



November 14, 2013

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Ms. Dana Allen
 City of Sacramento - Community Development Department
 300 Richards Boulevard, 3rd Floor
 Sacramento, CA 95811

Subject: Notice of Availability – Draft Environmental Impact Report for the McKinley Village Project (P08-086)

Dear Ms. Allen:

Sacramento Regional County Sanitation District (Regional San) has reviewed the subject document and has the following comments.

The proposed project consists of development of 328 residential units, a neighborhood recreation center, parks, and other public spaces on an approximately 48.75-acre site located in the City of Sacramento (City).

Local sewer service for the proposed project site will be provided by the City's local sewer collection system. Ultimate conveyance to the Sacramento Regional Wastewater Treatment Plant (SRWTP) will be provided via the City Interceptor. Cumulative impacts of the proposed development will need to be quantified by the developer to ensure adequate wet weather and dry weather capacity within the City Interceptor.

In March 2013, the Regional San Board of Directors adopted the Wastewater Operating Agreement between Regional San and the City.

Section 3.H. Combined Wastewater Control System (CWCS) ALLOWABLE FLOW ALLOCATIONS of the Wastewater Operating Agreement states:

Regional San agrees to operate Regional San facilities as necessary to accept flows via the CITY Interceptor from CITY service areas up to the maximum instantaneous flow rates indicated in the table below:

<u>Service Area</u>	<u>Maximum Flow Rate</u>
Sump 2 and 2A	60 MGD
Sump 2, 2A, 21, 55, and 119	98 MGD
Total combined flows to City Interceptor from Sumps 2, 2A, 21, 55, 119, and five (5) trunk connections	108.5 MGD

Ms. Dana Allen
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Total flow to the City Interceptor from the five trunk connections may exceed 10.5 MGD so long as the City does not exceed the 108.5 total flow limitations set forth in the Wastewater Operating Agreement. The City and Regional San will monitor flow conditions and will coordinate operations of their respective facilities, to the extent feasible for each party, to prevent or reduce the risk of SSOs in their respective facilities.

The Regional San Board of Directors adopted the Interceptor Sequencing Study (ISS) in February 2013. The ISS updated the Regional San Master Plan 2000 and can be found on the Regional San website at <http://www.srcsd.com/interceptor-study.php>.

Regional San is not a land-use authority. Regional San sewer systems are designed using predicted wastewater flows that are dependent on land use information provided by each land use authority. Projects identified within Regional San planning documents are based on growth projections provided by land-use authorities. Sewer studies, including points of connection and phasing information will need to be completed to fully assess the impacts of any project that has the potential to increase existing or future flow demands. Onsite and offsite impacts associated with constructing sanitary sewers facilities to provide service to the subject project must be included in environmental impact reports.

The SRWTP provides secondary treatment using an activated sludge process. Incoming wastewater flows through mechanical bar screens through a primary sedimentation process. This allows most of the heavy organic solids to settle to the bottom of the tanks. These solids are later delivered to the digesters. Next, oxygen is added to the wastewater to grow naturally occurring microscopic organisms, which consume the organic particles in the wastewater. These organisms eventually settle on the bottom of the secondary clarifiers. Clean water pours off the top of these clarifiers and is chlorinated, removing any pathogens or other harmful organisms that may still exist. Chlorine disinfection occurs while the wastewater travels through a two mile "outfall" pipeline to the Sacramento River, near the town of Freeport, California. Before entering the river, sulfur dioxide is added to neutralize the chlorine. The design of the SRWTP and collection system was balanced to have SRWTP facilities accommodate some of the wet weather flows while minimizing idle SRWTP facilities during dry weather. The SRWTP was designed to accommodate some wet weather flows while the storage basins and interceptors were designed to accommodate the remaining wet weather flows.

A new NPDES Discharge Permit (Permit) was issued to Regional San by the Central Valley Regional Water Quality Control Board (Water Board) in December 2010. The Water Board amended the Permit in December 2011 to make minor changes to the Monitoring and Reporting Plan and other changes. In adopting the Permit, the Water Board required Regional San to meet significantly more restrictive treatment levels over its current levels and Regional San believes that many of these new conditions go beyond what is reasonable and necessary to protect the environment. As a result, Regional San appealed the Permit to the State Water Resources Control

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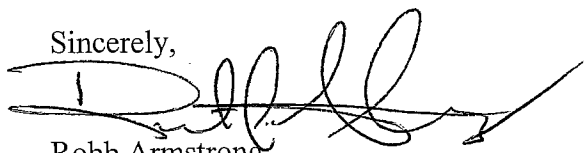
Board (State Board). The State Board adopted an Order in December 2012 essentially upholding the Water Board Permit.

Following the State Board decision Regional San filed litigation in California Superior Court. A decision on the merits of the litigation is expected in the summer of 2014. Regional San and the Water Board entered into a partial settlement agreement where Regional San agreed to implement some Permit requirements and the Water Board agreed to amend the Permit for specific conditions, while litigation on other requirements will proceed forward. In the meantime, Regional San is required to begin the necessary activities, studies and projects to meet the new Permit conditions. Some of the new treatment facilities must be completed by May 2021, while other new treatment facilities must be completed by May 2023, if Regional San is unsuccessful in its litigation.

Customers receiving service from Regional San are responsible for rates and fees outlined within the latest Regional San ordinance. Fees for connecting to the sewer system are set up to recover the capital investment of sewer and treatment facilities that serves new customers. The Regional San ordinance is located on the Regional San website at <http://www.srcsd.com/ordinances.php>.

If you have any questions regarding this letter, please feel free to contact me at (916) 876-6104 or by e-mail at armstrongro@sacsewer.com.

Sincerely,

A handwritten signature in black ink, appearing to read 'Robb Armstrong', written over a horizontal line.

Robb Armstrong
Regional San

RA: ra(ra)

Dana Allen

From: Chris Pair <CPair@sacrt.com>
Sent: Friday, December 20, 2013 11:09 AM
To: Dana Allen; Evan Compton
Cc: RoseMary Covington
Subject: McKinley Village Project DEIR and application review

Dana,
RT has one additional comment in response to the DEIR for McKinley Village. The DEIR describes the access to existing bus service in East Sacramento (which RT provided clarification on in our comment letter). Our additional comment is:

- Considering how far away the bus stops are and the limited access points, RT requests that the developer provide way finding to the nearest bus stops from each access point.

Evan - RT would like to see this as a condition on the project please. The applicant can contact RT if they have questions or want suggestions for the way finding.

Thank you,

Chris Pair
Assistant Planner
Sacramento Regional Transit
Planning Dept
Phone (916) 556-0514
Fax (916) 456-1752



Regional Transit

Sacramento Regional
Transit District
A Public Transit Agency
and Equal Opportunity Employer

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Bus 36,38,50,67,68)

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2700 Academy Way
Sacramento, CA 95815
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December 18, 2013

Dana Allen
Associate Planner
City of Sacramento, Community Development Department
300 Richards Boulevard, 3rd Floor
Sacramento, CA 95811

NAME OF DEVELOPMENT: McKinley Village

CONTROL NUMBER: P08-086

TYPE OF DOCUMENT DEIR

The McKinley Village project proposes 328-unit residential development, a neighborhood recreation center with some retail, and parks in the Heavy Industrial (M-2) zone. The project site encompasses 48.75 acres and the community will be accessed from two main entrances; the extension of 40th Street through a new undercrossing of the UPRR on the east and on A Street to the west. There is also a proposed bike/pedestrian underpass at the northerly end of Alhambra Boulevard. The site is located south of Business 80, north of the UPRR and SPRR tracks, east of Alhambra Boulevard and west of Lanatt Street in the East Sacramento community.

Bus route 34 provides 60-minute weekday service 1/4 mile from the proposed project while Routes 67 and 68 provide 30-minute weekday and 60-minute weekend service just over 1/2 mile from the proposed project site.

Regional Transit (RT) staff has reviewed the DEIR and has the following comments:

- In Section 4.9, Transportation and Circulation, on page 4.9-15 under Transit System, the first paragraph should be adjusted as follows to clarify distances to bus stops:

"The Sacramento Regional Transit District (RT) provides transit service in the study area, including three bus routes located in the vicinity of the project site: Route 34, Route 67, and Route 68. All three of these routes have stops located to the south of the project site. However, existing bus stops are at least a quarter mile to 1/2 mile walking/biking distance from the three proposed site access points (the closest stop to the project site serves Route 34, and is located just over a quarter mile south of the proposed bicycle/pedestrian access point at the intersections of E Street/Alhambra Boulevard). However, with the proposed Caltrans closure of the E Street ramp, several stops on 30th Street in the project vicinity that service Routes 67 and 68 northbound will no longer be available. The closest bus stop available for Route 67/68 northbound travel will be located at L

Street and 30th Street just under a one mile distance. Stops in the study area are marked by a posted sign. Select stops include a bus shelter or a bench located on a 4-5 foot sidewalk. Figure 4.9-5 displays existing bus routes and stop locations within the study area. Detailed descriptions of the three RT routes in the vicinity of the project site are provided below:"

Thank you for the opportunity to comment. Please send any subsequent documents and hearing notices that pertain to this project as they become available. If you have further questions regarding these recommendations, please contact me at (916) 556-0514 or cpair@sacrt.com.

Sincerely,



Chris Pair
Assistant Planner

c: RoseMary Covington, AGM Planning and Transit Systems Development, RT
Jeffrey Damon, Director, Long Range Planning, RT

**Environmental Management
Department**

Val F. Siebal, Director



County of Sacramento

Divisions

Environmental Compliance
Environmental Health

January 8, 2014

Dana Allen
City of Sacramento Community Development Department
Environmental Planning Services
300 Richards Blvd. 3rd Floor
Sacramento, CA 95811

Dear Ms. Allen:

**SUBJECT: LEA COMMENTS RE: MCKINLEY VILLAGE PROJECT DRAFT
ENVIRONMENTAL IMPACT REPORT (DEIR)**

Sacramento County Environmental Management Department (EMD) staff have reviewed the DEIR for the McKinley Village project. EMD acts as the Local Enforcement Agency (LEA) for the California Department of Resources, Recycling, and Recovery (CalRecycle) in Sacramento County. EMD has the authority for regulatory oversight of solid waste handling and disposal sites in the Cities and County of Sacramento.

The proposed project, which would include development of a 328-unit residential neighborhood, is to be located just to the south of the 28th Street Sanitary Landfill, separated by the Capital City Freeway.

The LEA previously provided comments on the Notice of Preparation (NOP) for this project on June 25, 2013, and on the Administrative Draft EIR on October 1, 2013. The LEA provides the following comments regarding the DEIR:

- 1) Title 27, section 21190, prescribes development standards for structures located on landfills within 1,000 feet of waste. The project site is not located within the permitted boundary of the 28th Street Landfill and is therefore, not within the LEA's jurisdiction. However, the project is located within 250' of the landfill's Waste Management Unit B. As such, there is the possibility that landfill gas could migrate from the landfill to the project site. The current status of the project site is that of an empty field through which migrating landfill gas can vent into open air. The impact of the project would include placement of structures over the field, inhibiting the venting to open air and creating the possibility of landfill gas accumulation in structures and utility corridors. The project would also have the effect of drawing a significant number of people into an environment through which landfill gas may vent or accumulate.

Given the above, the LEA recommends that as a condition of development approval, enclosed structures to be built within 1,000 feet of the landfill's waste footprint be required to comply with the measures specified in section 21190(g) to prevent gas migration into the

structures. Alternatively, the project could include a setback with engineered mitigation measures to protect the entire development, as approved by CalRecycle engineering staff.

- 2) The proposed project, which would bring sensitive receptors to within 1,000' of the landfill's waste footprint, may prompt the LEA to require the landfill operator to reduce the spacing between monitoring wells along the landfill boundary opposite the project site per 27CCR sections 20925(b)(3), 20925(c)(3), and 20921(e) as necessary to protect persons and structures that could potentially be impacted by landfill gas migration in the event of a failure of the landfill gas control system. If additional gas monitoring wells are required on the landfill, it would result in the impact of additional costs to the landfill operator.
- 3) Landfill gas control systems are not always 100% effective. The DEIR notes the incident in September of 2008, when a large-scale increase in methane concentrations occurred on the landfill as a result of a surface fire that damaged the landfill's gas control system. Although exceedances of the 5% regulatory level were not noted at the probes located on the project site, exceedances well in excess of 5% were registered with the landfill boundary probes directly across the freeway from the project site. In addition, this incident occurred in the late summer when cyclical gas levels tend to be lower. The DEIR also notes that in 1994/5, there was a "methane excursion" over a two month period during which methane concentrations were detected on the project site in excess of 40%. This was before the landfill's gas control system was installed, but these conditions could be repeated in the event of a significant, extended failure of the landfill's gas control system. Also, as documented in the LEA focused inspection report dated 11/12/2013, the gas probes located on the project site do not appear to be Title 27 compliant and may not provide reliable gas monitoring information. As per the inspection report, the landfill operator should have the landfill gas monitoring network, including the probes on the project site, assessed by a professional engineer for operational condition and Title 27 compliance.
- 4) As stated in the DEIR, the six landfill gas monitoring wells (and two groundwater monitoring wells) located on the project site are proposed to be moved to new locations on the project site. The six "Lennane" gas monitoring wells are part of the landfill's gas monitoring network as indicated by their inclusion in maps and drawings of the network included with the landfill's Closure and Post-Closure Maintenance Plan amendments, updates, inspections, and related documents. The new locations, spacing, construction, and depths must be approved in advance by the LEA, CalRecycle, and the RWQCB, and comply with the requirements of Title 27 section 20925, and landfill staff must be ensured continued, unimpeded access to the well/probes in order to monitor and maintain them. Also, permits must be obtained from the EMD Well Program for destruction of old wells as well as for the construction of the new ones, pursuant to the Sacramento County Well Ordinance.
- 5) It is noted that throughout the document, the adjacent 28th Street Landfill is referred to as a "former" Landfill. This term may be construed to imply that it is no longer a landfill and has undergone "clean closure" to remove the wastes to another location. The 28th Street Landfill is a "closed landfill" that still contains landfill waste, and should be referred to as such for accuracy.

- 6) Sections 1.3 and 4.4.4 state that "should waste be determined to be located beneath the road alignment that connects the A Street Bridge to 28th Street, both the LEA and the CARWQCB may be required to make modifications to the Post Closure Land Use Plan (PCLUP), the Closure/Postclosure Maintenance Plan (C/PCMP), and Corrective Action Order, respectively." Please note that the responsibility to modify the PCLUP and C/PCMP to reflect changes in post-closure land use and/or maintenance would fall upon the operator of the landfill, and not the LEA or RWQCB.
- 7) As stated in the DEIR, improvements are proposed to A Street which passes through the 28th Street Landfill, to connect the project site to 28th Street. In a meeting on October 18, 2013, representatives of the developer described to LEA and CalRecycle staff improvements to A Street that would continue to ensure landfill site security and safe, efficient access to the landfill from the road by landfill staff so that landfill maintenance activities are in no way impeded. Measures that were described included strong, attractive fencing on both sides of the road matching the fencing around the landfill's flare station and turn-outs for landfill vehicles with locking access gates with adequate room to provide for the safety of landfill staff as well as for the occupants of passing vehicles. It should be noted that should the developer fail to adequately address these issues, the city, as operator of the landfill, would be responsible for doing so.
- 8) The two closed disposal site inspection reports (July 11, and July 26, 2013) are incorrectly attributed to CalRecycle in Section 4.4.5 Sources Cited. Both reports were prepared by the Sacramento County LEA.

Sincerely,



John Lewis
Environmental Specialist III
Environmental Management Department
Solid Waste Program

JL:LJ:jm

c: Wes Mindermann, CalRecycle
Diana Nordstrom-Lamkin, CalRecycle
John Moody, RWQCB
Steve Harriman, City of Sacramento

January 3, 2014

Ms. Dana Allen
Associate Planner
City of Sacramento, Community Development Department
300 Richards Blvd., 3rd Floor
Sacramento, California 95811
916.808.2762
dallen@cityofsacramento.org

Subject: McKinley Village Draft Environmental Impact Report (November 2013)

City Project #: P06-118

SMAQMD Project #: SAC200601408

Dear Ms. Allen,

Thank you for the opportunity to comment on the McKinley Village DEIR. The Sacramento Metropolitan Air Quality Management District (SMAQMD) has worked closely with the City and project proponents for several years to ensure adequate analysis and disclosure of toxic diesel particulate matter and potential cancer risk due to locomotives and motor vehicles adjacent to the project. SMAQMD staff reviewed the draft health risk assessment (HRA, Sept 2013) (a component of the administrative draft EIR), which we found adequate for CEQA purposes. Unfortunately, the City revised the HRA and did not afford us the opportunity to review the changes prior to the DEIR's release. We noted several areas of concern with the public draft, which we conveyed to the City and project consultants via a conference call on December 19. Our comments are repeated in this letter.

To begin, we understand the difficult task that the City faces in conveying a project's advantages and disadvantages to the public and decision makers. This is especially true given the CEQA framework, where decision-makers must weigh many factors in the decision to approve or deny a project. In this case, the City is presented with two competing factors related to air quality: the potential exposure of future residents to toxic air contaminants from nearby sources, and, the overall air quality benefits from reduced vehicle miles traveled and associated motor vehicle pollutants due to its infill location and

consistency with the 2035 Metropolitan Transportation Plan/Sustainable Communities Strategy¹. Therefore, the following comments reflect specific issues with the environmental document for this project, and not the project itself.

HRA Issues

First, the DEIR implies that risk below 276/million is considered by SMAQMD to be less than significant- which is a serious misinterpretation of our guidance: *"The HRA indicates that future residents would not be subject to a substantial increase in lifetime cancer risk as a result of exposure to TACs from mobile sources based on the SMAQMD guidance"* (4.1-51).

SMAQMD's evaluation criterion is not a health-based significance threshold, but merely a screening tool to determine if a site specific HRA is recommended. Our guidance does not provide a threshold of significance, nor does it provide guidance on the "substantial increase" concept. We therefore recommend clarifying this statement by striking "based on the SMAQMD guidance".

Second, and of greater concern, is the HRA's attempt to provide perspective by deemphasizing the cancer risk results:

This Health Risk Assessment (HRA) finds that only one residence at the far eastern end of the project site would expose residents to a maximum cancer risk of approximately 120 in 1 million under a 70-year exposure scenario, which is less than SMAQMD's evaluation criterion of 276 in 1 million. Residents in nearly all of the project site, however, would be exposed to a cancer risk of approximately 80 in 1 million or less (HRA iv).

The HRA downplays the maximally exposed receptor's cancer risk by remarking that "only one" receptor would be exposed to that risk, and, by inappropriately pointing out that the risk is lower than our evaluation criterion. Then, the risk for the rest of the project's receptors is downplayed via an improper comparison to the highest risk.

Our evaluation criterion is merely the point at which the screening process indicates the need for a site specific health risk assessment. It is a product of very conservative inputs, and should not be compared to the results of a refined site-specific health risk assessment.

Though the City may simply be attempting to provide perspective, risk assessment norms dictate that cancer risk be plainly stated.

In addition to cancer risk, the HRA analyzes cancer burden and chronic non-cancer health impacts, respectively. These types of analyses are more commonly seen in stationary source risk assessments and may not be appropriate in conveying near-roadway and rail health impacts.

EIR Issues

The FEIR should discuss applicable General Plan policies designed to reduce exposure to mobile-source toxic air contaminants, similar to the approach the City took in the Northwest Land Park EIR.

¹ City of Sacramento, *McKinley Village Draft Environmental Impact Report Appendix N*: McKeever, Mike. Letter to Jim McDonald. Oct 10, 2013.

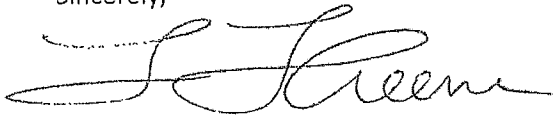
To reduce pollution exposure, the FEIR and final approval documents should require high efficiency particle filtration systems for every residence within McKinley Village. The City should require filters with the highest rated Minimum Efficiency Reporting Value (MERV). To ensure that the health benefits are realized over the long term, the City or a homeowner's association should educate residents as to their proper use and maintenance. For more information on filtration systems and their effectiveness in reducing particulate matter, please refer to the California Air Resources Board's document entitled Status of Research on Potential Mitigation Concepts to Reduce Exposure to Nearby Traffic Pollution (August 23, 2012) (Attachment 1).

The DEIR's requirement for redwood trees in the landscape buffer (DEIR 4.1-48) should be included in the FEIR and approval documents. Special attention should be paid to ensuring long-term viability of the trees, including planting techniques, long-term responsibility of care, and contingency measures if any tree fails to thrive or dies. We recommend working closely with the City of Sacramento's Urban Forestry Division, the Sacramento Tree Foundation, and Breathe California of Sacramento Emigrant Trails in this regard.

Finally, all projects are subject to our rules and regulations in effect at the time of construction. Please refer to Attachment 2. For a complete list, please visit our website at <http://www.airquality.org/rules/index.shtml> or call 916.874.4800.

We thank the City for the opportunity to comment. Please do not hesitate to contact me or Rachel DuBose of my staff if you have any questions or concerns. Rachel can be reached at 916.874.4876 or rdubose@airquality.org. I can be reached at 916.874.4800 or lgreene@airquality.org.

Sincerely,



Larry F. Greene
Executive Director
Sacramento Metropolitan Air Quality Management District

C: Larry Robinson, Sacramento Metropolitan Air Quality Management District

Attachments:

1. Status of Research on Potential Mitigation Concepts to Reduce Exposure to Nearby Traffic Pollution (August 23, 2012)
2. Rules and Regulations (March 2012)

**STATUS OF RESEARCH
ON POTENTIAL MITIGATION CONCEPTS
TO REDUCE EXPOSURE TO
NEARBY TRAFFIC POLLUTION**

August 23, 2012

California Environmental Protection



Air Resources Board

Introduction

Air Resources Board (ARB) staff has prepared this document to provide information on scientific research that has been conducted on various building-related and site mitigation concepts suggested as potentially effective approaches for reducing the traffic-related exposures of those living near high traffic roadways. While it provides useful information for consideration of potential mitigation approaches, this paper is not intended as guidance for any specific project, and does not provide a methodology for determining appropriate mitigation measures for purposes of compliance with the California Environmental Quality Act. This review looked only at the current status of air pollution research, and does not address other potential community benefits of the concepts, such as the aesthetic and noise reduction benefits of adding vegetation or sound walls.

The State's current set-back requirement for schools (500 feet [ft]; PRC 21151.8) and the ARB's recommendations on siting for housing and other sensitive uses (e.g., 500 ft from major roadways and 1000 ft from busy distribution centers and rail yards; ARB 2005a) are intended to help protect the public from exposure to traffic emissions. Such emissions have been associated with a variety of serious health impacts in epidemiological studies, including exacerbation of respiratory and cardiovascular diseases and conditions, increased asthma and bronchitis in children, and increased risk of premature death. Traffic pollutant concentrations near high traffic roadways have been found to be 2 to 10 times higher than levels at a distance from the roadways. Also, recent studies have shown elevated traffic pollutant levels at greater distances from the roadway than previously measured.

ARB and the U.S. EPA continue to adopt increasingly stringent regulations limiting emissions from vehicles of all types, which have substantially reduced, and will continue to reduce, vehicle emissions. However, recently adopted regulations have compliance dates extending as far as 2025 for full implementation, and fleet turnover to zero or near-zero technologies will take 20 to 30 years. New reductions in vehicle emissions are improving regional air quality throughout California, including near roadways. As the ARB and the air districts work to reduce emissions from diesel PM and other pollutants, the impact of proximity will also be reduced. However, the differential exposure to high air pollution near high traffic roadways compared to other locations makes the siting of housing in those locations a continuing health concern. Recognizing that unhealthy levels of air pollution is a long term problem, ARB is funding research to identify advanced technologies to further reduce vehicle emissions, to better understand traffic related air pollution exposures, and to explore the benefits of high efficiency filtration in California homes.

As communities plan for more compact development, the potential health impacts of infill projects will need to be considered. Infill development can reduce urban sprawl and has other potential health and environmental benefits. It also has the potential to increase exposure to traffic pollution due to the proximity of the infill areas to established traffic routes.

Status of Research on Traffic Exposures and Health Impacts

Measurements of air pollutants near roadways show a consistent finding of elevated levels based on proximity. Black carbon, often used as an indicator of diesel exhaust, and ultrafine particles (particles less than 0.1 microns in size), which are emitted in very high numbers from vehicles, are often 2 to 10 times (or more) higher near roadways and freeways (Zhu et al., 2002a, 2002b, 2006; Kuhn et al., 2005; Westerdahl et al., 2005; Ntziachristos et al., 2007; Kozawa et al., 2009a). Concentrations of PM_{2.5} (particles 2.5 microns or less in diameter) near busy roadways can be about 20% higher than levels at a distance (Zhu et al., 2002a; Kim et al., 2004; Janssen et al., 2001). Nitrogen oxides also are elevated near roadways, usually about 2 to 3 times the levels measured at a distance from the roadway (Kim et al., 2004; Singer et al., 2004; Kozawa et al., 2009a; Durant et al., 2010).

Previous studies of near roadway pollutant levels showed that concentrations of pollutants emitted from vehicles were highest right at the roadway and decreased substantially in the first 300-500 feet from the roadway (Zhu et al., 2002b; Knape 1999). These results were consistent with health studies that showed a stronger association of health impacts for those living within 300-500 ft of the roadway compared to those living farther than 500 ft from the roadway (Brunekeerf et al., 1997; Venn et al., 2001; English et al., 1999). More recent studies have shown a somewhat longer plume of increased pollutant concentrations farther from the roadway. Using data collected mostly during the day and near roadways, a meta-analysis of many studies found that for almost all pollutants, elevated levels of pollutants caused by the increased contributions from roadways returns to background levels at 160 - 570 meters (m; 525 - 1870 ft; Karner et al., 2010). The range of distances needed to reach background is usually a result of local meteorological conditions, which can vary significantly; however, a more constant observation is a steep concentration gradient observed closest to the roadway, within 500 ft, with a more gradual and extended decline at further distances. Another meta-analysis found that the "spatial extent of impact" of motor vehicles can extend up to 400 m (1312 ft) for black carbon and particles and 500 m (1640 ft) for nitrogen dioxide (NO₂; Zhou and Levy 2007). Levels of traffic pollutants near roadways vary due to many factors, including traffic type and density, wind direction and speed, local and roadway topography, and time of day and season (Zhu et al., 2004; Kuhn et al., 2005; Moore et al., 2007; Ning et al., 2007; Hu et al., 2009; Kozawa et al., 2009a, 2009b).

In a major 2008 review of the scientific literature by the Health Effects Institute (HEI), proximity to busy roadways was found to be associated with a variety of adverse health impacts, the strongest association being exacerbation of asthma, with others including asthma onset in children, impaired lung function, and increased heart disease (HEI, 2010). More recent studies have added to the list of effects and heightened concern regarding exposure to traffic emissions. Respiratory and cardiovascular effects seen in these studies include an increased risk of new-onset chronic obstructive pulmonary disease (Andersen et al., 2010), a faster progression of atherosclerosis in those living within 100 m of highways in Los Angeles (Künzli et al., 2010), increased risk of

premature death from circulatory disease (Jerrett et al., 2009), and increased incidence of new heart disease (Kan et al., 2008). Other effects include increased risk of low birth weight (Brauer et al., 2008; Llop et al., 2010) and increased risk of pre-term delivery (Wilhelm and Ritz, 2003; Wilhelm et al., 2011) for mothers living very near heavy traffic, lower immune function in post-menopausal women living within 150 m of arterial roads (Williams et al., 2009), and increased risk of Type 2 diabetes in post-menopausal women (Krämer et al., 2010).

Children appear to be particularly vulnerable to the adverse effects of traffic emissions. Epidemiological studies have found significant associations of children living near high traffic areas with decreased lung function (Brunekreef et al., 1997; Gauderman et al., 2007), increased medical visits and hospital admissions for childhood asthma (English et al., 1999; Lin et al., 2002), increased wheezing (Venn et al., 2001), and increased childhood asthma and bronchitis (Kim et al., 2004; Gauderman et al., 2005; McConnell et al., 2006), including development of new asthma cases (McConnell et al., 2010; Gehring et al., 2010). Children living near busy roadways are especially likely to experience elevated exposures because they would also play outdoors in the neighborhood and typically would attend nearby schools. Their higher breathing rates per unit of body mass relative to adults (Adams, 1993) and their developing immune, neurological, and respiratory systems make them especially susceptible to impacts from air pollution.

ARB's recommendation to avoid siting sensitive land uses such as new housing within 500 ft of busy roadways was based on the traffic exposure and health studies completed as of 2005. More recent studies confirm the relationship, and indicate that in some situations an elevated risk extends well past 500 ft. A few studies have measured elevated pollutant levels at distances well beyond 1000 ft (305 m; Karner et al., 2010; Zhou and Levy, 2007). For example, Hu and colleagues (2009) found that in the pre-dawn hours in Los Angeles, elevated ultrafine particle number concentration, nitric oxide, and particle-bound polycyclic aromatic hydrocarbons extended at least 1200 m (3937 ft) downwind of the freeway and did not reach background levels until a distance of 2600 m (8530 ft). More importantly, results from the Southern California Children's Health Study on the association of residential distance to traffic and lung function development, performed in the same general location as the Hu et al. study, found adverse health effects in children living as far as 1500 m (4921 ft) from roads (Gauderman et al., 2007). These are not unique findings; in the HEI (2010) report mentioned above, the authors noted that studies showed that people living up to 500 m (1640 ft) from heavy traffic are most at risk from the health effects of traffic pollution.

Status of Research on Mitigation Concepts

Various building and site mitigation approaches have been suggested as potential means to reduce exposure to traffic pollution near roadways. A review by ARB staff found that there has been limited study of most of these approaches. Building measures examined include high efficiency filtration for residences through either central, in-duct type filtration or portable air cleaners; and external building design

measures, such as locating the air intakes for ventilation systems on the opposite side of the building from outdoor sources, reducing the size and number of openable windows on the side of the building nearest the outdoor sources, or housing people in tall buildings. Site mitigation measures examined include the use of sound walls and vegetation as barriers. These measures are all assessed further below. Studies of elevated and below-grade roadways and freeway caps (also called freeway decks, lids or covers), which are covers over a sunken roadway that produce a road tunnel, also were reviewed, but studies were limited and results variable, and these measures are not feasible or are impractical for most new housing developments. Traffic measures such as those to reduce vehicle miles traveled also were considered; most such measures are typically integrated into roadway and community planning for regional benefits.

Building-related Measures: Filtration

No single building-related measure has been identified as adequate to reduce entry of pollutants from nearby roadways to the extent expected from set-back under common conditions. However, the use of high efficiency filtration appears to be relatively effective in most circumstances, as discussed below. It is especially appropriate for new homes because new homes in California must have mechanical ventilation systems [CCR 2008, Title 24, Section 150(o)], and those systems purposely pull outdoor air into the home that often is not filtered at all or is poorly filtered. High efficiency filtration also appears useful in existing homes without mechanical ventilation as discussed below. Mechanical ventilation systems and the Code requirement are discussed further in the Addendum at the end of this paper.

Background for Filtration

Outdoor-generated pollutants enter and leave buildings through three primary mechanisms: mechanical ventilation systems, which actively draw in outdoor air through an intake vent and distribute it throughout the building; natural ventilation (opening of doors or windows), which is the typical ventilation mode for most homes and small commercial buildings in California; and infiltration, which is the passive entry of unfiltered, outdoor air through small cracks and gaps in the building shell. Both natural ventilation and infiltration allow unfiltered air into the building and reduce the effectiveness of any filtration device.

Filter efficiency is rated using several scales, the most common of which is the Minimum Efficiency Reporting Value (MERV) rating system (ASHRAE 52.2-2007 as cited in EPA 2009). Flat fiberglass filters are the most common filters used in residential heating and air systems, and are rated at only MERV 1 to 4; they remove only a portion of the largest particles in the airstream that passes through the filter. MERV 5 to 8 filters are medium efficiency filters that remove some additional types of particles such as mold spores and cat and dog dander, but they still do not remove the finer particles produced on roadways. MERV 9 to 12 filters begin to remove particles smaller than PM_{2.5}. Higher efficiency MERV 13 to 16 filters are rated to remove a portion of the ultrafine and submicron particles emitted from vehicles. True HEPA (high efficiency particle

arrestance) filters (equivalent to MERV 17 to 20) remove 99.97% to 99.999% of particles less than 0.3 microns, but these generally have not been available for residential applications. High efficiency filters associated with central heating, ventilating and air conditioning (HVAC) systems must be carefully selected to assure the mechanical system can handle the increased airflow resistance. Additional information on MERV ratings, the size particles they remove, and typical applications are provided in Table 1 in the Addendum at the end of this paper.

High Efficiency Filtration with Mechanical Ventilation

Because mechanical ventilation has not been used in residential buildings until recently, there has been limited assessment of its impact on entry of particles and other pollutants into homes. However, a few recent studies of homes and schools have shown that high efficiency filtration in mechanical ventilation systems can be effective in reducing levels of incoming outdoor particles. In a seven-home study in northern California, Bhangar et al. (2010) found that the two homes with active filtration in a mechanical system had a notably lower portion of indoor particles from outdoors when the systems were on (filtration active) than when they were turned off (no filtration). In a modeling study of Korean residential units with mechanical ventilation, Noh and Hwang (2010) found that filters rated lower than MERV 7 were insufficient for reducing contaminants that enter through the ventilation filter, and concluded that filters should exceed MERV 11. In a school pilot study, a combination of MERV 16 filters used as a replacement for the normal panel filter in the ventilation system and in a separate filtration unit reduced indoor levels of outdoor-generated black carbon, ultrafine particles and PM_{2.5} by 87% to 96% in three southern California schools (SCAQMD, 2009). Use of the MERV 16 panel filter alone in the HVAC system achieved average particle reductions of nearly 90%. In a study of a single school in Utah, indoor submicron particle counts were reduced to just one-eighth of the outdoor levels in a building with a mechanical system using a MERV 8 filter (Parker et al., 2008). The investigators noted that the building shell and other mechanical system components appeared to play a significant role in the submicron particle removal as well.

These findings are similar to those from earlier studies of mechanically ventilated office buildings (e.g., Jamriska et al., 2000; Fisk et al., 1998). Fisk et al. (2000) concluded that use of higher efficiency filters instead of normal filters can reduce indoor numbers of submicron particles by 90% and that there is evidence of a large rate of removal of submicron indoor particles by processes (e.g., deposition) other than ventilation and filtration.

Because most of the studies discussed above were conducted in buildings with few or no indoor sources of submicron particles, the measured efficiencies of filters for reducing indoor concentrations of submicron particles from all sources may be overestimated. Many other studies have identified activities such as unvented cooking, cigarette smoking, and use of unvented gas appliances as indoor sources of submicron particles (ARB, 2005b, studies cited). These would only be removed by filtration to the extent the indoor air is re-circulated through the filters.

High Efficiency Portable Air Cleaning Devices

Portable or stand-alone air cleaners are generally not as capable as in-duct air cleaners and those associated with mechanical ventilation systems for cleaning large areas such as an entire home (Consumer Reports, 2007). However, when they are appropriately sized for the space to be treated, and when they use high efficiency or HEPA filters, portable air cleaners can significantly reduce particles in the treated area and serve as an adjunct to other pollutant reduction measures (Hacker and Sparrow, 2005; Shaughnessy et al., 1994; Shaughnessy and Sextro, 2006; Skulberg et al., 2005; Ward et al., 2005). In the pilot study conducted in three southern California schools (discussed above), a large stand-alone air cleaner with MERV 16 filters reduced black carbon, ultrafine particles and PM_{2.5} counts by 90% or more, and PM_{2.5} mass by 75%, when the HVAC system was not running (SCAQMD, 2009). Barn et al. (2008) found median removal efficiencies of 55% to 65% for PM_{2.5} from fires and wood burning by a HEPA air cleaner in 21 winter homes and 17 summer homes. In other work, Fisk et al. (2002) estimated an 80% reduction in outdoor fine mode particles with stand-alone air cleaners using filters in the MERV 11 to 13 range.

Because new California homes are now required to have mechanical ventilation, stand-alone air cleaners are less relevant to the assessment of measures for new California home construction. However, highly efficient portable air cleaners may be useful in reducing indoor exposure to pollutants in existing homes that do not have mechanical ventilation, and in homes that use bathroom exhaust type mechanical ventilation systems, which by their design cannot incorporate filtration of the incoming air because the supply air enters through leakage points throughout the building.

Removal of Gaseous Pollutants

There are limited options for effective removal of gaseous pollutants such as volatile organic chemicals, or VOCs, and NO₂ in central systems, and although the number and variety of technologies are increasing, there has been only limited research to date on their effectiveness. However, a few studies have examined the effectiveness of stand-alone filtration technologies intended to remove gaseous pollutants from the airstream (Shaughnessy and Sextro, 2006). The most comprehensive study was conducted by Chen et al. (2005), who tested the initial performance of 15 air cleaners with a mixture of 16 representative VOCs in a chamber study. Sorption filtration (e.g., activated carbon) removed some but not all VOCs (light and very volatile gases such as aldehydes and dichloromethane were not well removed). However, devices that included sorption media such as activated alumina impregnated with potassium permanganate showed better VOC removal efficiencies. In the schools study discussed above, the stand-alone unit used in one of the schools included charcoal sorbent for removal of gaseous pollutants; it removed 52% of the benzene indoors and 15% of total VOCs when operated with the HVAC turned off (SCAQMD, 2009). In a children's daycare center in Finland, Partti-Pellinen et al. (2000) found that up to 50% to 70% of nitrogen oxides could be removed by chemical filtration using a combination of charcoal, aluminum oxide and potassium permanganate, while another study found about 50% NO₂ removal by a HEPA air cleaner with large quantities of carbon in the adsorption bed, but little or no removal by other types of air cleaners (Shaughnessy et al., 1994).

Results from these studies show effectiveness for some technologies but are not conclusive due to their limited number and scope, including a relative lack of real world measurements. Additionally, some investigators have found that some filters re-emit VOCs that have been removed over time, or emit reaction products from the matter collected on the filter (Daisey and Hodgson, 1989; Fisk, 2007; Destailats et al., 2011; Hyttinen et al., 2006, 2007).

Limitations of High Efficiency Filtration

Although they can substantially reduce indoor concentrations of pollutants, mechanical filtration systems alone are insufficient to fully protect occupants from particles and other emissions from nearby roadways, for several reasons.

- First, most people tend to open their windows or doors at least part of each day (Offermann, 2009; Phillips et al., 1990), and such natural ventilation involves no filtration of incoming air and can diminish any pollutant reductions attained through the use of the mechanical system. The effectiveness of high efficiency filtration in homes whose occupants open their doors and windows regularly has not been quantified.
- Second, as higher MERV filters are used, greater attention must be paid to the increased air flow resistance that occurs with some filter types; mechanical system motors must be sufficiently sized to accommodate the air flow needs.
- Third, studies have shown that homeowners are not provided with sufficient information regarding use and maintenance of their central HVAC systems, or do not read and follow instructions for maintaining their filters (EPA, 2009; Offermann, 2009). Filtration is only effective if filters are well-fitted and are replaced or maintained according to the manufacturer's recommendations, and duct leakage is minimized (Thatcher et al., 2001; Wallace et al., 2004). Older (aged) filters have been associated with increased irritant health symptoms and decreased work performance in studies of filtration maintenance in workplaces (Clausen, 2004; Seppänen and Fisk, 2002; Wargocki et al., 2004).
- Finally, as discussed above, gaseous pollutants are not removed by most particle filters, and the technologies for VOC removal in residential applications are limited and still evolving.

Expected Benefits of High Efficiency Filtration

High efficiency filtration has been used in homes and schools only recently, and there is a range of highly variable building characteristics, filtration technologies, and occupant behaviors that determine the effectiveness of high efficiency filters in reducing the overall levels of pollutants indoors. Accordingly, it is difficult to accurately quantify the actual reduction in particulate matter that would be achieved by introducing high efficiency filtration on a widespread basis across the population of California homes and schools. For example, while filters with a MERV 16 rating remove more than 95% of particles from 0.3 to 3 microns in diameter, only those particles in the airstream actually passing through the filter are removed. Factors that determine the fraction of particles removed from the air in a building include the airflow rate through the unit, the amount

of time that the system is “on”, the extent to which windows and doors are opened, and other factors. While results from the studies conducted in homes and schools to date appear promising, those studies usually limited the opening of windows and doors or followed other specific protocols. Thus, although a substantial reduction in particles would be expected, the reduction that would be realized across the wide variety of conditions in California homes and schools cannot be confidently estimated.

Two kinds of programs are currently being implemented that will provide critical information needed to help confirm and quantify the effectiveness of high efficiency filtration. First, ARB is funding two key studies of high efficiency filtration in homes. Second, several local air quality management districts and school districts are implementing programs to install high efficiency filtration devices in a substantial number of schools in California, and collecting data regarding the performance of the filtration units. These are discussed below.

ARB’s Planned High Efficiency Filtration Research

ARB is funding a project entitled “Reducing In-Home Exposure to Air Pollution” to measure the exposure reduction and energy use of combinations of mechanical ventilation and filtration systems in order to identify compatible, low-energy systems that are effective at reducing indoor exposures to indoor, and incoming outdoor, pollutants. The study will be conducted by Drs. Brett Singer and Iain Walker of Lawrence Berkeley National Laboratory. The investigators plan to evaluate 15 current and new systems, and test seven of the most promising systems in a test home near a major roadway in an area with high ambient ozone and PM_{2.5} levels. They will measure fine and ultrafine particles, ozone, VOCs, NO₂ and black carbon, both indoors and outdoors, along with energy consumption and the performance of systems as filters age. This project is needed because new California homes are now required to have mechanical ventilation as discussed above, and the most widely used, low energy mechanical ventilation systems, bathroom exhaust systems, do not filter the incoming air; hence, the occupants’ indoor exposure to outdoor air pollutants can potentially increase with these systems.

ARB is also funding a second study entitled “Benefits of High Efficiency Filtration to Children with Asthma”. Dr. Deborah Bennett from the University of California at Davis will conduct this 4-year study of 200 children with asthma in Fresno and Riverside to quantify the exposure and asthma reduction benefits of high efficiency filtration in their homes. One intervention group will have high efficiency filters or filtration systems installed in their homes’ central heating and air conditioning systems. The second group will have high efficiency portable air cleaners placed in the child’s bedroom and in the main living area. Filters with a MERV rating of 15 or higher will be used. Improvements in asthma symptoms will be evaluated in a randomized cross-over design, with each participant receiving high efficiency air filtration for a year and no filtration for a year, allowing the investigators to identify the improvements related to the air filtration. During the control periods, “sham” filters with little or no particle removal capability will be used. Half of the homes with portable air cleaners will also have filters that remove ozone and VOCs. The extent to which particulate matter (PM₁₀, PM_{2.5}

and ultrafine particles), ozone, black carbon, and nitrogen oxides are reduced will be measured. Key asthma health endpoints will also be examined, including unplanned utilization of the healthcare system for asthma-related illness, short-term medication use, symptom diaries, peak exhaled flow, spirometry and exhaled nitric oxide.

Current Programs Using High Efficiency Filtration

Several programs have been completed or are underway in the State to install and/or test high efficiency filters, primarily in schools, to reduce exposures to pollutants from heavy traffic and/or port-related emissions. Since 2008, the South Coast Air Quality Management District (SCAQMD) has approved \$3 million for installation of high efficiency air filtration devices in a total of 18 schools and one community center in the Long Beach and Los Angeles Unified School Districts, San Bernardino and the Boyle Heights area (Kwon, 2012). SCAQMD also has agreed to oversee implementation of a program to utilize \$5.4 million in settlement funds to install and maintain high performance air filtration devices at about 47 schools in Wilmington and San Pedro. Installation of the filtration devices was scheduled to begin in summer 2012. Detailed site assessments of the schools are underway prior to installation in order to determine the best filtration device for each classroom and to facilitate assessment of actual improvements in classroom air.

Also, the Bay Area Air Quality Management District (BAAQMD) is conducting a school air filtration project in five schools for about \$300,000 (Smith, 2012). In 2010, a contractor completed installation of high efficiency air filtration equipment at five elementary schools located in the Bay View Hunters Point neighborhood of San Francisco. The filtration equipment is designed to reduce exposure inside the schools to particles from outdoor sources, as well as indoor-based particles such as some allergens. Initial monitoring results indicate that there has been a substantial reduction of particulate matter (up to about 50% to 75% for PM_{2.5} and higher for very small particles) inside the classrooms as a result of the newly installed high performance filters (IQAir, 2012).

To date, these programs appear successful, but overall cost, changes to the operation of the classrooms' central HVAC systems (such as running the system continuously rather than allowing it to switch on and off based on temperature needs) and other considerations (noise, drafts) may reduce the feasibility of the current technologies for use in all classrooms and require further refinements. However, because of the similarities of schools to homes with mechanical ventilation systems, one would expect comparable reductions in particle levels from high efficiency HVAC filtration in new and retrofitted homes.

Cost of High Efficiency Filtration

About a dozen companies offer high efficiency filtration devices incorporated into, or suitable for, residential mechanical ventilation systems, and most offer just one or two models. The devices are rated from MERV 11 to 16, plus several are true HEPA filters (equivalent to about MERV 17 to 20). Initial costs range from about \$200 to \$2800 for a

very high end system; however, most cost less than \$500. This range does not include installation, although in a new home the added cost over the installation of the mechanical system itself would be expected to be minimal. Annual filter replacement and/or maintenance cost ranges from about \$25 to \$255 per year, depending on MERV rating, number of filter changes needed per year, and whether the system includes a carbon filter for VOCs (which increases the cost of filter replacement, as these typically need to be replaced several times per year).

For existing homes and those that are renovated and do not have a mechanical ventilation system, either higher efficiency filters in the central heating and air system or portable high efficiency filtration devices could be used. High efficiency filters for central systems that can accept them cost about \$20. However, the increased airflow resistance may cause the central system to be less efficient. Effective, high efficiency portable units range in purchase cost from about \$200 to \$1250 depending on the size of the room or space to be treated and the specific technologies included (e.g., MERV rating and charcoal or other VOC removal filters) and would typically not involve any installation costs. Replacement filters and maintenance range from about \$75 to \$500 per year, again depending on the types of filters included and how dirty the air is, which would determine the frequency of filter changes needed. To adequately treat the living areas of most homes (e.g., bedrooms, family room, living room), two or more portable units may be needed.

External Building Design Measures

Moving Air Intakes

Research focused on assessing external building design measures is generally not readily available. Locating air intakes for mechanical ventilation systems on the opposite side of the building from the nearby outdoor source and prevailing wind direction seems logical. However, the reduction of pollutant entry in such a case would depend on the distance of the intake from the outdoor source, the consistency of the prevailing wind direction, and any local geographical or structural objects that might produce wind turbulence or eddies near the building and the air intake. One particle expert has noted that moving the intake would likely only be beneficial when the outdoor source is very near the intake and the intake is moved fairly far away; otherwise, because particles tend to disperse quickly and particle plumes “flow” around buildings, elevated particle concentrations around the building will be fairly consistent (Thatcher, 2010). This view appears at least partially substantiated by an Australian study that found that the concentration of submicron particles was consistently high and relatively undiluted around a building that was within 15 m of the roadway (Morawska et al., 1999). However, because this option has received little scientific study, and because all new California homes are required to use mechanical ventilation, which will often include a supply air intake, this option warrants further study to determine whether there are conditions under which strategic placement of air intakes might provide some benefits.

Reducing Openable Windows

Reducing the size and number of openable windows on the side of the building nearest the outdoor source would likely do little to reduce entry of particles and other pollutants into homes. Furthermore, this potential measure may not be acceptable to homeowners, who often open windows to take advantage of the breeze, from which the benefit arises primarily from opening windows on the prevailing wind side of the building. Windows opened only on the opposite side may result in little air movement in the home. In regions of the State where window opening currently replaces air conditioning in the summer evening and nighttime periods, there could be substantial energy and cost penalties for the increased use of mechanical air conditioning to cool the home. Additionally, increased indoor air stagnation and condensation may occur, which can result in mold issues. Thus, for all of these reasons, this option does not appear practical for single family dwellings. This measure might be acceptable in multi-family dwellings, depending on the specific building design and the ventilation systems used. However, inclusion of a sufficient number of windows (even if unopenable) would allow more daylight into the building, which would reduce energy use for indoor lighting and provide the satisfaction and efficiency benefits that accompany daylighting (Heschong Mahone Group, 2003a, 2003b).

Taller Buildings

Housing people in taller buildings has also been suggested as a possible exposure reduction measure. However, one of the few relevant studies of multi-story buildings near busy roadways found that vertical differences in fine and ultrafine particle concentrations outside buildings with 9 to 26 stories were not significant and can be highly variable, depending on other local sources and local meteorological conditions (Morawska et al., 1999). A second study, conducted in New York, found significant decreases for outdoor black carbon and non-volatile polycyclic aromatic hydrocarbons for floors 6 to 32 during the non-heating season only (Jung et al., 2011). Additionally, floors 3 to 5 showed the highest median outdoor concentrations for all pollutants measured, although the trend was not statistically significant and the elevated pollutants were believed to come from nearby rooftop exhausts. Thus, multi-story housing may reduce exposure in some situations but requires further research to determine conditions under which tall buildings might provide a reliable approach to reduce exposure near busy roadways.

Site-related Measures

The primary site-related measures reviewed by ARB staff were sound walls and vegetation barriers.

Sound Walls

Sound walls appear to reduce pollutant concentrations near the roadway; near-road concentrations (within 15-20 m [49-66 ft]) have shown reductions up to about 50% (Ning et al., 2010; Baldauf et al., 2008; Bowker et al., 2007; Hagler et al., 2012). However, in some studies higher levels of pollution were seen behind the barrier and at a distance from the sound walls and roadways, although in some of these studies the higher levels

appear related to other sources of pollution (Ning et al., 2010; Bowker et al., 2007; Hagler et al., 2010; Baldauf et al., 2008). In one of the few field measurement studies of sound walls, conducted along two southern California freeways, Ning et al. (2010) found that concentrations at farther distances (about 80 to 100 m from the roadway) were typically greater for the portions of the roads with sound walls, and background levels behind sound walls were not reached until 250 to 400 m as compared to 150 to 200 m without sound walls. Modeling and tracer studies (Heist et al., 2009; Finn et al., 2009) showed that barriers reduced air pollution downwind of the barrier, although in some cases trapping of pollution and increased levels on the road would occur (Hagler et al., 2011; Finn et al., 2009). Nearby buildings and structural barriers can also affect the attenuation and dispersion of pollution from roadways, but results vary with different meteorological conditions (Bowker et al., 2007; Hagler et al., 2010; Hagler et al., 2012).

Vegetation Barriers

Results for vegetation alone are more variable than those for sound walls. Vegetation can remove some gaseous pollutants by uptake or absorption, and particles are removed primarily by interception (impaction or physical adherence; Nowak et al., 2006; Fujii et al., 2008; Smith, 1990; Pardyjak et al., 2008; Baldauf et al., 2008). However, particles can be resuspended, apparently even at very low wind speeds (Fujii et al., 2008; Smith, 1990). Vegetation may restrict dispersion and increase concentrations on-road in street canyons with closer spacing of trees, particularly in low wind conditions (Gromke, 2011; Gromke and Ruck, 2007, 2009; Buccolieri et al., 2009). Another study has further shown the complexity of the effects of vegetation; investigators found different results depending on particle size and wind speed, and a non-linear increase of particle removal with increased leaf area density, which varies by tree species and season (Steffens et al., 2012). Gaps in vegetation barriers can have a significant negative impact on their effectiveness (Hagler et al., 2012), which needs to be addressed in future California research because California roadside vegetation tends to be less dense than that in the eastern U.S., where most previous field studies have been conducted. Also, some types of vegetation can trigger asthma and allergy attacks, and some emit reactive VOCs that contribute to the formation of ozone.

Sound Walls and Vegetation Combined

A combination of sound walls and vegetation appears to be more effective than either one alone. The two used together have been shown to disperse pollutants more consistently and to greater distances than either alone, with up to about a 60% reduction in near roadway levels (Baldauf et al., 2008; Bowker et al., 2007). While sound walls alone and sound walls combined with vegetation show promise, the increase in concentrations on-road and at a distance seen in some studies can increase exposures of others in the population and thus redistributes, rather than removes, pollutants. Additionally, the complexity of pollutant movement under varying conditions makes accurate prediction of exposure reduction difficult. Specific conditions under which sound walls and vegetation can reliably and consistently reduce exposures to air pollution have not been identified, especially in California.

Reduction of Indoor-generated Pollutants to Reduce Overall Exposure

Particles, NO₂ and other pollutants emitted by vehicles and other outdoor sources also have indoor sources that can produce higher indoor concentrations at times (ARB, 2005b, Section 2, and sources cited). Therefore, a reduction in indoor emissions and exposures can reduce the overall health impact of exposure to outdoor pollutants because the total exposure (indoor plus outdoor) to those pollutants experienced by the building occupants would be reduced. A number of studies have identified unvented cooking, cigarette smoking, the use of unvented gas appliances, burning of candles and incense, and woodburning as indoor sources of fine and ultrafine particles (Bhangar et al., 2010; ARB, 2005b; Fortmann et al., 2001; Wallace, 1996; Wallace, 2005; Wallace et al., 2008). High fine and ultrafine particle counts have been measured from such indoor sources. In homes with such sources, average indoor concentrations and occupants' personal exposures to fine and ultrafine PM are dominated by those indoor sources. Thus, measures to reduce indoor sources can help to significantly reduce occupants' peak and overall daily exposures to key pollutants emitted from both traffic and indoor sources.

Summary of Research Review

ARB has developed and adopted increasingly stringent regulations limiting emissions from passenger cars, trucks and buses, which have substantially reduced, and will continue to reduce, vehicle emissions. However, recently adopted regulations have compliance dates extending as far as 2025 for full implementation, and fleet turnover to zero or near-zero technologies will take 20 to 30 years. The set-back of buildings from high traffic roadways remains the most certain approach for preventing the residual health risk from traffic pollution exposures for those living closest to the roadways because it distances them from the highest pollutant concentrations. Research conducted since the publication of ARB's recommendations in 2005 further supports the use of set-back.

There are two mitigation measures that can be effective for exposure reduction. Increased filtration of air and reduction of indoor pollution sources potentially can reduce the overall pollution burden in homes. These measures warrant consideration especially in light of recent studies showing that the pollutant plumes at times can extend beyond 1000 ft (305 m) from the roadway. For most residential applications near busy roadways, high efficiency (MERV 13 to 16, or higher) pleated particle filters would generally be considered the most effective approach to filtration because they can remove the very small particles emitted by motor vehicles without emitting ozone, formaldehyde, or other harmful byproducts. Based on a limited number of studies, such high efficiency filtration has been shown to reduce indoor PM_{2.5} and ultrafine particle levels by up to 90% relative to incoming outdoor levels when doors and windows are kept mostly closed. Purchase costs for high efficiency filtration devices or systems that are compatible with residential mechanical ventilation systems (which are now required

in new residential construction in California) range from \$200 up to \$2800, but most are available for under \$500. Because Title 24 now requires mechanical ventilation for new residential construction, enhanced filtration can help avoid increased exposures to outdoor pollutants that may occur. The use of high efficiency air filters in central heating and air systems or stand-alone air cleaning devices can also reduce exposures in existing homes and homes that use certain types of mechanical ventilation systems that cannot accommodate central filtration.

While research shows that high efficiency filtration can be effective, it has several limitations. Filtration cannot remove all incoming outdoor pollutants because of normal building leakage and the fact that most people open windows and doors at least a portion of the day, allowing entry of unfiltered air. Additionally, not all pollutants are filtered by the filter media. Moreover, studies show irregular homeowner maintenance of filters and central systems, and regular maintenance is critical for effective removal of pollutants. ARB is funding two studies that should help further identify the approximate reduction in exposure that high efficiency filtration can provide in homes. High efficiency filtration is already being used or is planned for use in over 70 schools in California; these programs should provide comparable information for high efficiency filtration in classrooms.

The benefits are less clear for most of the other potential mitigation measures examined. Studies have shown that the use of sound walls alone, or sound walls and vegetation together, can reduce near roadway concentrations by about 50% and 60%, respectively. However, the extent of exposure reduction is quite variable under different conditions of meteorology and topography, and increased levels of pollutants can occur on-road and at a distance from the roadway. Thus, unlike the situation with filtration, pollutants are primarily redistributed rather than removed; while individuals living near the roadway would benefit, those traveling on the road or living at a distance could experience elevated exposures at times. The effectiveness of vegetation alone is even more variable, and has not been well-quantified. Furthermore, vegetation with low allergenic potential and low reactive VOC formation needs to be identified and tested, and other limitations of vegetation as a pollution barrier need to be better understood. Research is needed that identifies the specific conditions under which sound walls and vegetation can consistently provide a reliable exposure reduction benefit with limited disbenefits. In particular, California field studies are needed because of the significant differences in California meteorology, building practices, and flora from those of the eastern U.S.

The limited studies conducted to date on other potential mitigation concepts are not promising, although further research may identify situations in which they are generally effective. Placement of air intakes on the side of the building opposite the roadway may make little difference in terms of exposure, due to rapid particle movement around buildings. Locating windows only on the side of the building opposite the roadway reduces indoor daylighting, air circulation and cooling, and may do little to reduce exposure. Finally, taller buildings do not necessarily experience substantially reduced pollutant levels at higher floor levels, depending on local meteorology and other nearby

sources of pollution. However, further research on placement of air intakes and housing in taller buildings may identify conditions under which these measures reliably reduce exposures. Research is warranted on these measures and the measures discussed above as effective or showing promise in order to further identify cumulative measures that together can assure sufficient exposure reduction and health protection for those living near busy roadways.

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ADDENDUM

Current California Building Code Requirements

Section 150(o) of Title 24 of the California Code of Regulations (CCR 2008) requires mechanical ventilation in all new residential construction in California built after January 1, 2010. Section 150(o) allows the requirement to be met through a variety of system types (CEC 2010). "Exhaust only" type systems increase the entry of unfiltered outdoor air through leakage points in the building shell and can result in negative pressure indoors, thus increasing the possibility of backdrafting of combustion emissions from gas water heaters, fireplaces and other combustion appliances. These are the most widely used systems in California. "Supply systems" typically use a small motor to bring outdoor air in through a ducted supply and can include high efficiency filters to filter the air as it is brought in, prior to circulation of the air throughout the home. Combination (supply and exhaust) systems are available, with some linked to the central heating and air system; these include filtration of incoming outdoor air. However, the Code requires only a MERV 6 air filter (an increase to MERV 8 is proposed in the 2012 revisions to Title 24), which does not remove the smaller particles emitted by vehicles which are the particles of greatest concern. In future construction, the type of mechanical system used in new homes will have a major impact on the entry of outdoor pollutants indoors – if filtration is not included or is weak, indoor exposures to outdoor pollutants likely will increase.

Table 1. MERV Ratings*					
MERV Rating	Average Particle Size Efficiency (PSE), microns – % Removal			Typical Controlled Contaminant or Material Sources (ASHRAE 52.2)	Typical Building Applications
	0.3-1.0	1.0-3.0	3.0-10.0		
1-4			<20%	> 10 Microns Textile Fibers Dust Mites, Dust, Pollen	Window AC units Common Residential Minimal Filtration
5			20-35	3.0 to 10.0 Microns Cement Dust, Mold Spores, Dusting Aids	Industrial Workplace Better Residential Commercial
8			>70		
9		<50	>85	1.0 to 3.0 Microns Legionella, Some Auto Emissions, Humidifier Dust	Hospital Laboratories Better Commercial Superior Residential
12		>80	>90		
13	<75	>90	>90	0.3 to 1.0 Microns Bacteria, Droplet Nuclei (sneeze), Most Tobacco Smoke, Insecticide Dust	Superior Commercial Smoking Lounge Hospital Care General Surgery
16	>95	>95	>95		
17**	≥ 99.97			<0.3 Microns (HEPA/ULPA filters)** Viruses, Carbon Dust, Fine Combustion Smoke	Clean Rooms Carcinogenic & Radioactive Matls., Orthopedic Surgery
18**	≥ 99.99				
19, 20**	≥ 99.999				

* Adapted from EPA 2009; originally from ANSI/ASHRAE Standard 52.2-2007.

** Not part of the official ASHRAE Standard 52.2 test, but added by ASHRAE for comparison purposes.

SMAQMD Rules & Regulations Statement (revised 3/12)

*The following statement is recommended as standard condition of approval or construction document language for **all** development projects within the Sacramento Metropolitan Air Quality Management District (SMAQMD):*

All projects are subject to SMAQMD rules in effect at the time of construction. A complete listing of current rules is available at www.airquality.org or by calling 916.874.4800. Specific rules that may relate to construction activities or building design may include, but are not limited to:

Rule 201: General Permit Requirements. Any project that includes the use of equipment capable of releasing emissions to the atmosphere may require permit(s) from SMAQMD prior to equipment operation. The applicant, developer, or operator of a project that includes an emergency generator, boiler, or heater should contact the SMAQMD early to determine if a permit is required, and to begin the permit application process. Portable construction equipment (e.g. generators, compressors, pile drivers, lighting equipment, etc.) with an internal combustion engine over 50 horsepower are required to have a SMAQMD permit or a California Air Resources Board portable equipment registration. Other general types of uses that require a permit include, but are not limited to dry cleaners, gasoline stations, spray booths, and operations that generate airborne particulate emissions.

Rule 403: Fugitive Dust. The developer or contractor is required to control dust emissions from earth moving activities, storage or any other construction activity to prevent airborne dust from leaving the project site.

Rule 414: Water Heaters, Boilers and Process Heaters Rated Less Than 1,000,000 BTU PER Hour. The developer or contractor is required to install water heaters (including residence water heaters), boilers or process heaters that comply with the emission limits specified in the rule.

Rule 417: Wood Burning Appliances. This rule prohibits the installation of any new, permanently installed, indoor or outdoor, uncontrolled fireplaces in new or existing developments.

Rule 442: Architectural Coatings. The developer or contractor is required to use coatings that comply with the volatile organic compound content limits specified in the rule.

Rule 460: Adhesives and Sealants. The developer or contractor is required to use adhesives and sealants that comply with the volatile organic compound content limits specified in the rule.

Rule 902: Asbestos. The developer or contractor is required to notify SMAQMD of any regulated renovation or demolition activity. Rule 902 contains specific requirements for surveying, notification, removal, and disposal of asbestos containing material.

Naturally Occurring Asbestos: The developer or contractor is required to notify SMAQMD of earth moving projects, greater than 1 acre in size in areas "Moderately Likely to Contain Asbestos" within eastern Sacramento County. Asbestos Airborne Toxic Control Measures, Section 93105 & 93106 contain specific requirements for surveying, notification, and handling soil that contains naturally occurring asbestos.