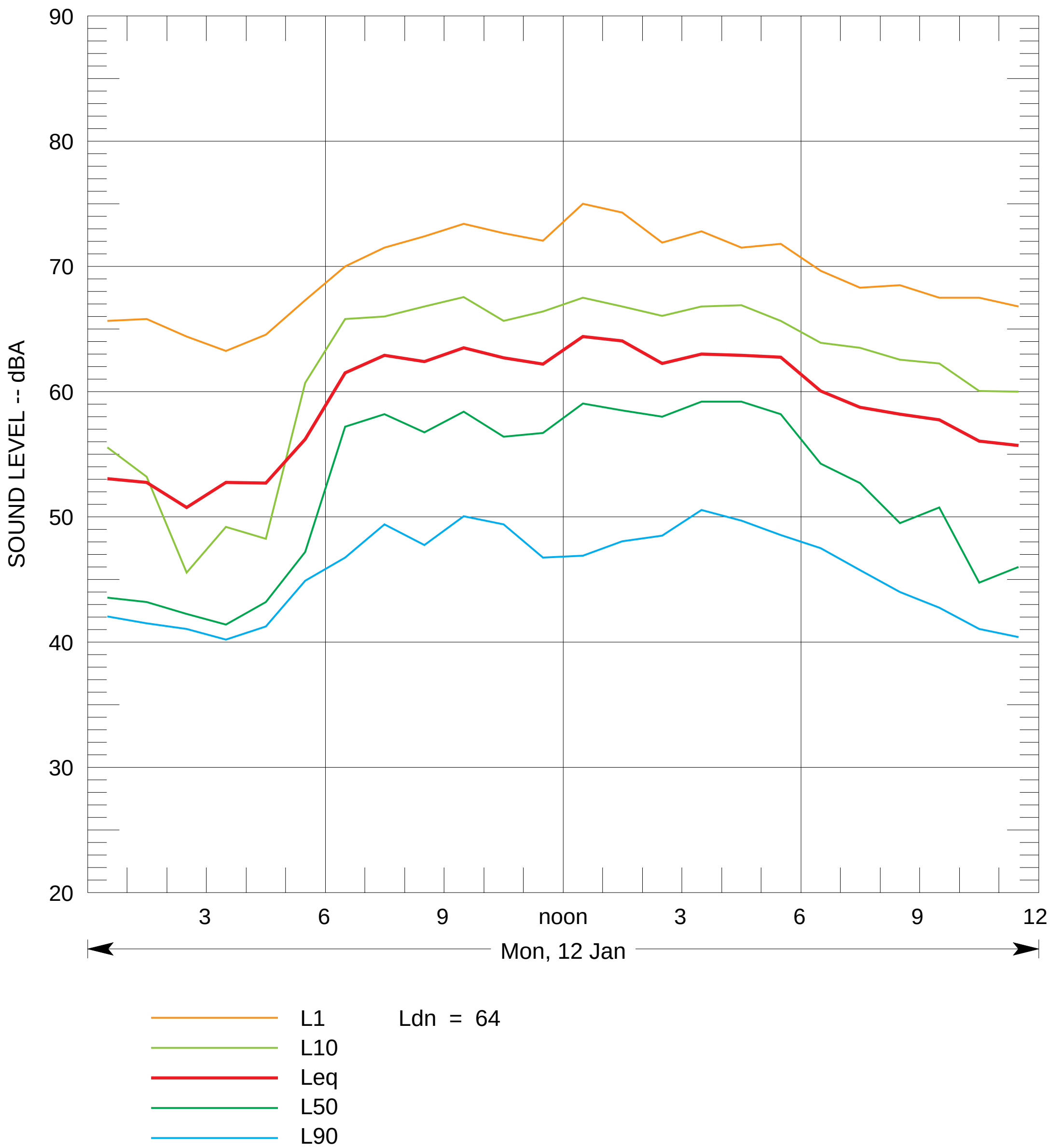


Figure A-15 Ambient Noise Levels Measured at Location N5
Hawes Street near Hunters Point Boulevard
Monday, 12 January 2009

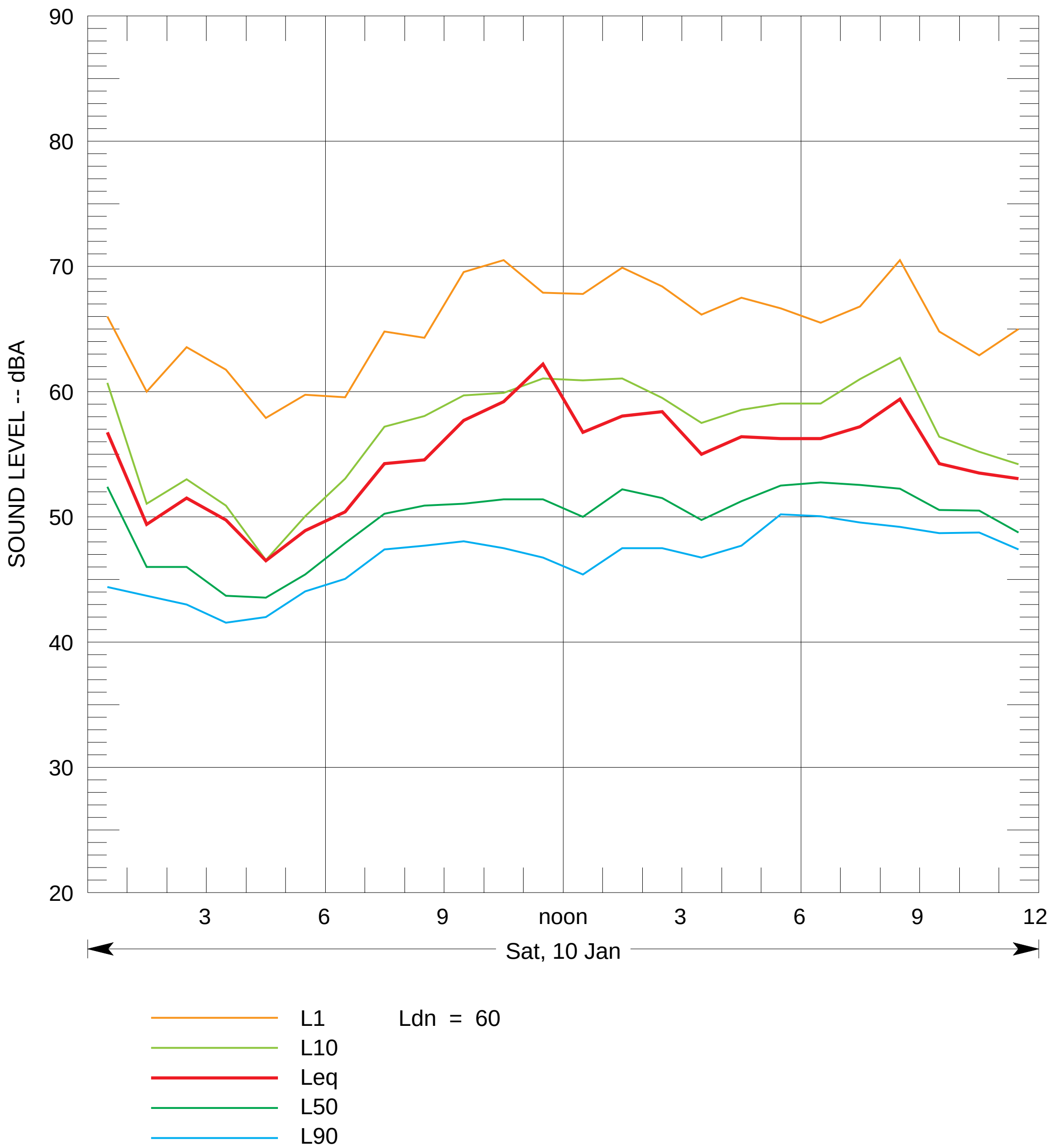


Figure A-16 Ambient Noise Levels Measured at Location N6
Jamestown Avenue at Hawes Street
Saturday, 10 January 2009

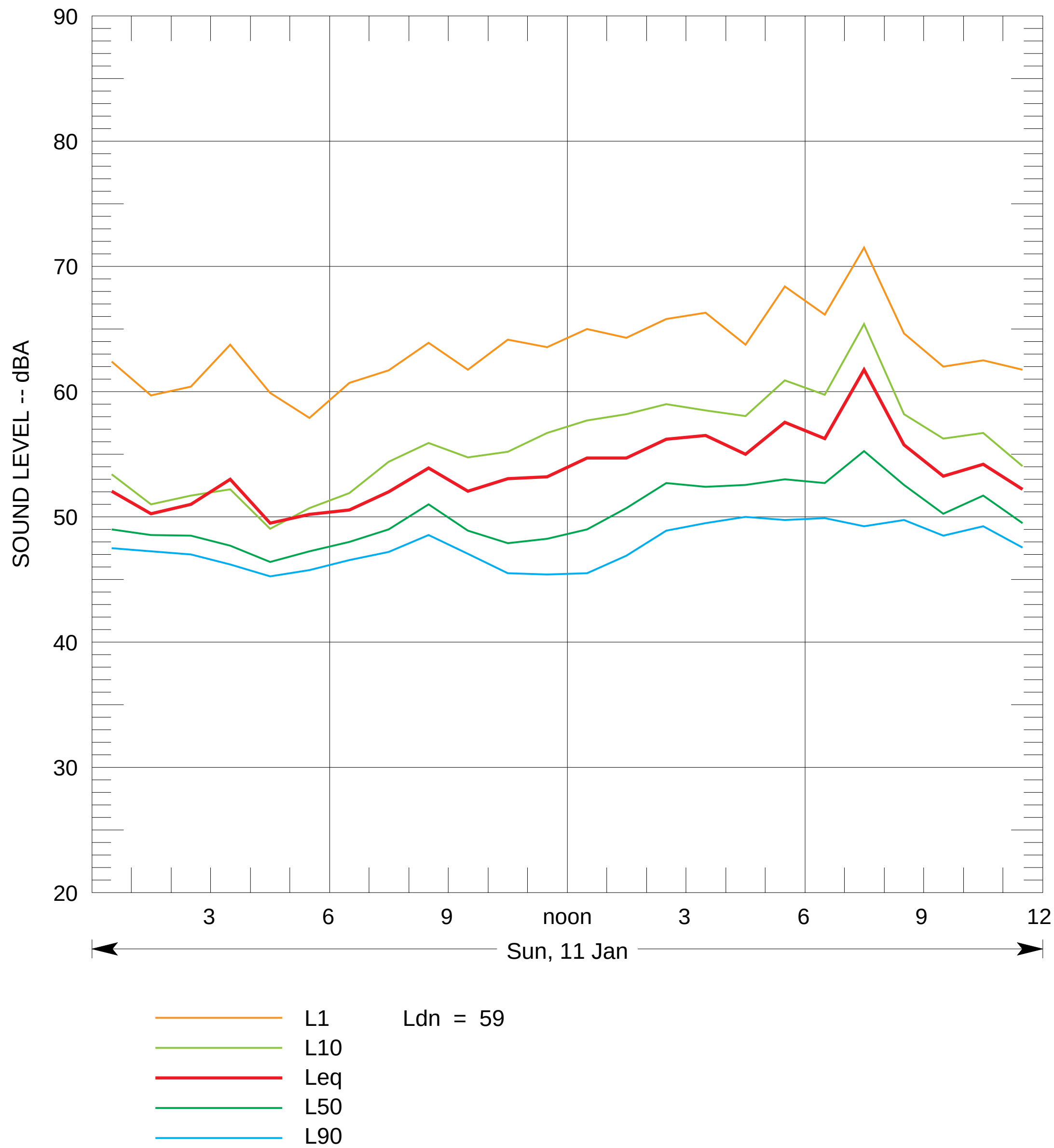


Figure A-17 Ambient Noise Levels Measured at Location N6
Jamestown Avenue at Hawes Street
Sunday, 11 January 2009

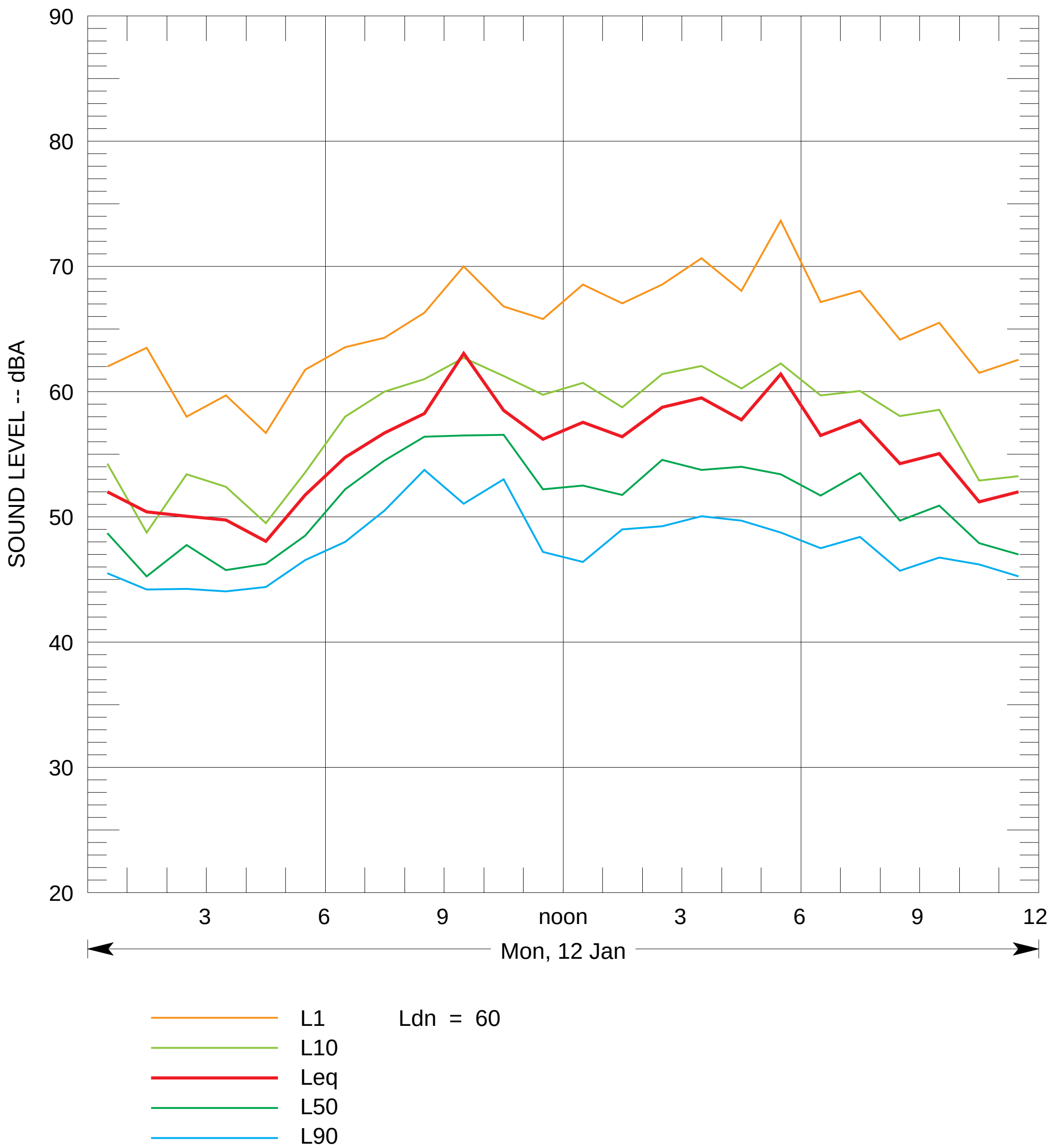


Figure A-18 Ambient Noise Levels Measured at Location N6
Jamestown Avenue at Hawes Street
Sunday, 12 January 2009

Appendix I2 PBS&J Short-Term Noise Measurements, May 20, 2009

MEASUREMENT DATASHEET: SHORT-TERM (AMBIENT): L1-10-50-90-95-99

Location # 1

Project: Bayview Hunter's Point	**Date:** 5/20/09	**Eqpt:** LD 820	**Photos:** Y
Temp: Hot Warm Mild Cool Cold	**Wind (mph):** ≤2.5 2.5-5 5-10 ≥10 (dir): N E S W Δ		**Cloud Cover:** Clear Pt. Cld. Clouds Fog
Location Desc.: Candlestick Condos	**Noise Source(s):** traffic on Candlestick, 101 and air traffic		
Rcp. Info: Residential	**Ground Effects:**		
Barrier Effects:			

Meas. Int.:

Roadway: Candlestick

Segment:

Spd: *Post:* *Trav.:*

Auto	MT	HT	Dir.
26	2	4	NB/EB
17	0	4	SB/WB

Meas. Int.:

Roadway:

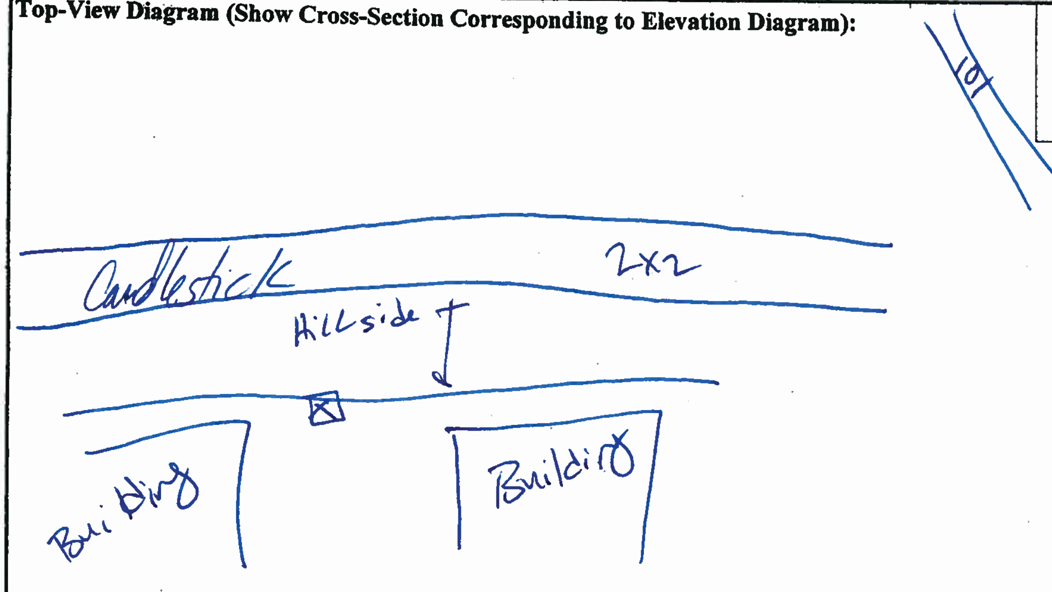
Segment:

Spd: *Post:* *Trav.:*

Auto	MT	HT	Dir.
			NB/EB
			SB/WB

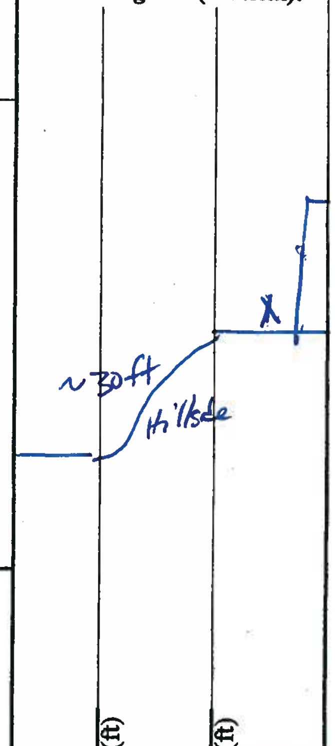
Cal. Δ @Int1		Cal. √		Offset
Yes	No	Int #:		

Top-View Diagram (Show Cross-Section Corresponding to Elevation Diagram):



Show North

Elv. Diagram (vertical):



General Comments:

Description	Int. #	Start (h:m(:s))	Duration ((h:)m:s)	SEL	Leq	Lmin	Lmax	L1	L10	L50	L90	L95	L99	Event/Anomaly Info Description	Lmax	Begin	End
		3:10	15mins		66.8	60.5	87.3		69.6	64.7	62.9	62.5					

11/4/97(MSR-FORM.XLS; ST 1-10-50-90-95-99)

Data File: ____________

Recorded By:

MEASUREMENT DATASHEET: SHORT-TERM (AMBIENT): L1-10-50-90-95-99 Location # 2

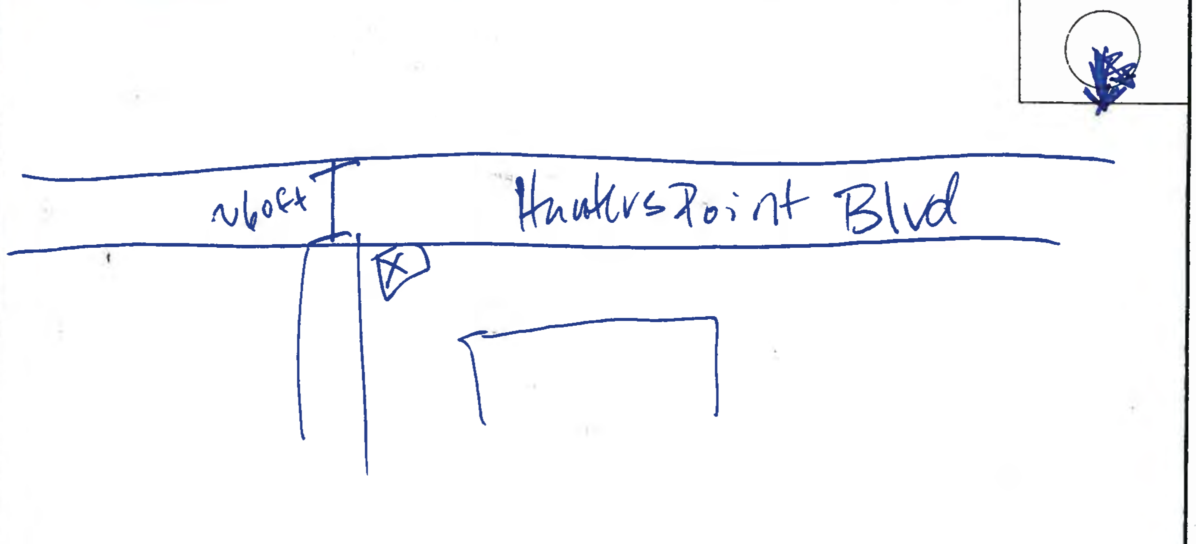
Project: Bayview Hunters Point	**Date:** 5/20/09	**Eqpt:** LD820	**Photos:** Y
Temp: Hot Warm Mild Cool Cold	**Wind (mph):** ≤2.5 2.5-5 5-10 ≥10 (dir): N E S W Δ		**Cloud Cover:** Clear Pt. Cld. Clouds Fog
Location Desc.: HuntersPointBlvd ~~[illegible]~~	**Noise Source(s):** traffic		
Rcp. Info: Residential	**Ground Effects:** pavement		
Barrier Effects: None			

Meas. Int.:			
Roadway: HuntersPoint			
Segment:			
Spd: *Post:* *Trav.:*			
Volumes			
Auto	**MT**	**HT**	**Dir.**
[illegible]	2	0	NB/EB
24	3	2	SB/WB

Meas. Int.:			
Roadway:			
Segment:			
Spd: *Post:* *Trav.:*			
Volumes			
Auto	**MT**	**HT**	**Dir.**
			NB/EB
			SB/WB

Top-View Diagram (Show Cross-Section Corresponding to Elevation Diagram):

Show North



Elv. Diagram (vertical):

(ft) (ft)

General Comments: sirens in distance

Cal. Δ @Int1		Cal. √		Offset
Yes	No	Int #:		

Description	Int. #	Start (h:m(:s))	Duration ((h:)m:s)	SEL	Leq	Lmin	Lmax	L1	L10	L50	L90	L95	L99	Event/Anomaly Info Description	Lmax	Begin	End
		4:00	15		67.8	47.1	86.3		70.9	55.7	50.6	49.9					

11/4/97(MSR-FORM.XLS; ST 1-10-50-90-95-99) **Data File:** ______ **Recorded By:**

MEASUREMENT DATASHEET: SHORT-TERM (AMBIENT): L1-10-50-90-95-99 Location # 3

Project: Bayview/HP	**Date:** 5/20/09	**Eqpt:**	**Photos:**
Temp: Hot Warm Mild Cool Cold	**Wind (mph):** ≤2.5 2.5-5 5-10 ≥10 (dir): N E S W Δ	**Cloud Cover:** Clear Pt. Cld. Clouds Fog	
Location Desc.:	**Noise Source(s):**		
Rcp. Info:	**Ground Effects:**		
Barrier Effects:			

Meas. Int.:

Roadway: palou

Segment: W/o Jennings

Spd: *Post:* ***Trav.:***

Volumes			
Auto	MT	HT	Dir.
27	3	0	NB/EB
34	2	0	SB/WB

Meas. Int.:

Roadway:

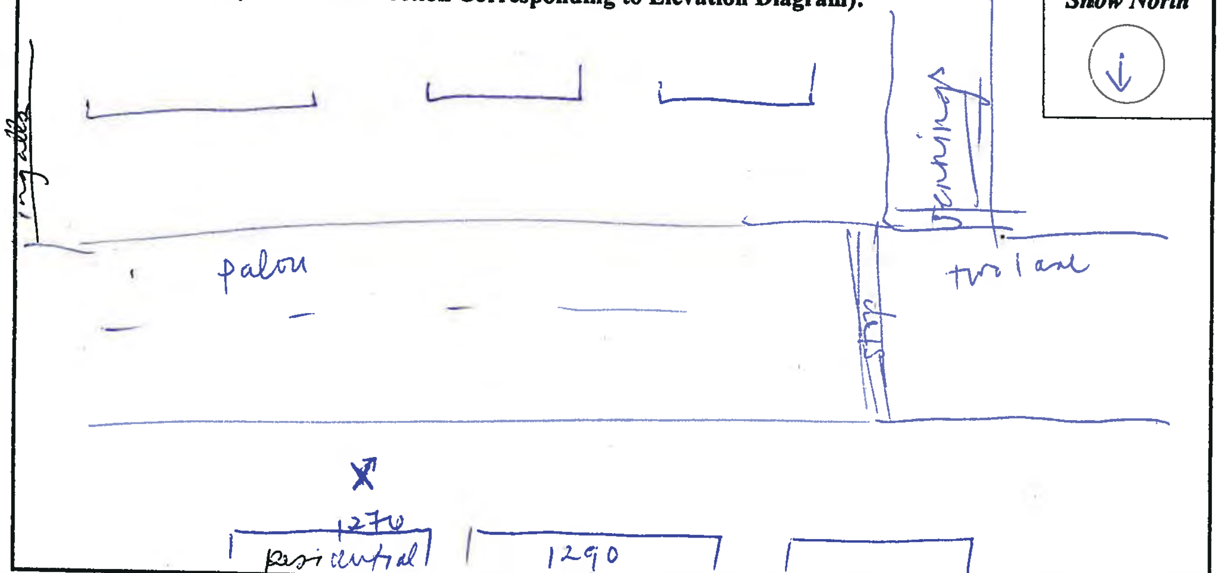
Segment:

Spd: *Post:* ***Trav.:***

Volumes			
Auto	MT	HT	Dir.
			NB/EB
			SB/WB

Cal. Δ @Int1		Cal. √	Offset
Yes	No	Int #:	

Top-View Diagram (Show Cross-Section Corresponding to Elevation Diagram):



Show North

Elv. Diagram (vertical):

(ft) (ft)

General Comments: Majority cars, people walking/talking. car starting, door slamming, [illegible]

Description	Int. #	Start (h:m(:s))	Duration ((h:)m:s)	SEL	Leq	Lmin	Lmax	L1	L10	L50	L90	L95	L99	Event/Anomaly Info Description	Lmax	Begin	End
		4:25	15min		65.8	51.6	84.4		68.7	60.1	54.4	53.9					

11/4/97(MSR-FORM.XLS; ST 1-10-50-90-95-99) **Data File:** ______ **Recorded By:**

MEASUREMENT DATASHEET: SHORT-TERM (AMBIENT): L1-10-50-90-95-99

Location # 4

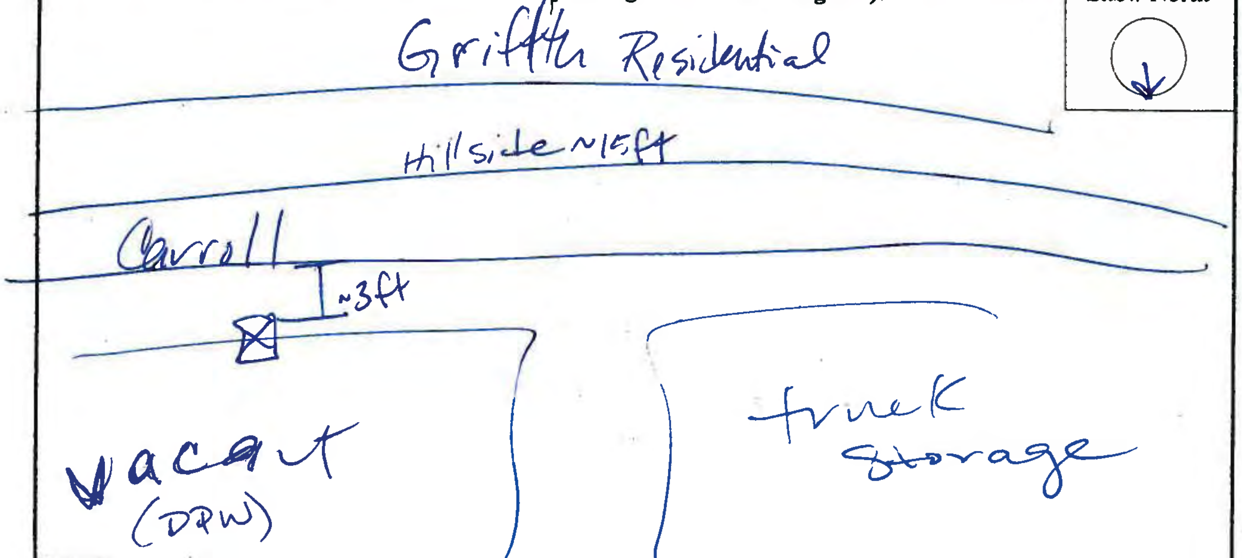
Project: Bayview Hunters Point	**Date:** 5/20/09	**Eqpt:** LD820		**Photos:** Y	
Temp: Hot Warm Mild Cool Cold	**Wind (mph):** ≤2.5 2.5-5 5-10 ≥10	**(dir):** N E S W Δ	**Cloud Cover:** Clear Pt. Cld. Clouds Fog		
Location Desc.: Carroll / Griffith	**Noise Source(s):** traffic				
Rcp. Info: None/Residential across street	**Ground Effects:** pavement				
Barrier Effects: None					

Meas. Int.:			
Roadway: Carroll			
Segment:			
Spd: *Post:*	*Trav.:*		
Volumes			
Auto	**MT**	**HT**	**Dir.**
12	1	∅	NB/EB
6	1	∅	SB/WB

Meas. Int.:			
Roadway:			
Segment:			
Spd: *Post:*	*Trav.:*		
Volumes			
Auto	**MT**	**HT**	**Dir.**
			NB/EB
			SB/WB

Cal. Δ @Int1		**Cal. √**	**Offset**
Yes	No	Int #:	

Top-View Diagram (Show Cross-Section Corresponding to Elevation Diagram):



Show North

Elv. Diagram (vertical):

(ft) (ft)

General Comments:

Description	Int. #	Start (h:m(:s))	Duration ((h:)m:s)	SEL	Leq	Lmin	Lmax	L1	L10	L50	L90	L95	L99	Event/Anomaly Info Description	Lmax	Begin	End
		4:50	15min		64.8	46.9	88.0		64.1	51.5	48.9	48.6					

Data File: ____________ **Recorded By:**

MEASUREMENT DATASHEET: SHORT-TERM (AMBIENT): L1-10-50-90-95-99 — Location # 5

Project: Bayview Hunters Point	**Date:** 5/20/09	**Eqpt:** LD820	**Photos:**
Temp: Hot Warm Mild Cool Cold	**Wind (mph):** ≤2.5 2.5-5 5-10 ≥10 (dir): N E S W Δ		**Cloud Cover:** Clear Pt. Cld. Clouds Fog
Location Desc.: Gilman	**Noise Source(s):** traffic		
Rcp. Info: Residential/School	**Ground Effects:** Pavement		
Barrier Effects: None			

Meas. Int.:

Roadway: Gilman

Segment:

Spd: *Post:* *Trav.:*

Volumes			
Auto	MT	HT	Dir.
16	1	0	NB/EB
10	0	0	SB/WB

Meas. Int.:

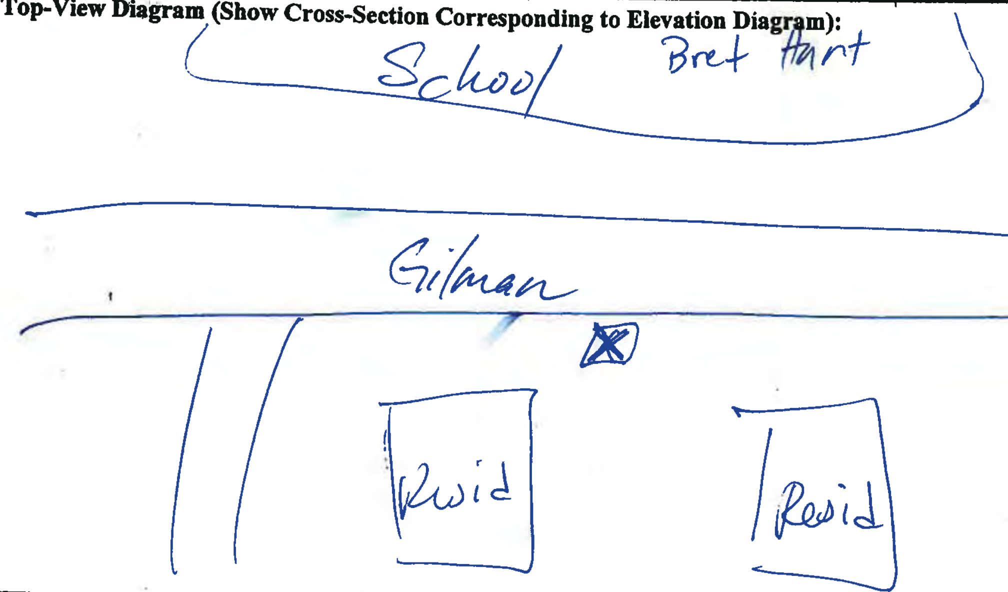
Roadway:

Segment:

Spd: *Post:* *Trav.:*

Volumes			
Auto	MT	HT	Dir.
			NB/EB
			SB/WB

Top-View Diagram (Show Cross-Section Corresponding to Elevation Diagram):



Show North

Elv. Diagram (vertical):

(ft) (ft)

General Comments:

Cal. Δ @Int1		Cal. √		Offset
Yes	No	Int #:		

Description	Int. #	Start (h:m(:s))	Duration ((h:)m:s)	SEL	Leq	Lmin	Lmax	L1	L10	L50	L90	L95	L99	Event/Anomaly Info Description	Lmax	Begin	End
		5:20	15min		61.4	52.4	78.9		64.1	57.0	54.2	53.9					

11/4/97(MSR-FORM.XLS; ST 1-10-50-90-95-99) **Data File:** ______ **Recorded By:**

Appendix I3 PBS&J Traffic Noise Model Output, October 6, 2009

PBSJ							**6 October 2009**					
NI							**TNM 2.5**					
							Calculated with TNM 2.5					
RESULTS: SOUND LEVELS												
PROJECT/CONTRACT:		**Candlestick Hunters Point**										
RUN:		**Existing**										
BARRIER DESIGN:		**INPUT HEIGHTS**						**Average pavement type shall be used unless**				
								a State highway agency substantiates the use				
ATMOSPHERICS:		**68 deg F, 50% RH**						**of a different type with approval of FHWA.**				

Receiver												
Name	**No.**	**#DUs**	**Existing**	**No Barrier**					**With Barrier**			
			LAeq1h	**LAeq1h**		**Increase over existing**		**Type**	**Calculated**	**Noise Reduction**		
				Calculated	**Crit'n**	**Calculated**	**Crit'n**	**Impact**	**LAeq1h**	**Calculated**	**Goal**	**Calculated**
							Sub'l Inc					**minus**
												Goal
			dBA	dBA	dBA	dB	dB		dBA	dB	dB	dB
Innes	1	1	0.0	55.3	66	55.3	10	----	55.3	0.0	8	-8.0
3rd Street north of Palou	2	1	0.0	64.0	66	64.0	10	----	64.0	0.0	8	-8.0
Cesar Chavez	3	1	0.0	61.4	66	61.4	10	----	61.4	0.0	8	-8.0
Palou	4	1	0.0	58.8	66	58.8	10	----	58.8	0.0	8	-8.0
Ingalls	5	1	0.0	58.7	66	58.7	10	----	58.7	0.0	8	-8.0
Carroll	8	1	0.0	54.6	66	54.6	10	----	54.6	0.0	8	-8.0
Gilman	10	1	0.0	59.7	66	59.7	10	----	59.7	0.0	8	-8.0
Jamestown	11	1	0.0	53.4	66	53.4	10	----	53.4	0.0	8	-8.0
Harvey Way residences	12	1	0.0	54.6	66	54.6	10	----	54.6	0.0	8	-8.0
Bayshore residences	14	1	0.0	67.1	66	67.1	10	Snd Lvl	67.1	0.0	8	-8.0

Dwelling Units	**# DUs**	**Noise Reduction**		
		Min	**Avg**	**Max**
		dB	**dB**	**dB**
All Selected	10	0.0	0.0	0.0
All Impacted	1	0.0	0.0	0.0
All that meet NR Goal	0	0.0	0.0	0.0

PBSJ **6 October 2009**
NI **TNM 2.5**
Calculated with TNM 2.5

RESULTS: SOUND LEVELS
PROJECT/CONTRACT: **Candlestick Hunters Point**
RUN: **Future**
BARRIER DESIGN: **INPUT HEIGHTS**
ATMOSPHERICS: **68 deg F, 50% RH**

Average pavement type shall be used unless a State highway agency substantiates the use of a different type with approval of FHWA.

Receiver Name	No.	#DUs	Existing LAeq1h	No Barrier LAeq1h Calculated	Crit'n	Increase over existing Calculated	Crit'n Sub'l Inc	Type Impact	With Barrier Calculated LAeq1h	Noise Reduction Calculated	Goal	Calculated minus Goal
			dBA	dBA	dBA	dB	dB		dBA	dB	dB	dB
Innes	1	1	0.0	62.9	66	62.9	10	----	62.9	0.0	8	-8.0
3rd Street north of Palou	2	1	0.0	69.3	66	69.3	10	Snd Lvl	69.3	0.0	8	-8.0
Cesar Chavez	3	1	0.0	65.5	66	65.5	10	----	65.5	0.0	8	-8.0
Palou	4	1	0.0	63.6	66	63.6	10	----	63.6	0.0	8	-8.0
Ingalls	5	1	0.0	63.7	66	63.7	10	----	63.7	0.0	8	-8.0
Griffith Park	8	1	0.0	55.8	66	55.8	10	----	55.8	0.0	8	-8.0
Gilman	10	1	0.0	62.6	66	62.6	10	----	62.6	0.0	8	-8.0
Jamestown	11	1	0.0	57.5	66	57.5	10	----	57.5	0.0	8	-8.0
Harvey Way residences	12	1	0.0	61.1	66	61.1	10	----	61.1	0.0	8	-8.0
Bayshore residences	14	1	0.0	70.5	66	70.5	10	Snd Lvl	70.5	0.0	8	-8.0

Dwelling Units	# DUs	Noise Reduction Min	Avg	Max
		dB	dB	dB
All Selected	10	0.0	0.0	0.0
All Impacted	2	0.0	0.0	0.0
All that meet NR Goal	0	0.0	0.0	0.0

PBSJ							**6 October 2009**					
NI							**TNM 2.5**					
							Calculated with TNM 2.5					
RESULTS: SOUND LEVELS												
PROJECT/CONTRACT:		**Candlestick Hunters Point**										
RUN:		**Future with Project**										
BARRIER DESIGN:		**INPUT HEIGHTS**						**Average pavement type shall be used unless**				
								a State highway agency substantiates the use				
ATMOSPHERICS:		**68 deg F, 50% RH**						**of a different type with approval of FHWA.**				

Receiver												
Name	**No.**	**#DUs**	**Existing**	**No Barrier**					**With Barrier**			
			LAeq1h	**LAeq1h**		**Increase over existing**		**Type**	**Calculated**	**Noise Reduction**		
				Calculated	**Crit'n**	**Calculated**	**Crit'n**	**Impact**	**LAeq1h**	**Calculated**	**Goal**	**Calculated**
							Sub'l Inc					**minus**
												Goal
			dBA	dBA	dBA	dB	dB		dBA	dB	dB	dB
Innes	1	1	0.0	62.9	66	62.9	10	----	62.9	0.0	8	-8.0
3rd Street north of Palou	2	1	0.0	70.3	66	70.3	10	Snd Lvl	70.3	0.0	8	-8.0
Cesar Chavez	3	1	0.0	65.5	66	65.5	10	----	65.5	0.0	8	-8.0
Palou	4	1	0.0	64.1	66	64.1	10	----	64.1	0.0	8	-8.0
Ingalls	5	1	0.0	65.1	66	65.1	10	----	65.1	0.0	8	-8.0
Griffith Park	8	1	0.0	60.3	66	60.3	10	----	60.3	0.0	8	-8.0
Gilman	10	1	0.0	65.8	66	65.8	10	----	65.8	0.0	8	-8.0
Jamestown	11	1	0.0	64.3	66	64.3	10	----	64.3	0.0	8	-8.0
Harvey Way residences	12	1	0.0	61.6	66	61.6	10	----	61.6	0.0	8	-8.0
Bayshore residences	14	1	0.0	70.8	66	70.8	10	Snd Lvl	70.8	0.0	8	-8.0

Dwelling Units	**# DUs**	**Noise Reduction**		
		Min	**Avg**	**Max**
		dB	**dB**	**dB**
All Selected	10	0.0	0.0	0.0
All Impacted	2	0.0	0.0	0.0
All that meet NR Goal	0	0.0	0.0	0.0

Appendix J Page & Turnbull Secretary's Standards Evaluation of Proposed Treatments for Dry Docks 2, 3, and 4, October 5, 2009

DATE	October 5, 2009	PROJECT NO.	09061a
TO	Therese A. Brekke	PROJECT NAME	Hunters Point Shipyard
OF	Lennar Urban 49 Stevenson Street, Ste. 600 San Francisco, CA 94105 415.344.8853	FROM	Lada Kocherovsky and Richard Sucré
CC		VIA	Email

REGARDING : SECRETARY'S STANDARDS EVALUATION OF PROPOSED TREATMENTS FOR DRY DOCKS 2, 3 AND 4

This memorandum provides an evaluation of the proposed treatments planned for Dry Docks #2, #3, and #4, which are part of the Hunters Point Shipyard. These treatments are part of the proposed project being undertaken by Lennar Urban for the Candlestick Point/Hunters Point Redevelopment Project. The three dry docks under review will no longer be used as dry docks, and will function as elements of the shoreline flanked by public open space. As part of the proposed project, the area surrounding Dry Docks #2 and #3 will be known as Heritage Park, while the area surrounding Dry Dock #4 will be known as the Waterfront Promenade. Both areas will feature a park-like setting. The proposed treatments have been outlined by Moffatt & Nichol in a series of reports, which study the dry docks and shoreline, including:

- Moffatt & Nichol, *Candlestick Point/Hunters Point Redevelopment Project, Proposed Shoreline Improvements* (September 2009);
- Moffatt & Nichol, *Hunters Point Shoreline Structures Rapid Reconnaissance Investigation* (June 2009); and
- Moffatt & Nichol, *Hunters Point Shoreline Structures Assessment* (August 2009).

Dry Docks #2 and #3 are contributing elements of the Hunters Point Commercial Dry Dock and Naval Shipyard Historic District, which has been determined to be eligible for listing in the National Register of Historic Places (National Register). Dry Dock #4 has been individually recognized as a structure, which is eligible for listing in the National Register. Therefore, Dry Docks #2, #3, and #4 are considered to be historic resources.

This memorandum also addresses the requirements outlined in the Memorandum of Agreement (MOA) between the United States Navy, the Advisory Council on Historic Preservation, and the California State Historic Preservation Officer regarding the interim leasing and disposal of historic properties on the former Hunters Point Naval Shipyard in San Francisco, California. As noted in the MOA:

> *5. Leasing of Historic Properties*
>
> *a. Prior to the transfer, sale or conveyance by some other means from the control and jurisdiction of the Navy, the Navy may enter into interim leases which will permit tenants to adaptively reuse Shipyard's National Register eligible properties, provided that the lease agreements require tenants to follow the recommended practices of the Secretary of the Interior's Standards for Rehabilitation and Guidelines for Rehabilitating Historic Buildings (Standards) in maintaining or adapting these historic properties for use.*

b. Until the Shipyard's National Register eligible properties are transferred, sold, or conveyed by some other means from the control and jurisdiction of the Navy, the Navy shall require the Agency to seek the comments of the San Francisco Landmarks Preservation Advisory Board prior to seeking Navy approval for adaptive reuses of Drydock 4 and the Hunters Point Commercial Drydock Historic District.

This memorandum analyzes the proposed treatments outlined for Dry Docks #2, #3, and #4, and would satisfy the requirements of the MOA. It should be noted that the San Francisco Landmarks Preservation Advisory Board has been replaced by the San Francisco Historic Preservation Commission.

Description: Dry Dock #2

Dry Dock #2 was completed in 1903 and was constructed as part of the San Francisco Dry Dock Company (formerly California Dry Dock Company and the predecessor to the Hunter Point Naval Shipyard). As noted in the DPR 523 forms completed by Circa: Historic Property Development in June 2008:

Dry dock 2 is a graving dry dock, measuring 750' by 122' at ground level and 712' by 74' at the base. It is approximately 30 feet deep. The dry dock was filled through 13, 30-inch culverts in the steel caisson. A discharge channel runs east from the dry dock to the Bay (NAVSEA). Typical of many dry docks, it was constructed in a terraced manner, with a regular series of shelf-like ridges excavated into the bedrock. The basin was lined primarily in concrete and at the gates, just above water level, the basin is lined with what appear to be granite blocks. The gates and gate structures were removed sometime after 1988 and the dry dock can no longer be dewatered (JRP). The crane ways, railroad spurs, perimeter fence, bollards and other site features are largely intact.

In the *Hunters Point Shoreline Structures Rapid Reconnaissance Investigation,* Moffatt & Nichol provide a description of all three dry docks, as follows:

Dry Docks 2, 3, and 4 consist primarily of concrete walls. Cross-sectional shape varies within these dry docks, ranging from trapezoidal to rectangular sections. The bottom surfaces are concrete. The sides are constructed of smooth-surfaced reinforced concrete walls and stepped reinforced concrete walls. Concrete steps are found at various locations along the sides. Concrete overhangs with hand railing are found intermittently above the waterline.[1]

Description: Dry Dock #3

Dry Dock #3 was completed in 1918, and was constructed to replace the original dry dock (Dry Dock #1), which was constructed in 1867. As noted in the DPR 523 forms completed by Circa: Historic Property Development in June 2008:

Dry dock 3 is a graving dry dock that is located north of and parallel to Dry dock 2. It measures 1,076' by 153' at ground level and 1,020' by 110' at the bottom. A channel for water from Dry dock 3 passes in a straight line north from the dry dock through Pumphouse 3 (Building 140) to the Bay (NAVSEA). Like Dry dock 2, it was constructed in a terraced manner, with a regular series of shelf-like ridges constructed to create the basin. The basin was then lined primarily in concrete and at the gates, just above water level, the

[1] Moffatt & Nichol, *Hunters Point Shoreline Structures Rapid Reconnaissance Investigation* (June 2009) 3.

basin is lined with stone blocks. The gates and gate structures were removed sometime after 1988 and the dry dock can no longer be dewatered (JRP). The crane ways, railroad spurs, perimeter fence, bollards and other site features are largely intact.

<u>*Description: Dry Dock #4*</u>

Dry Dock #4 was completed in 1943 by naval architect and engineer Hugo Fear and the Pacific Bridge Company. It is noted as one of the largest graving dry docks on the Pacific Coast is one of the largest of its kind in the world. As noted in the DPR 523 forms completed by Circa: Historic Property Development in August 2008:

Dry Dock 4 is 1,092' by 143' northwest to southeast, 143' east to west and 53-foot-deep concrete graving dry dock, with a rounded northwest end. Access steps are recessed into the sloped sidewalls and the floor is flat. The dry dock is outlined by a crane track that permits access to ships in the dock from all angles. Two or more smaller ships could be docked for servicing at the same time. A caisson or closing gate is located at the south end of the dry dock and the drainage system runs from the southeast corner of the structure eastward to the Bay. Crane ways, rail spurs, bollards and cleats surround the dry dock at ground level and are still extant.

Dry Dock #4 is a graving dock. A graving dock is cut (engraved) into the base rock, as opposed to a floating dry dock that is constructed of wood and other materials and has no foundation other than water. Graving docks; when located adjacent to deep water channels, supported by land transportation systems, and work forces, are the more efficient. They are also stable and require less maintenance than the floating dry dock. For these reasons graving dry docks are preferred, particularly for servicing large ships.

In *Hunters Point Shoreline Structures Assessment*, Moffatt & Nichol describe Dry Dock #4 as:

Drydock no. 4 is a reinforced concrete structure with concrete sidewalls. The cross section of the drydock varies in trapezoidal shapes the entrance has steeper sloping walls compared to the main drydock with flatter sloping walls. It is larger compared to drydocks 2 and 3.[2]

---

[2] Moffatt & Nichol, *Hunters Point Shoreline Structures Assessment* (August 2009) 5.
[3] Moffatt & Nichol, *Hunters Point Shoreline Structures Rapid Reconnaissance Investigation* (June 2009) 6.
[4] Moffatt & Nichol, *Hunters Point Shoreline Structures Assessment* (August 2009) 13.
[5] Moffatt & Nichol, *Hunters Point Shoreline Structures Rapid Reconnaissance Investigation* (June 2009) 10.
[6] Moffatt & Nichol, *Candlestick Point/Hunters Point Redevelopment Project, Proposed Shoreline Improvements* (September 2009) 9-10.
[7] Moffatt & Nichol, *Hunters Point Shoreline Structures Assessment* (August 2009) 21.
[8] Morton, W. Brown III, Gary L. Hume, Kay D. Weeks, and H. Ward Jandl, *Secretary of the Interior's Standards for Rehabilitation & Illustrated Guidelines for Rehabilitating Historic Buildings* (Washington, D.C.: U.S. Department of the Interior, National Park Service, Cultural Resources, Preservation Assistance Division, 1992). The *Standards*, revised in 1992, were codified as 36 CFR Part 68.3 in the July 12, 1995 Federal Register (Vol. 60, No. 133). The revision replaces the 1978 and 1983 versions of 36 CFR 68 entitled *The Secretary of the Interior's Standards for Historic Preservation Projects*. The 36 CFR 68.3 *Standards* are applied to all grant-in-aid development projects assisted through the National Historic Preservation Fund. Another set of *Standards*, 36 CFR 67.7, focuses on "certified historic structures" as defined by the IRS Code of 1986. *The Standards* in 36 CFR 67.7 are used primarily when property owners are seeking certification for Federal tax benefits. The two sets of *Standards* vary slightly, but the differences are primarily technical and are not substantive in nature. The *Guidelines*, however, are not codified in the Federal Register.

Condition

As documented by Moffat & Nichol in *Hunters Point Shoreline Structures Rapid Reconnaissance Investigation* (June 2009), the condition of Dry Dock #2 and #3 was noted as follows:

> *These dry docks are rated in POOR condition. Although widespread, damage is primarily characterized by minor, infrequent spalls with occasional vertical cracks extending the full height of the concrete from above the waterline. Approximately half of these cracks show discoloration. The more widespread damage was observed on the concrete just above the waterline, which exhibits smaller cracking in vertical and horizontal directions. This type of cracking (see Photograph D3.4) typically shows corrosion, and is found along approximately half of the total length that bounds Dry Dock No. 3. As indicated on the stepped side in Photograph D2.1, the concrete matrix has deteriorated due to its age, and air pockets have expanded into large voids, displaying a rough outer surface. A rough outer surface is also visible on vertical and sloped portions of the wall (see Photograph D2.2).*[3]

Further observation of the condition of Dry Docks #2 and #3 noted that vertical cracks extend the full height of the walls and that air pockets have expended into large voids.[4]

For Dry Dock #4, Moffat & Nichol noted the condition as follows:

> *Dry dock No. 4 is rated in POOR condition. Advanced deterioration is widespread throughout the structure. Greater than 40% of the concrete structure exhibits patches of open and closed corrosion spalls and delamination. The majority of these types of damages are exhibited along the full height of the concrete, as shown in Photographs D4.1 through D4.6. Delaminations are observable on open faces of concrete, as well as around openings for utility lines (see Photograph D4.4). Spalls are also localized around cold joints and corners of various parts of concrete, such as the corners at the slots where the gate was positioned during periods of dry dock usage (see Photograph D4.8). Damage also consists of horizontal corrosion cracking, as shown in Photograph D4.7, where horizontal cracks with discoloration were observed in the splash zone.*[5]

Proposed Treatments

Based upon the proposed improvement concepts outlined by Moffatt & Nichol in *Candlestick Point/Hunters Point Redevelopment Project, Proposed Shoreline Improvements*, Dry Docks #2, #3, and #4 would be modified as follow:

- Addition of Weep Holes: The project will add weep holes on the sidewall to reduce pressure behind it. These weep holes shall be located above the lowest tide and shall extend to near the top of the dry dock walls;
- Addition of Rock/Sand Buttresses: The project will add rock or sand buttresses on the face of the dry dock walls at the bottom. This will result in additional passive resistance with the intent of increasing slope stability.
- Concrete Repair: The project will repair the exposed dry dock walls by patching any spalls, exposed and corroded reinforcing bars, and broken concrete. This will include applying high strength concrete grout to exposed surfaces and/or epoxy mix application to cracks. It should extend from below the lowest tide up to near the top of the dry dock walls.[6]

The quantity of these repairs is as follow:

- *Dry Dock #2* = Concrete Repair (9,000 square feet); Addition of Rock/Sand Buttresses (32,000 cubic yards); and Addition of Weep Holes (360 ea)
- *Dry Dock #3* = Concrete Repair (19,300 square feet); Addition of Rock/Sand Buttresses (44,500 cubic yards); and Addition of Weep Holes (440 ea)

PAGE & TURNBULL
724 PINE STREET, SAN FRANCISCO, CALIFORNIA 94108 TEL 415.362.5154 FAX 415.362.5560
2401 C ST., STE. B, SACRAMENTO, CALIFORNIA 95816 TEL 916.930.9903 FAX 916.930.9904
417 S. HILL ST., STE. 211, LOS ANGELES, CALIFORNIA 90013 TEL 213.221.1200 FAX 213.221.1209
page-turnbull.com

- *Dry Dock #4* = Concrete Repair (38,000 square feet); Addition of Rock/Sand Buttresses (49,700 cubic yards); and Addition of Weep Holes (460 ea)

In detail, the concrete repairs are described as follows:

> *Concrete repairs include spall and crack repair above and under water. Concrete wall, caisson and underside of wharf deck repairs above the waterline will be completed from small floating platforms or temporary scaffolding. Spalled concrete areas above water will have the spalls removed (by grinding or abrasive blasting) and replaced with pneumatically placed concrete (shotcrete) or trowel applied mortar. Large-width concrete cracks will be cleared of debris (by air-blasting or hand tools) and pressure-injected with epoxy or cementitious grout.*
>
> *Underwater concrete repairs includes concrete removal (by high pressure water jets, pneumatic- or hydraulic-powered chipping hammers or saws), surface preparation (by high pressure water jets, abrasive blasting or mechanical scrubbers), installation of anchors and placement of concrete (for spalls) or epoxy (for cracks) by pipe and pump, injection or hand placement, spall repairs will be held in place by form work where spall sizes are large. Underwater repair work will be accomplished with support crew and equipment on a floating platform or barge.*[7]

In addition to the proposed treatments outline above, new guardrails would be added to the perimeter of each of the dry docks.

<u>*Evaluation*</u>
This section provides an evaluation of proposed treatments and examines their consistency with each of the Standards for Rehabilitation. *The Secretary of the Interior's Standards for Rehabilitation & Illustrated Guidelines for Rehabilitating Historic Buildings* (Standards) provide guidance for reviewing proposed work on historic properties.[8] The Standards are used by Federal agencies in evaluating work on historic properties. The Standards have also been adopted by local government bodies across the country (including the Historic Preservation Commission) for reviewing proposed rehabilitation work on historic properties under local preservation ordinances. The Standards are a useful analytic tool for understanding and describing the potential impacts of substantial changes to historic resources. The following analysis applies each of the Standards to the proposed treatment.

1. *A property will be used as it was historically or be given a new use that requires minimal change to its distinctive materials, features, spaces, and spatial relationships.*

The three dry docks under review will be used as an open space amenity and will no longer be used as a dry dock facility. This new use will require minimal change to the resource's distinctive materials, features, spaces and spatial relationships. The proposed treatments outlined for the dry docks provide for the repair and retention of the historic elements, including the concrete and trapezoidal or rectangular shape. Therefore, the proposed treatments for the three dry docks are consistent with Rehabilitation Standard #1.

2. *The historic character of a property will be retained and preserved. The removal of distinctive materials or alteration of features, spaces, and spatial relationships that characterize a property will be avoided.*

The overall historic character of the three dry docks will be retained and preserved by the proposed treatments. The proposed treatments call for the installation of weep holes into the concrete dry docks sidewalls, in order to reduce the pressure from behind. This treatment will involve the removal of some distinctive materials. These weep holes will be approximately 6" in diameter and spaced ten feet on center along the sidewalls of the dry docks. The weep holes will be located above the lowest tide point and will extend towards the top of the dry dock walls. Although the installation of the weep holes removes some distinctive materials, this treatment can be considered a minor alteration, especially when examined against the vast amount of surface area of the dry dock sidewalls. The amount of concrete sidewall being removed is minor compared to the overall size and scale of the dry docks. The installation of the weep holes provides for continued use of the dry dock walls, and the distinctive materials of the dry docks are largely retained and preserved as part of the project. Therefore, the proposed treatments for the three dry docks are consistent with Rehabilitation Standard #2.

3. *Each property will be recognized as a physical record of its time, place, and use. Changes that create a false sense of historical development, such as adding conjectural features or elements from other historic properties, will not be undertaken.*

The proposed treatments for the three dry docks under review will not feature changes that create a false sense of historical development. The addition of the rock and sand buttresses will be clearly differentiated from the historic concrete form of the dry dock. Therefore, the proposed treatments for the three dry docks are consistent with Rehabilitation Standard #3.

4. *Changes to a property that have acquired historic significance in their own right will be retained and preserved.*

In general, few alterations have occurred to Dry Docks #2, #3, and #4. These dry docks have not acquired changes, which have garnered historic significance in their own right. Therefore, the proposed treatments for the three dry docks are consistent with Rehabilitation Standard #4.

5. *Distinctive materials, features, finishes, and construction techniques or examples of craftsmanship that characterize a property will be preserved.*

The proposed treatments will preserve distinctive materials, features, finishes and construction techniques found in the three dry docks under review. In particular, the proposed treatments call for the repair of exposed dry dock walls, which may include patching any spalls, removal and replacement of exposed and corroded reinforcing bars, and broken concrete that can't be patch. Overall, the distinctive features of the three dry docks, including the concrete sidewalls, overall form, and location, are being maintained by the proposed treatments. Therefore, the proposed treatments for the three dry docks are consistent with Rehabilitation Standard #5.

6. *Deteriorated historic features will be repaired rather than replaced. Where the severity of deterioration requires replacement of a distinctive feature, the new feature will match the old in design, color, texture, and, where possible, materials. Replacement of missing features will be substantiated by documentary and physical evidence.*

As mentioned previously, the proposed treatments call for the repair of the exposed dry dock walls, which includes patching any concrete spalls, repairing and/or replacing exposed or corroded reinforcing bars, and repairing broken concrete. These treatments are all consistent with Rehabilitation Standard #6, since they involve repairing, not replacing, deteriorated historic features. Where deteriorated beyond repair, the proposed treatments will replace materials in-kind, keeping the character of the dock walls consistent with the original design. Where parts of concrete walls need to be replaced due to severe deterioration, the replacement surface will be similar in texture and color to the original concrete wall finish. Therefore, the proposed treatments for the three dry docks are

PAGE & TURNBULL
724 PINE STREET, SAN FRANCISCO, CALIFORNIA 94108 TEL 415.362.5154 FAX 415.362.5560
2401 C ST., STE. B, SACRAMENTO, CALIFORNIA 95816 TEL 916.930.9903 FAX 916.930.9904
417 S. HILL ST., STE. 211, LOS ANGELES, CALIFORNIA 90013 TEL 213.221.1200 FAX 213.221.1209
page-turnbull.com

consistent with Rehabilitation Standard #6.

7. *Chemical or physical treatments, if appropriate, will be undertaken using the gentlest means possible. Treatments that cause damage to historic materials will not be used.*

The proposed treatments do not involve chemical or physical treatments, which may damage historic materials. Therefore, the proposed treatments for the three dry docks are consistent with Rehabilitation Standard #7.

8. *Archeological resources will be protected and preserved in place. If such resources must be disturbed, mitigation measures will be undertaken.*

If archaeological resources are uncovered during the implementation of the proposed treatments, the project sponsor will seek consultation from a qualified archaeologist (meeting or exceeding the Secretary of the Interior's Professional Qualification Standards in Archaeology) and shall undertake appropriate mitigation measures. Since this resource involves underwater resources, specialized knowledge of underwater archaeology may be required. The environmental document for the proposed project should outline the appropriate mitigation measures for archaeological resources. If undertaken as outlined, the proposed treatments for the three dry docks would be consistent with Rehabilitation Standard #8.

9. *New additions, exterior alterations, or related new construction will not destroy historic materials, features, and spatial relationships that characterize the property. The new work shall be differentiated from the old and will be compatible with the historic materials, features, size, scale and proportion, and massing to protect the integrity of the property and its environment.*

The proposed treatments for the three dry docks under review involve the new addition of rock/sand buttresses and the installation of weep holes. These two treatments will affect the historic concrete sidewalls and the overall shape of the dry docks basins. However, these two treatments will not negatively impact these two features, or any other important historic materials, features, and spatial relationships that characterize the property. The proposed treatments provide for the longevity and continued use of the resource, and when viewed in reference to the overall size and scale of the dry docks, these treatments can be considered minor. The new work will be clearly differentiated from the historic dry docks, since the original form of the dry docks only included concrete, and new materials include rock and sand. Overall, the integrity of the property is maintained, since a minimal amount of historic materials are being removed and since the form, size, scale are being preserved. Therefore, the proposed treatments for the three dry docks are consistent with Rehabilitation Standard #9.

10. *New additions and adjacent or related new construction will be undertaken in such a manner that, if removed in the future, the essential form and integrity of the historic property and its environment would be unimpaired.*

The proposed treatments involve new construction consisting of new guardrails along the perimeter of the dry docks and new sand/rock buttresses, which will be located underwater in the basin of the dry dock. This new construction will not affect the overall form and integrity of the three dry docks, since its original concrete construction and trapezoidal/rectangular shape will be retained. Furthermore, the individual contributing features of the dry docks, including the concrete staircases, filling culverts, discharge culverts and adjacent decks will not be impacted by the proposed treatments, and will remain in place. Therefore, the proposed treatments for the three dry docks are consistent with Rehabilitation Standard #10.

Recommendations

The rehabilitation strategies and treatments, as outlined in Moffat & Nichol's reports, are preliminary. We recommend that, as the Dry Docks are evaluated further, details of the proposed treatments be reviewed for consistency with the Standards. For example, weep holes should be installed in a manner that would have the least visual impact on the face of the concrete wall, avoiding exposed piping and anchors. The specifications for the concrete patching should be developed to allow close matching of the texture and color of existing concrete surfaces. New elements, such as guardrails and handrails, should be designed to maintain the overall simple industrial character appropriate to the shipyard's original utilitarian uses. Contingencies should be included in the overall cost estimates for the future project in order to accommodate these recommendations.

Conclusion

The proposed treatments for Dry Docks #2, #3, and #4 are consistent with the Secretary of the Interior's Standards for Rehabilitation. The treatments outlined provide a methodology for resolving severe deterioration issues, and ultimately provide for the longevity of the historic resources.

This memorandum and evaluation has been undertaken by professionals whom meet the Secretary of the Interior's Professional Qualification Standards in Historic Architecture and Architectural History.

Appendix K There is no appendix associated with Section III.K