City of Seal Beach

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July 16, 2012

Smita Deshpande, Environmental Chief
California Department of Transportation
District 12, Branch A
2201 Dupont Drive, Suite 200
Irvine, California 92612

VIA HAND DELIVERY

Subject: Draft Environmental Impact Report/Environmental Impact Statement San Diego Freeway Improvement Project, Orange and Los Angeles Counties, CA SCH #2009091001

Dear Ms. Deshpande:

The City of Seal Beach (City) hereby submits the following comments to the California Department of Transportation (Caltrans or Lead Agency) in response to your agency's recent release of the "Draft Environmental Impact Report/Environmental Impact Statement – San Diego Freeway Improvement Project, Orange and Los Angeles Counties, California, SCH #2009091001" (DEIR/S), dated May 7, 2012, for the San Diego Freeway Improvement Project. These comments are submitted within the designated comment period established by the Lead Agency and, by their hand delivery within that time period, become a component of the environmental review record for the proposed action. In compliance with the provisions of the California Environmental Quality Act (CEQA), the National Environmental Policy Act (NEPA), and their implementing guidelines, detailed written responses to the issues, comments, and inquiries presented in the attached document are required. As further stipulated therein, the Lead Agency's draft responses shall be submitted to the City not less than ten (10) days prior to any formal action by your agency.

Based on the information presented in the DEIR/S, the City believes that it is a "participating agency" under NEPA and a "responsible agency" under CEQA. In that capacity, the City is required to utilize the Lead Agency's CEQA documentation as the environmental basis for those discretionary actions that may be required from the City for the approval, construction, and operation of the proposed project. As evidenced by the attached comments, the City has identified a number of unaddressed environmental and socioeconomic issues with regards to the proposed project. In its present form, the City believes that the DEIR/S fails to identify and effectively mitigate the significant and potentially significant environmental and socioeconomic effects of the proposed project (e.g., air quality, human health, noise, land use, circulation, environmental justice), requires substantive augmentation in order to address those issues, and necessitates recirculation.

At a community meeting conducted by the City on June 26, 2012 at the Seal Beach Community Center (3333 St. Cloud, Seal Beach), William Kempton, the Orange County Transportation

Authority's (OCTA) Chief Executive Officer (CEO), stated that the "OCTA is the decision-making body" for the proposed project. In contrast, the DEIR/S only identifies the OCTA as the "project sponsor." This apparent inconsistency is problematic since Caltrans' "lead agency" status and the role that the OCTA and its contractors played in the preparation of the DEIR/S is brought into question. At that same meeting, the City was informed that the OCTA's Board of Directors would be taking formal action on the project at their August 13, 2012 meeting, substantially in advance of the culmination of the environmental process. Prior to the certification of the EIR and approval of the environmental impact statement (EIS), the City believes that any action committing any public agency (inclusive of the OCTA) to a specific course of action would be premature.

Additional correspondence concerning the proposed project and the adequacy of the DEIR/S have been submitted to Caltrans and the OCTA under separate cover.

On behalf of its residents and business community, the City appreciates the opportunity to submit comments on the DEIR/S. Should you have any questions concerning these comments or would like to schedule a meeting to discuss the City's concerns, please contact me at (562) 431-2527, extension 1318.

Sincerely,

Mike Levitt
Mayor

Enclosures

cc: Will Kempton, OCTA CEO
Niall Barrett, OCTA Project Manager (w/enclosures)
405.dedcomments.Parsons@parsons.com (w/ enclosures)

Proof of Delivery:

Signature of accepting party or date stamp

Third-Party Review
Technical Comments
(July 12, 2012)

Draft Environmental Impact Report
Environmental Impact Statement
San Diego Freeway Improvement Project
Orange and Los Angeles Counties, California
SCH No. 2009091001

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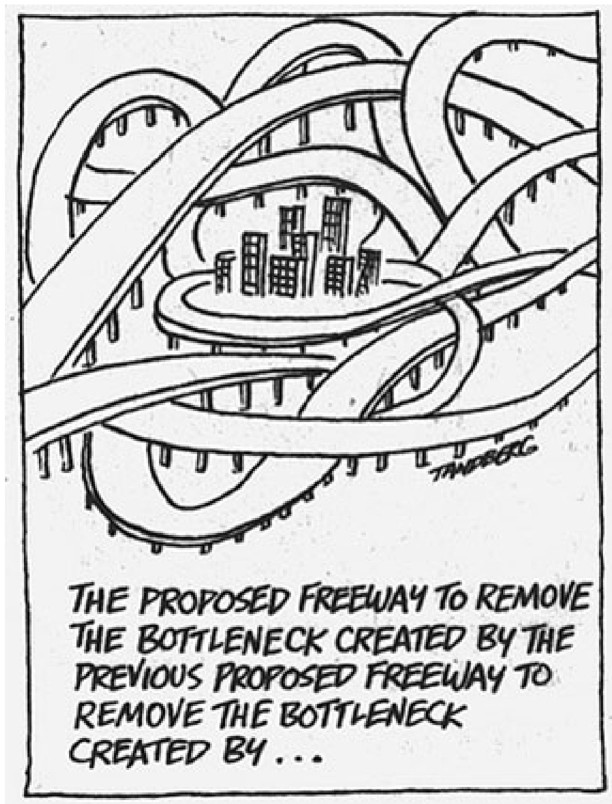
July 12, 2012



Source: Federal Highway Administration, An Agency Guide on Overcoming Unique Challenges to Localized Congestion Reduction Projects, September 2011.

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List of Acronyms

Acronym

A	
AADT	annual average daily trips
AASHTO	American Association of State Highway and Transportation Officials
AB	Assembly Bill
ADT	average daily traffic or average daily trips
AQR	Air Quality Report - San Diego Freeway (I-405) Improvement Project SR-73 to I-605, Orange and Los Angeles Counties
B	
BAU	business as usual
BC	black carbon
BRT	bus-rapid-transit
C	
CAA	Clean Air Act
CAAA	Federal Clean Air Act Amendments
Caltrans	California Department of Transportation
CARB	California Air Resources Board
CBO	Congressional Budget Office
CCR	California Code of Regulations
CDPH	California Department of Public Health
CEQ	Council on Environmental Quality
CEQA	California Environmental Quality Act
CEQ Memorandum	Memorandum to Heads of Agencies on the Application of the National Environmental Policy Act to Proposed Federal Actions in the United States with Transboundary Effects
CEQ Regulations	Council on Environmental Quality Regulations
C.F.R.	Code of Federal Regulations
CH_4	methane
CIA	Community Impact Assessment – San Diego Freeway (I-405) Improvement Project SR-73 to I-605, Orange and Los Angeles Counties"
City	City of Seal Beach
CMP	2011 Orange County Congestion Management Program or congestion management process
CMS	Congestion Management System
CO	carbon dioxide
CO_2	carbon monoxide
CRS	California Road System
CSMPs	Corridor System Management Plans
CTC	California Transportation Commission
CTC Needs Assessment	Statewide Transportation Needs Assessment, Final Report
D	
dB	decibel
dBA	decibel – A weighted
DEIR/S	Draft Environmental Impact Report/Environmental Impact Statement – San Diego Freeway Improvement Project, Orange and Los Angeles Counties, California, SCH #2009091001
Department	California Department of Transportation
diesel PM	diesel particulate matter
DOT	United States Department of Transportation
E	
EIR	environmental impact report
EO	Executive Order
ESA	Environmentally Sensitive Area
F	
F&E System	California Freeway and Expressway System
FHWA	Federal Highway Administration

List of Acronyms
(Continued)

Acronym

FTA	Federal Transit Administration
G	
GHG	greenhouse gas
GP	general purpose
H	
HC	hydrocarbons
HCA	high consequence areas
HCM	Highway Capacity Manual
HFCs	hydrofluorocarbons
HOT	high-occupancy toll
HOV	high-occupancy vehicle
HP	high pressure
H.R.	House Resolution
HUD	United States Department of Housing and Urban Development
I	
I	Interstate
I-405	San Diego Freeway
I-5	Santa Ana Freeway
I-5 FEIR/S	Final Environmental Impact Report/ Environmental Impact Statement – Interstate 5 (Santa Ana Freeway) from State Route 91 in Orange County to Interstate 605 in Los Angeles County, California
I-710	Long Beach Freeway
I-710 Corridor DEIR/S	Draft Environmental Impact Report/Environmental Impact Statement and Section 4(f) Evaluation - I-710 Corridor Project, Los Angeles County, California, District 07-LA-710-PM 4.9/24.9, EA 249900
ILEV	inherently low-emission vehicle
IMP	integrity management program
ISA	Initial Site Assessment – San Diego Freeway (I-405) Improvement Project SR-73 to I-605, Orange and Los Angeles Counties”
K	
kV	kilovolt
L	
LACMTA	Los Angeles County Metropolitan Transportation Authority
Lead Agency	California Department of Transportation
LEM	low-emission vehicle
level of service	LOS
LSP	Final Report - Traffic Congestion and Reliability: Linking Solutions to Problems
LRTP	2006 Long-Range Transportation Plan
2010 LRPT	Destination 2035 – Moving Toward a Green Tomorrow
M	
MAOP	maximum allowable operating pressure
MATES-II	Multiple Air Toxics Exposure Study, Final Report (2000)
MATES-III	Multiple Air Toxics Exposure Study (2008)
Measure M2	Renewed Measure M Program
Methodology	Final Localized Significance Threshold Methodology
Metro	Los Angeles County Metropolitan Transportation Authority
MF	mixed flow
MIS	Interstate 405 Major Investment Study, Final Report
MOE	measures of effectiveness
MOV	multiple-occupant vehicle
MP	Mile Post

List of Acronyms
(Continued)

Acronym

MPAH	Master Plan of Arterial Highways
MPO	metropolitan planning organization
MSATs	mobile source air toxics
N	
NAVWPNSTA	Naval Weapons Station
NEPA	National Environmental Policy Act
NH_3	ammonia
N_2O	nitrous oxide
NOI	Notice of Intent
NOP	Notice of Preparation
NOx	oxides of nitrogen
NRC	National Research Council
O	
OBNE	Our Built and Natural Environments: A Technical Review of the Interactions between Land Use, Transportation, and Environmental Quality
OC/LA Intercounty Study	Orange and Los Angeles Intercounty Transportation Study – Conceptual Alternatives Report
OCTA	Orange County Transportation Authority
OCTAM	Orange County Transportation Analysis Model
OH	overhead
OPR	Governor's Office of Planning and Research
OPS	Office of Pipeline Safety
P	
p.	page
P&N	purpose and need
Parsons	Parsons Transportation Group
PDT	project development team
PFCs	perfluorocarbons
PIR	potential impact radius
PM	particulate matter
PRC	Public Resources Code
psi	pounds per square inch
PSR/PDS	Project Study Report/Project Development Support
P3	public-private partnership
PTI	planning time index
R	
RCR	Route Concept Report – Interstate 405, San Diego Freeway, 12-ORA P.M. 0.23/24.18
RIM	Draft Relocation Impact Memorandum – San Diego Freeway (I-405) Improvement Project SR-73 to I-605, Orange and Los Angeles Counties
RCS	Ramp Closure Study
ROW	right-of-way
RTP	regional transportation plan
2012 RTP/SCS	2012-2035 Regional Transportation Plan/Sustainable Communities Strategy
S	
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
SAFETEA-LU Guidance	SAFETEA-LU Environmental Review Process Final Guidance
SANBAG	San Bernardino Associated Governments
SB	Senate Bill
SCAG	Southern California Association of Government
SCAQMD	South Coast Air Quality Management District'
SCE	Southern California Edison

List of Acronyms
(Continued)

Acronym

Seal Beach	City of Seal Beach
SF	self finance
SFDU	single-family dwelling units
SF_6	sulfur hexafluoride
SGP	Strategic Growth Plan
SHELL	Subsystem of Highway for the Movement of Extra Legal Loads
SHOPP	State Highway Operations and Protection Program
SHS	State Highway System
SOV	single-occupant vehicle
SOx	sulfur oxides
SR	State Route
SR-55	Costa Mesa Freeway
STAA	1990 Federal Surface Transportation Assistance Act
State CEQA Guidelines	Guidelines for the Implementation of the California Environmental Quality Act
STPP	Surface Transportation Policy Project
T	
TAC	toxic air contaminants
TASAS	Traffic Accident Surveillance and Analysis System
TCA	Transportation Corridors Agency
TDM	transportation demand management
Tg CO_2 Eq.	teragrams of CO_2 equivalent
TMA	Transportation Management Areas
TMP	Draft Transportation Management Plan for Interstate 405 Improvement Project
TOAR	I-710 Corridor Project Traffic Operations Analysis Report, Final Report
TOD	transit-oriented development
TOPS	Traffic Operations Strategies
TOT	truck only toll
Traffic Study	Traffic Study – San Diego Freeway (I-405) Improvement Project SR-73 to I-605, Orange and Los Angeles Counties
TRB	Transportation Research Board
Triennial Report	Measure M2 Triennial Performance Assessment Status Report, Staff Report
TSM	transportation management system
TTI	travel time index
U	
UFP	ultrafine particulates
U.S.	United States
U.S.C.	United States Code
USDOT	United States Department of Transportation
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
USNWP	United States Naval Weapons Station
V	
VIA	Visual Impact Assessment – San Diego Freeway (I-405) Improvement Project SR-73 to I-605, Orange and Los Angeles Counties
VMT	vehicle miles traveled
VOCs	volatile organic compounds
vph	vehicles per hour
vphpl	vehicles per lane per hour”
W	
WCC	West Orange County Connector Project
WCC FEIR/S	Final Environmental Impact Statement and Environmental Impact Report – State Route 22/West Orange County Connector, SCH No. 98064001
WGZE	W.G. Zimmerman Engineering, Inc.

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1.0 INTRODUCTION

Although not clearly specified as such, the proposed action is predicated, in whole or in part, on the passage of both “Measure M,” as approved by Orange County voters in November 1990, authorizing a 20-year program (sunset on March 31, 2011) to finance specific transportation projects, and the “Renewed Measure M Program” (Measure M2) Program, as approved by Orange County’s voters on November 7, 2006 (sunset on March 31, 2041). Specifically identified therein was “Project K (San Diego Freeway [I-405] Improvements between the I-605 Freeway in Los Alamitos area and Costa Mesa Freeway [SR-55]),” authorizing the construction of “new lanes on the San Diego Freeway between the I-605 and SR-55 Freeways, generally within the existing right-of-way.” Because it was a voter-approved measure, the Orange County Transportation Authority (OCTA) has an obligation to Orange County’s voters to pursue that mandate. Within the mandate of Measures M/M2, OCTA’s transportation planners have sought to fulfill that obligation and to “make best use of available freeway property, update interchanges and widen all local overcrossings according to city and regional master plans” (Measure M2). Because “best” can be highly subjective, the term “best use” must first be defined so that an objective, measureable yardstick can be established against which alternatives can be judged.

To the extent that the proposed action is directly tied to specific freeway improvements previously identified and supported by more than two-thirds of the Orange County’s voters, surprising absent from the project’s declared “purpose and need” (P&N) statement and specified project objective(s) is any explicit reference to Measures M/M2 therein. If so linked and if a more voter-specific alternative had been presented for public consideration, accomplishable within the budgetary limitations approved by the voters, it is reasonable to assume that greater support for the proposed action could have been engendered within the City of Seal Beach (City or Seal Beach). Whether the result of subsequent engineering analysis or a behind-the-scenes determination that a more extensive improvement project could be undertaken within the general confines of the existing right-of-way, the project has now mushroomed into something barely resembling the Measure M/M2 project description and subsequent voter’s authorization.

A larger and more encompassing project may, in fact, have merit from a traffic engineering perspective. However, if the project is no longer that which was first envisioned by the County’s voters (and costing substantially more than the amount authorized), sound planning and prudent management of public funds suggests that a “step back” rather than a blind “leap forward” is called for, including a reasonable dialogue as to what might constitute “best use.” Since that did not occur, the City must respond specifically to the information and analysis (or absence of information and analysis) presented in the “Draft Environmental Impact Report/Environmental Impact Statement – San Diego Freeway Improvement Project, Orange and Los Angeles Counties, California, SCH #2009091001” (DEIR/S) rather than working cooperatively with the OCTA to engage Seal Beach’s residents, business community, and the California Department of Transportation (Lead Agency or Caltrans, or Department) in a broader discussion of sound transportation planning solutions to the mobility and accessibility issues confronting the region.

1.1 Introduction to the City’s Written Comments

The following comments are submitted by or on behalf of the City in response to Caltrans’ release of the DEIR/S on May 18, 2012 and are intended for inclusion in the environmental review record established under the provisions of the: (1) National Environmental Policy Act (NEPA), as codified in Sections 4321-4347 in Title 42 of the United States Codes (U.S.C.); (2) the Council on Environmental Quality’s (CEQ) “Regulations for Implementing the Procedural

Provisions of the National Environmental Policy Act" (CEQ Regulations), as codified in Parts 1500-1508 in Title 40 of the Code of Federal Regulations (C.F.R.); (3) the California Environmental Quality Act (CEQA) as codified as Sections 21000 et seq. in the California Public Resources Code (PRC), and (4) the "Guidelines for the Implementation of the California Environmental Quality Act" (State CEQA Guidelines), as codified in Sections 15000 et seq. in Title 14, Chapter 3 of the California Code of Regulations (CCR).

Through the presentation of these comments, the City seeks to raise certain environmental and socioeconomic issues with regards to the proposed action, articulate the concerns which have been presented to City staff and Seal Beach's elected officials by City residents and members of the City's business community, ensure that the City's issues and concerns become part of the environmental review process for the proposed project, and elicit detailed, written responses from the Lead Agency and OCTA for the purpose of promoting informed decisionmaking.

Because the I-405 (San Diego) Freeway traverses the City, any physical changes to that facility or functional changes affecting its operation and use have the potential to adversely affect Seal Beach, its residents, and business community. In recognition of the project's potential to adversely affect this community and the long-term environmental consequences of the proposed action, the City (acting on its on and on-behalf of the City's affected residents and businesses) constitutes an affected stakeholder with legitimate and appropriate standing to actively participate in the CEQA and NEPA process.

The Lead Agency states that the project's effectuation may be dependent upon the issuance or approval of one or more discretionary actions from the City (Table 2-2, p. 2-52). As a result, since Seal Beach must satisfy its own environmental compliance obligations, these comments are presented in the context of CEQA and NEPA and are intended to seek clarification of and/or expansion upon the information presented in the DEIR/S and the planning process upon which that analysis was derived. Because of our many shared interests, the need for cooperation and effective communication is particularly evident when regional and subregional issues are at hand. For all activities undertaken within its corporate boundaries, the City seeks to ensure a collaborative and cooperative planning and entitlement process through which Seal Beach's issues and concerns are given both ample voice and deferential consideration with regards to project-related and cumulative impacts on the residents and business interests within the City.

The City recognizes that prudent short-term and well-founded, long-term actions are called for in order to address existing and reasonably foreseeable traffic and transportation-related issues affecting the southern California area. As the major regional conduit serving Seal Beach, the City recognizes that improvements to and/or modifications of the I-405 Freeway may be required as part of a broader strategy to address those traffic and transportation needs. As a likely beneficiary, the City is an advocate for both prudent, well-planned improvements to the interstate and arterial highway system and for other accessibility-enhancing travel options.

Except where another document is first identified, excerpts and page references cited herein are with regards to the DEIR/S and are intended to be illustrative and not exhaustive (e.g., issues being raised may be systemic and not isolated to the single reference being cited). Excerpts extracted from the DEIR/S are presented only as examples of the relevancy of the specific issue or issues being raised by the City and should not be interpreted as constituting the only citation within the environmental review record where that issue or those issues have potential applicability. Document citations presented herein are for the sole convenience of the Department. The City's unintended misidentification of a page reference or citation, the City's failure to accredit a source document to all of its co-authors, or the likely presence of typographical and/or other unintended errors herein should not serve as an excuse by the Lead Agency not to fully respond to the issues and concerns being expressed.

In the preparation of these comments, the City has sought to use typical writing conventions (e.g., utilization and application of parenthesis/bracketing and underlining to reflect emphasis or call attention to an item). Use or application of those writing conventions, as well as the use of headings, capitalization, and punctuation herein, are presented to facilitate communication and are provided for convenience purposes only and should not be construed as limiting the nature or broader relevancy of the City's comments. Similarly, the organization of these comments should neither serve as an artificial constraint to the Lead Agency's obligations under CEQA and NEPA nor should they serve to limit the nature of the Lead Agency's responses thereto.

The DEIR/S is a voluminous undertaking and a lot of effort was expended in its preparation. Hours expended and volume and weight should not, however, be confused with substance. Unsupported statements and unsubstantiated conclusions should not be confused with substantial evidence (14 CCR 15384[d]) or with objective and good-faith efforts at full disclosure (Residents Ad Hoc Stadium Commission v. Board of Trustees). Independent of the merits or lack of merits of the proposed action, because the DEIR/S does not presently satisfy the requirements of CEQA/State CEQA Guidelines and NEPA/CEQ Regulations, the Lead Agency's existing environmental documentation fails to provide an adequate basis for informed governmental action and public participation. In its decision to submit comments on the DEIR/S, it has been the City's intent to support and assist the Lead Agency in its efforts to faithfully fulfill its environmental compliance obligations, including ensuring "that decisions be informed and balanced" (14 CCR 15003[j]).

1.2 Introduction to the Proposed Action

As indicated in the DEIR/S, "[t]he proposed project is a 'Major Project' as defined by the Federal Highway Administration (FHWA) because it would cost in excess of $500 million" (emphasis added) (p. 2-50). As further indicated in the "Air Quality Report - San Diego Freeway (I-405) Improvement Project SR-73 to I-605, Orange and Los Angeles Counties" (Caltrans, May 2011) (AQR), included in the DEIR/S, the project is "a Project of Air Quality Concern" and "is considered regionally significant" (emphasis added) (pp. 1 and 61). In addition, the proposed action constitutes a "significant operational change," as defined in the OCTA's "Orange County High Occupancy Vehicle (HOV) Operations Policy Study" (August 1, 2002) (emphasis added) (p. 66).

As evidence, in part, by the Department's and OCTA's own categorization of the proposed action as a MAJOR PROJECT, a PROJECT OF AIR QUALITY CONCERN, REGIONALLY SIGNIFICANT, and a SIGNIFICANT OPERATIONAL CHANGE, it is readily apparent that the proposed action has serious and significant implications not only with regards to the affected right-of-way (ROW) but in the larger context of the larger southern California region. Actions that are taken by Caltrans and the OCTA concerning the I-405 Freeway will have lasting and long-term consequences and will, directly and/or indirectly, affect both the face of travel and travel choices on a regional scale well into the future. As a result, it is necessary to shine a bright light on the proposed action (including the planning and environmental review process and the range of options under consideration) to ensure that the choices made today benefit the region long and not merely perpetuate the continuation of old and outdated habits.

As an introduction to the proposed action, the project "abstract" states that "[t]he Interstate 405 (I-405) Improvement Project proposes to widen the corridor by adding: [1] one general purpose (GP) lane in each direction between Euclid Street and Interstate 605 (I-605) [Alternative 1]; or [2] two GP lanes in each direction between Brookhurst/Euclid Street and I-605 [Alternative 2]; or [3] one GP lane between Euclid Street and I-605 and one tolled Express Lane in each direction between State Route 73 (SR-73) and State Route 22 (SR-22) east of I-405 to be managed jointly as a tolled Express Facility with two lanes in each direction between SR-73 and I-605. The tolled Express Facility would operate so that HOV2s would be tolled and HOV3+ would either be free or receive a discount [Alternative 3]. The proposed action would improve the freeway mainline and interchanges on I-405 in Orange and Los Angeles counties for approximately 16 miles between 0.2-mile south of Bristol Street and 1.4 miles north of I-605, as well as portions of SR-22, SR-73, and I-605 to <u>reduce congestion</u> and improve lane continuity through the corridor" (emphasis added) (DEIR/S, Title Page). The "corridor" is alternatively referred to as comprising a length of "14-miles" (p. 2-20) and/or "15-miles" (AQR, p. 51).

Although serving to describe, at least in part, the physical components of the proposed action, by depicting the project merely in terms of "brick and mortar," the totality of the action's substance (and consequently its environmental effects) are ignored or "swept under the rug." Since CEQA is intended to address "the whole of the action" (14 CCR 15378), the proposed action is inclusive of not only the increase in total lane-miles to be constructed but also the actions that the project produces and the precedence that the project establishes.

It is immediately evident that the magnitude of the proposed action makes it unique and demanding serious consideration. As indicated in the State CEQA Guidelines: "The EIR shall focus on the significant effects on the environment. The significant effects should be discussed with emphasis in proportion to their severity and probability of occurrence" (14 CCR 15143). Unlike a store with a limited clientele, Caltrans' customers are everyone who drives a motor-operated vehicle in California (e.g., private motorists, freight haulers, commercial vehicle drivers, public transit operators, school and tour buses, emergency responders, motorcyclists, maintenance vehicles, national and civil defense vehicles), including those people and businesses who are dependent upon them.

As indicated in Caltrans' "California Interregional State Highways – Major Planning Considerations, Trends, and Implications" (January 2010): "The designated Interstate system is the backbone of the state's transportation network for interregional, interstate, and international goods movements, access to airports, air cargo terminals, and other major gateways in the urbanized area. The Interstate system is the only 'completed freeway system' in California in terms of continuous high facility standards. The Interstate system is less than 18 percent of all state highway miles, however, it carries over half of all VMT [vehicle miles traveled] annually (over 80 billion VMT) and half of all VMT in the urbanized and metropolitan areas. The State's large metropolitan centers in Southern California and the Bay Area in Northern California rely heavily on the Interstate system for interregional and regional mobility" (pp. 1-2). Within southern California, the I-405 Freeway is a critical component of the State's transportation infrastructure, part of the region's backbone system, and a "bypass route" to other north-south conduits linking Los Angeles, San Diego, and Orange Counties.

Not many projects have the potential to produce a fundamental shift in (driver's) behavior. However, in the case of the proposed action, the Lead Agency is actively seeking to alter a well-established, widely-accepted, and environmentally-based principal that has served as the foundation for State and federal transportation planning dating back to the 1980's.

For over 30 years, high-occupancy vehicle (HOV) facilities have been a part of urban transportation planning. By restricting certain highway lanes to exclusive use by multi-occupant vehicles (MOVs), HOV projects have served to improve the people-moving capacity of travel corridors and encouraged drivers to (at least on occasion) abandon their single-occupant vehicles (SOVs) and join carpools, vanpools, or use transit buses, resulting in substantial reductions in total VMT, consumption of petroleum products, and mobile source air emissions. The construction of HOV lanes was based both on sound traffic engineering (e.g., increasing the average number of persons per vehicle, preserving the people-moving capacity of travel corridors, and enhancing mobility options) and government-sponsored social engineering (e.g., HOV lanes do not force drivers to make changes but rather encourages them to do so).

In “HOV Facility Development: A Review of National Trends, Paper No. 02-3922” (Fuhs, C. and J. Obenberger, undated), the authors note: “Based on thirty years of experience from across the country, HOV lanes are a proven, viable, and effective alternative to mitigate the impacts of traffic congestion in urban and suburban areas. As a part of an overall approach to address travel demand and mitigate the impacts of congestion in a region, HOV lanes have the potential to move more people in fewer vehicles, improve the person moving capability and reliability, and efficiently utilize the available roadway infrastructure and transit fleet” (p. 1).

HOV lanes are a proven, viable, and effective alternative to mitigate the impacts of traffic congestion in urban and suburban areas. As a part of an overall approach to address travel demand and mitigate the impacts of congestion in a region, HOV lanes have the potential to move more people in fewer vehicles, improve the person moving capability and reliability, and efficiently utilize the available roadway infrastructure and transit fleet. As reported in the Los Angeles County Metropolitan Transportation Authority’s (LACMTA or Metro) “HOV Performance Program Evaluation Report” (November 22, 2002):

> The mere presence of the carpool lanes was a critical factor in many commuters decision to participate in a carpool or vanpool in order to realize the time savings. Almost 8 out of 10 peak-period carpool lane users (79%) say the presence of the lanes play an important role in their decision to carpool. For carpool lane transit service users, the response is even more overwhelming. Almost all the riders (95%) say the fact that the bus is using the carpool lanes is important in their decision to ride the bus. Over one half of those identified as carpool lane users previously drove alone in the general purpose lanes on the same freeway prior to using the carpool lane. On freeways without carpool lanes, 29% of peak-period drive-alone commuters say they would start to carpool if the lanes were added to their freeway, effectively removing vehicles from the freeway. The introduction of carpool lanes to a freeway has been effective at getting people to start to carpool. Los Angeles County commuters are willing to change their ways to use the carpool lanes, when the lanes are provided (p. 47).
>
> For SOV commuters on freeways without carpool lanes, almost 30% indicate that they would use carpool lanes if lanes were made available on their freeway. For general-purpose lane users on freeways with HOV lanes, two-thirds indicated that they could be influenced to carpool with some kind of inducement. One-quarter of these respondents indicated that some sort of employer incentive would be enticement to carpool, vanpool, or ride transit, while an additional 22% advised that an easy way to start or join a carpool or vanpool, like the availability of a rideshare program, would be sufficient inducement (p. 82).

The HOV lane of the I-405 Freeway does not suffer from the "empty lane syndrome" (e.g., motorists travelling along adjacent congested general-purpose lanes perceive the HOV lane to be underutilized) or lack of utilization. It appears that the opposite is the case. There are times when the level of service (LOS) on the HOV lane (e.g., LOS "F") matches that on the GP lanes, suggesting the need for an additional HOV lane.

The Department mischaracterizes the project by stating that "the project is not a precedent-setting action and would not affect resources of concern" (p. 3.1.2-9). At least with regards to Alternative 3, the proposed action is the linchpin of a much broader regional strategy designed to: (1) convert the southern California existing highway system (not just newly constructed toll roads) from "'free' ways" into "'toll' ways," thus creating a new social order of "those with transponders" and "those without"; (2) privatize components of the existing public transportation system, emphasizing the optimization of return-on-investment over the maximization of public benefit; and (3) change traditional design-then-build construction practices involving separate entities without possible economic entanglements into "design-build" contracts potentially favoring the profitability of a single entitle (or group of investors) over public safety and convenience. Once the step is taken, there is no turning back.

The Lead Agency seeks to induce a major change (paradigm shift) in driving habitats that would: (1) have ramifications and reverberations extending substantially beyond the edge of the I-405 Freeway right-of-way and which would negate the benefits that have predicated HOV development (e.g., reduction in VMT); and (2) prove irreparable because conversion back to pre-project conditions would meet with substantial resistance by well-heeled HOT-lane users. As proposed, the concept of dedicating HOV lanes to use first MOVs and public transit vehicles and subsequently to low-emission vehicles (LEMs) would be replaced by a "pay to play" concept that allocates an unlimited percentage of lane capacity to SOVs willing to pay a specified toll rate (e.g., "The volume of traffic in the Express Lanes would be actively managed to maintain high-speed operations with maximum hourly volumes of 3,400 [vehicles/hour]" Traffic Study, p. 3.1.6-95). Being pushed out of the HOV lanes are the MOVs and LEMs and being forfeited are the environmental and societal benefits attributable to use of HOV lanes by carpools, vanpools, and public transit vehicles.

As indicated in the "Orange County High Occupancy Vehicle (HOV) Operations Policy Study":

> According to the transportation planning requirements noted in 23 C.F.R. 450.320(c), in Transportation Management Areas (TMAs), the planning process must include the development of a CMS [Congestion Management System] that provides for the effective management of new and existing transportation facilities through the use of travel demand reduction, travel management, traffic operational strategies, and meets the requirements of 23 C.F.R. part 500. 23 C.F.R. 500.109 defines an effective CMS as a systematic process for managing congestion that provides information on transportation system performance, and on alternative strategies for alleviating congestion, to enhance the mobility of persons and goods to levels that meet State and local needs. The CMS encourages the consideration and implementation of strategies that provide the most efficient and effective use of existing and future transportation facilities. Consideration needs to be given to <u>strategies that reduce SOV travel</u> and improve existing transportation system efficiency (emphasis added) (p. 72).

Although it is OCTA's policy to "reduce SOV travel," to the detriment of carpool formulation and retention and public transit ridership, the proposed action serves to promotes travel by SOVs and, therefore, would appear to violate existing OCTA policies. In addition, as indicated in the OCTA's "Orange County High Occupancy Vehicle (HOV) Operations Policy Study," the proposed action "has the potential to adversely affect the area's flow of traffic, roadway and traveler safety, and the environment" (p. 72). As further indicated therein, "FHWA must be consulted if a proposed significant operational change can be reasonably expected to affect a specific HOV lane or portions of the regional HOV system, which were funded or approved by FHWA. This includes portions of the local, region, or Federal-aid Highway system, where operational changes to these facilities may also adversely affect the operation of one HOV lane, or portions of the regional HOV system" (p. 66). Notwithstanding any attempt to do so in the DEIR/S, the proposed action cannot be examined in the context of a single freeway segment but must be assessed in a broader regional context than now explored by the Lead Agency.

Notwithstanding the project's connection with Measures M/M2, the Lead Agency's singular focus on constructing new lane-miles has limited public discussion and corresponding environmental analysis of a substantially broader range of options that could be implemented to accomplish the proposed action's declared P&N (assuming that the P&N is appropriately identified and not alternative restricting). In the Department's blind pursuit of only one travel mode and one course of action (although minor variations relating to the quantity and placement of new pavement have been identified), despite the OCTA's willingness to spend an estimated $5.8 billion dollars in public funds in advancing a specific development proposal, a broader view of traffic and transportation are never introduced.

As outlined in the OCTA's "Destination 2035 – Moving Toward a Green Tomorrow" (2010) (2010 LRTP), by 2035, "about 50 percent of Orange County's freeways and about 20 percent of Orange County's roadways will operate under congested conditions during peak hours. Average peak period freeway speeds are expected to be close to 30 miles per hour (mph) in the mixed-flow lanes and about 35 mph in the HOV lanes. Average roadway speeds are expected to be about 13 mph during peak hours" (p. 36). As such, the problems that the proposed action purports to address are substantially greater than a short segment of a specific freeway. Where in the DEIR/S is that discussion?

How do you "reduce" something that is never first defined (e.g., "reduce congestion")? Absent from the DEIR/S is any effort by the Lead Agency to define "congestion." Congestion is far from a simple concept and its historic context, contributory components, universally accepted benchmark, and relevancy to transportation not universally understood. Absent that definition, how do you know if you have succeeded?

Because "whatever gets measured gets managed," the Department's fundamental folly is the selection of the wrong yardsticks (i.e., vehicle throughput and relative speed) both with regards to its definition and measurement of "congestion" and in its formulation and evaluation of project alternatives. Since neither vehicle throughput nor relative speed were identified as key variables in Measures M/M2, premising the entire project on those single variables creates no direct or indirect linkage between the proposed action and Measures M/M2. Sound transportation planning should be about moving people and goods, not about counting automobiles and trucks passing arbitrarily established fixed points that bear little relevancy to the lives of motorists (e.g., few individuals start and end their daily travels at the two assigned end points or limit their driving to the Lead Agency's designated "corridor"). The Lead Agency's selection of performance indices lacks reasonable connectivity with the project's declared P&N.

As described in the "Traffic Study – San Diego Freeway (I-405) Improvement Project SR-73 to I-605, Orange and Los Angeles Counties" (Caltrans and Albert Grover & Associates, May 2011) (Traffic Study), as included in the DEIR/S, "[t]hroughput is the general purpose flow rate multiplied by the number of lanes, plus the specialty lanes (HOV or express lanes) flow. The peak hour throughput is the number of vehicles able to pass a fixed point along the corridor during the hour of greatest demand" and is measured as "the number of vehicles able to pass a fixed point along the project route" (pp. ES-3 and 4-2). That definition, however, neither serves as an accurate measure of the number of individuals or the amount of freight that can be moved from Point A to Point B within a designated time period nor constitutes the sole indices for the assessment of "best use." By maintaining a myopic focus on vehicle throughput, the Lead Agency ignores the function of the automobiles and truck traffic traveling along the freeway, namely the efficient and effective movement of people and goods.

1.3 Understanding California Department of Transportation's and the Orange County Transportation Authority's Respective Roles

1.3.1 Orange County Transportation Authority

The DEIR/S notes that "[t]he proposed project is a joint project" undertaken by Caltrans and the FHWA (p. 4-1), a division of the United States Department of Transportation (DOT or USDOT). As represented, it is not a joint undertaking of Caltrans and the OCTA. The OCTA is identified in the DEIR/S as the "project sponsor" (p. 1-1) or "sponsor agency" (p. 5-5) for the action described therein. Under NEPA, the term "project sponsor" means the agency or other entity seeking "approval of the Secretary [of Transportation] for a project" (23 U.S.C. 139[a][3][B][7]) and the agency or entity, including any private or public-private entity, seeking "an Administration action" (23 C.F.R. 771.107[i]). Conversely, the term "sponsor" has no meaning in CEQA parlance.

Under NEPA, the term "applicant" means "[a]ny State, local, or federally-recognized Indian tribal governmental unit that requests funding approval or other action by the Administration and that the Administration works with to conduct environmental studies and prepare environmental review documents. When another Federal agency, or the Administration itself, is implementing the action, then the lead agencies (as defined in this regulation) may assume the responsibilities of the applicant in this part. If there is no applicant, then the Federal lead agency will assume the responsibilities of the applicant in this part" (23 C.F.R. 771.107[f]). Based on those definitions, the OCTA may be categorized as both "project sponsor" and "applicant."

With regard to OCTA's "responsibilities," the DEIR/S states that OCTA will "[p]rovide funds, resources, and leadership attention needed to complete EIR/EIS; provide comments on purpose and need, range of alternatives, and Draft/Final EIR/EIS" (Table 5-2, p. 5-5). However, nowhere in any documentation has the City found any declaration that the OCTA is serving either as "lead agency" or as "joint lead agency" for the purpose of environmental compliance (see 23 U.S.C. 139[a][3][B][4], 23 U.S.C. 139[c][2]-[3], and 14 CCR 15367).

Although no subsequent reference could be found in the DEIR/S, the "Notice of Preparation" (NOP), dated August 26, 2009, states that the OCTA is a "responsible agency and participating agency under CEQA and is also the funding agency" (p. 1). Because no similar reference can be found in the DEIR/S, the Lead Agency should clarify whether OCTA remains a "responsible agency" under CEQA and, if so, what its obligations are thereunder.

The DEIR/S includes the OCTA among the list of agencies with "probable permit requirements and approvals," specifically identifying the need for "Maintenance, Operations, and Law Enforcement Agreements (Alternative 3 Only)" (Table 2-2, p. 2-52). The DEIR/S does not, however, indicate whether those "agreements" constitute discretionary or ministerial actions under CEQA or whether any other discretionary actions will be required from the OCTA. As defined in the State CEQA Guidelines, "'[m]inisterial' describes a government decision involving little or no personal judgment by the public official as to the wisdom or manner of carrying out the project. The public official merely applies the law to the facts as presented but uses no special discretion or judgment in reaching a decision. A ministerial decision involves only the use of fixed standards or objective measurements, and the public official cannot use personal, subjective judgment in deciding whether or how the project should be carried out? (14 CCR 15369). "Ministerial projects" are statutorily exempt from CEQA (14 CCR 15268).

Absent discretionary authority over the proposed action, the role and responsibility of the OCTA with regards to both the project's CEQA and NEPA documentation and ability to dictate the nature of physical improvements to the federal highway system is unclear and requires further clarification. As purported in Table 2-2 (Probable Permit Requirements and Approval) in the DEIR/S, the only action required from the OCTA relates to "Alternative 3 only" (p. 2-52). If there are no discretionary "requirements or approvals" (p. 2-52) from the OCTA for Alternatives 1 and 2, then OCTA: (1) cannot be a "responsible agency" under CEQA; and/or (2) knew before the issuance of the NOP that the "preferred project" was going to be "Alternative 3 only." Any subterfuge to the contrary, either in the DEIR/S or elsewhere, is intended solely to confuse an unsuspected public and falsely suggest that the process has more transparency than truly deserved. It, therefore, appears disingenuous for the OCTA to assert that "we are proud of our long-time reputation of accountability, openness and transparency" (A Message from CEO Will Kempton, http://www.octa.net/righttoknow.aspx).

As indicated in the DEIR/S: "The entire length of I-405 is part of the National Highway System, the Department of Defense Priority Network, the Interstate Highway System, and the Strategic Highway Corridor Network. The 1990 Federal Surface Transportation Assistance Act (STAA) identifies I-405 as a "National Network" route for STAA trucks. Strategically, I-405 is a transportation link for national defense and transportation security, providing direct and indirect access to major military installations in the west, including Los Angeles Air Force Base to the north, and NAVWPNSTA [Naval Weapons Station] Seal Beach, Air Force Reserve Center Los Alamitos, and Camp Pendleton to the south" (p. 1-20). In addition, the I-405 Freeway is component of the "California Freeway and Expressway System" (F&E System) and part of the "State Highway System" (SHS). Caltrans has the statutory responsibility for operations, maintenance, design, construction, and long-range planning of the SHS and the State agency responsible for establishing standards and policies to maintain the system and administer the State Highway Operations and Protection Program (SHOPP) for the rehabilitation and operational improvements of the system (Source: Caltrans, California Interregional State Highways – Major Planning Considerations, Trends, and Implications, January 2010, p. 1).

As indicated in the OCTA's "2011 Orange County Congestion Management Program" (undated): "Caltrans is responsible for monitoring freeway performance and addressing any deficiencies on State operated facilities. Caltrans' responsibilities include, but are not limited to: (A) Evaluating current conditions and identifying deficiencies. (B) <u>Developing plans and strategies to address deficiencies</u>. (C) Evaluating development projects of local and regional significance to determine whether they will impact the State transportation system and, if so, working with lead agencies to develop potential mitigation measures" (emphasis added) (p. 5).

With regards to describing its own role under CEQA and NEPA, the Department states that its role is to only "provide comments on purpose and need, range of alternatives, and Draft/Final EIR/EIS" (emphasis added) (Table 5-2, p. 5-5). Under both CEQA and NEPA, the role of the "lead agency" extends substantially beyond "providing comments" to a "project sponsor" and "applicant" possessing, for the purpose of the proposed action, no discretionary authority.

Referencing the DEIR/S: "The environmental review, consultation, and any other action required in accordance with applicable federal laws for this project has been or is being carried out by the Department under its assumption of responsibility pursuant to 23 United States Code (U.S.C.) 327" (p. 1-1). Pursuant to Section 327(a)(2) therein, "[s]ubject to the other provisions of this section, with the written agreement of the Secretary and a State, which may be in the form of a memorandum of understanding, the Secretary may assign, and the State may assume, the responsibilities of the Secretary with respect to one or more highway projects within the State under the National Environmental Policy Act of 1969." As specified under Section 327(e), A State that assumes responsibility under subsection (a)(2) shall be solely responsible and solely liable for carrying out, in lieu of the Secretary, the responsibilities assumed under subsection (a)(2), until the program is terminated" (emphasis added) In accordance therewith, the Department cannot delegate to the OCTA its obligations under NEPA. Although the OCTA may be providing all or a portion of the funding for the proposed action, it is unclear how or why Caltrans is delegating its planning and environmental compliance responsibilities over the I-405 Freeway to a non-State agency (particularly an agency with a potential vested interest in a pre-determined outcome).

At a community meeting conducted by the City on June 26, 2012 at the Seal Beach Community Center (3333 St. Cloud, Seal Beach), which was graciously attended by Niall Barrett, OCTA's Project Manager and William Kempton, OCTA's Chief Executive Officer (CEO), Mr. Barrett informed the audience (which included representatives of the Seal Beach City Council and City staff) that: (1) the close of the comment period on the DEIR/S has been extended until July 17, 2012; and (2) the OCTA Board of Directors would be selecting a "preferred" alternative on August 13, 2012. Mr. Kempton stated that the "OCTA is the decision-making body" for the proposed project.

As the project's "decision-making body," the City is concerned that the Department's failure to identify the OCTA as either the "lead agency" or as "co-lead agency" is merely a veiled attempt to circumvent or otherwise bypass the OCTA's obligations under CEQA including, but not limited to, the OCTA's consideration of written comments received on the DEIR/S (14 CCR 15092) and the OCTA's adoption of requisite findings (14 CCR 15091 and 15092) and statement of overriding considerations (14 CCR 15093). As stipulated under the State CEQA Guidelines: "(b) If the project is to be carried out by a nongovernmental person or entity, the lead agency shall be the public agency with the greatest responsibility for supervising or approving the project as a whole" and "(c) Where more than one public agency equally meet the criteria in subsection (b), the agency which will act first on the project in question shall be the lead agency" (14 CCR 15051[b]-[c]). Because the OCTA has indicated a desire to pursue both a "design-build" contract and to convey control of the operation of a substantial portion of the proposed project to a private concessionaire, it is likely that the design, construction, and operation of the project, or a substantial portion thereof, will be performed by a non-governmental entity under the supervision of the OCTA (not Caltrans).

Although a non-governmental "project sponsor" and/or "applicant," lacking any discretionary authority over a proposed action, may not have obligations under CEQA, if that same sponsor and/or applicant is also a "responsible agency" (14 CCR 15381), it "complies with CEQA by considering the EIR or negative declaration prepared by the lead agency" (14 CCR 15096[a]). Based on the anticipated nature and extent of comments likely to be received by the Lead Agency on the DEIR/S, it is improbable that all comments received by the Lead Agency within the comment period and addressing the adequacy of the DEIR/S can be digested and formal responses formulated by the Lead Agency and those responses independently considered by OCTA's Board of Directors by August 13, 2012.

As specified under Section 21006 of CEQA, "[t]he legislature finds and declares that this division is an integral part of any public agency's decisionmaking process." Since the OCTA's Board of Directors will not have sufficient opportunity to review the totality of comments received in response to the dissemination of the DEIR/S, the Lead Agency's detailed written responses thereto, and any subsequent comments that may be submitted by commenting public agencies following their authorized review of the Lead Agency's draft reply (Section 21092.5(a), CEQA), the Board of Directors will not be fully informed and will not possess the information required under applicable statutes and regulations. As a result, any actions taken by OCTA's Board of Directors prior to the Lead Agency's certification of the EIR and the Board of Directors consideration thereof would appear to be in violation of CEQA.

1.3.2 Project Development Team

In the preparation of these comments, the terms "Lead Agency" and "Caltrans" or "Department" have been used interchangeably and with clear and intended distinction from "OCTA"; however, based on a presentation by Niall Barrett, OCTA's Project Manager at the Seal Beach Community Center on June 26, 2012, any distinction is now blurred. When asked about the identity of the project's decision-making body, Mr. Barrett repeatedly stated that future decision's regarding the project (including the choice among alternatives) will be made by a "Project Development Team" consisting of both representatives of Caltrans (purported to be the CEQA/NEPA "Lead Agency") and OCTA (identified in the DEIR/S as the "project sponsor").

Only minimal reference to the "Project Development Team" (PDT) is presented in the DEIR/S (e.g., "The potential effectiveness of each alternative to achieve the project purpose and address the project need was based on extensive deliberation by the Project Development Team [PDT]," p. 2-1; "To the extent that it is applicable or feasible for the project and through coordination with the project development team, the following measures will also be included in the project to reduce the GHG emissions and potential climate change impacts from the proposed project," p. 4-59). Specifically, no reference to the PDT (either as an entity or a non-entity) is presented in Table S-4 (Probable Permit Requirements and Approvals) (p. S-41 thru 43) or Table 2-2 (Probable Permit Requirements and Approvals) (p. 2-50 thru 53). With regards to those two tables (purporting to list all requisite discretionary actions), no agency is identified as the decision-making body for the certification of the CEQA document and adoption of the NEPA document.

The DEIR/S notes that "[a]fter the public circulation period for the Draft EIR/EIS, all comments will be considered, and the <u>Project Development Team (PDT) will select a preferred alternative and make the final determination of the project's effect on the environment</u>" (emphasis added) (p. 2-27). CEQA states that the "'[d]ecision-making body' means any person or group of people within a pubic agency permitted by law to approve or disapprove the project at issue" (14 CCR 15356). The PDT does not appear to be comprised of elected representatives, constitute a public entity, or be accountable to any particular constituency.

In Kleist v. City of Glendale (1976), the court stated that “Section 15050 of the State Guidelines requires each public agency subject to the CEQA to adopt its own procedures for the identification of projects which have a possible effect upon the environment, for the conduct of initial studies, for consultation with other public agencies and obtaining comments from them and from members of the public, for evaluation and response to comment, assignment of responsibility for specific functions to specific units of the public agency, and for preparation of EIR’s. Section 15050 requires further that the agency's procedures contain ‘(p)rovisions for the review and consideration of environmental documents by the person or decision-making body who will approve or disapprove a project,’ and ‘(p)rovisions for filing documents required or authorized by CEQA and (the state) guidelines’” [Citation].

Absent from the DEIR/S is any evidence that the PDT has been formally established by legislative action, comprised of representatives of “a” public agency, delegated any formal and official powers or authority, and/or “adopt[ed] its own procedures” (pursuant to Kleist v. City of Glendale). Similarly, there exists no reference to any established organization procedures, such as meeting noticing obligations, public disclosure requirements, opportunities for public participation, avoidance of conflicts of interest, voting procedures, and to who PDT actions would be appealable (see Section 21151[c], CEQA and Section 15090[b], State CEQA Guidelines).

As indicated in the DEIR/S” “Agency consultation and public participation for this project has been accomplished through a variety of formal and informal methods, including Project Development Team (PDT) meetings” (p. 5-1). Where each of the PDT meetings publicly noticed, in what manner did that noticing take place, and to whom were any direct mailings of that notice disseminated? Are transcripts of those meetings available?

The composition of the PDT is not even disclosed in the DEIR/S. When OCTA’s representative was asked for the names and contact information for the individuals comprising the PDT so that the affected public might provide input in order to assist in the decision-making process, the representative was evasive and the public was directed to file a “Public Records Act” request if they sought the names of the PDT. Since the composition of the PDT, therefore, remains a mystery, the City asks for full disclosure.

In Kleist v. City of Glendale, the court found that “the Glendale City Council was required itself to review and consider the EIR and could not delegate that function to some other agency of city government.” It is likely that the court’s ruling would equally apply to the assignment of similar responsibilities to the PDT.

1.3.3 California Department of Transportation

As indicated by Niall Barrett, OCTA’s Project Manager at the Seal Beach Community Center on June 26, 2012, the OCTA Board of Directors would be selecting a “preferred” alternative on August 13, 2012. Although not using the word “rubberstamp” and only paraphrasing Mr. Barrett’s comments, the OCTA’s representative stated that “since we’re the project sponsor and will be paying for it, Caltrans won’t make a decision other than the one selected by the project sponsor.” William Kempton, OCTA’s CEO (who was also in attendance at that meeting) make no attempt to clarify or refute his staff’s public position. While acknowledging that one agency’s representative cannot commit the actions of another governmental entity, the statement clearly suggests that Caltrans’ has or will likely fail to fulfill its independent obligations under CEQA and NEPA.

Absent from the DEIR/S is any evidence that Caltrans is anything other than a "rubberstamp" and that the process is not being unduly manipulated by the OCTA. As evidenced by anything other than tacit involvement in the CEQA and NEPA process, available evidence suggests that the State's transportation planning agency has failed not only in its leadership but also in its lack of vision and forward planning and in its obligation to defend and uphold its CEQA/NEPA requirements.

Under CEQA, "[t]he lead agency shall evaluate comments on environmental issues received from persons who reviewed the draft EIR and shall prepare a written response" (14 CCR 15088[a]). In its handout at the June 26, 2012 community meeting, OCTA indicated that "e-mail comments" should be sent to "405.dedcomments.parsons@parsons.com." In contravention of CEQA, because Parsons is operating under contract to the OCTA and not Caltrans, the "project sponsor" (rather than the Lead Agency) appears to be tasked with the assemblage of comments on the DEIR/S and the preparation of written responses thereto.

As stipulated under Section 15003 of the State CEQA Guidelines: (1) "The EIR serves not only to protect the environment but also <u>to demonstrate to the public that it is being protected</u>"; (2) "The EIR is to <u>demonstrate to an apprehensive citizenry</u> that the agency has, in fact, analyzed and considered the ecological implications of its actions"; and (3) "The EIR process will enable the public to determine the environmental and economic values of their elected and appointed officials thus allowing for appropriate action come election day should a majority of the voters disagree" (emphasis added).

1.4 Stipulating the City of Seal Beach's Role

1.4.1 California Environmental Quality Act

The DEIR/S states that a "freeway agreement" will be required from the City (Table 2-2, p. 2-53). In addition, implementation of the proposed action appears to necessitate the need for additional real property within the City (differentiating between "Existing R/W" and "Proposed R/W," Appendix K, Sheets U-24 and 2-25), the relocation of the existing soundwall along Almond Avenue (e.g., "Numerous soundwalls within the corridor would be replaced to accommodate the widened paving," p. 3.1.7-31), and the relocation of the existing overhead utility lines in proximity to that soundwall. In addition, as a result of the loss of existing pavement width, because Almond Avenue would no longer conform to the "City of Seal Beach Municipal Code" (Seal Beach Municipal Code) street width and design standards, the City may be required to amend the "City of Seal Beach General Plan" (Seal Beach General Plan) in response thereto.

The Lead Agency recognizes the need for local governments to amend their existing policy documents in response to the proposed action. In response, the following "measure" is identified in the DEIR/S: "If a build alternative is selected for implementation, OCTA shall request the County of Orange and the cities along the project corridor to amend their respective General Plans to reflect the selected build alternative and the modification of land use designations for properties that would be acquired for the project that are not currently designated for transportation uses" (Measure LU-1, p. 3.1.1-33).

In addition to its role as an affected stakeholder, while not formally acknowledged as such in the DEIR/S, based on the City's location, jurisdictional authority, obligations as a municipality, the Lead Agency's identification of the need or potential need for one or more discretionary actions from the City for the project's effectuation, and the City's independent determination that one or more discretionary actions would either be required or desirous, Seal Beach possesses "responsible agency" (14 CCR 15381) status under CEQA.

1.4.2 National Environmental Policy Act

In holding that a municipalities interests fall within the scope of NEPA's protections, a federal court noted that "[t]he policies underlying NEPA are extremely broad [Citation] and the environmental interests it seeks to protect are shared by all citizens. In a sense, therefore, the intended beneficiaries of NEPA are individual citizens; but the statute expressly contemplates that state and local governments are to play an important role in the effectuation of national environmental policy [Citation]. Thus, while a municipality's interest in agency compliance with NEPA in one sense derives from the interests of its citizens in avoiding the consequences of environmental damage, under California law it is the municipality which is entrusted with protection of certain of these environmental interests, by virtue of statutory duties to develop and enforce a general plan, to maintain or contract for a municipal water supply, and so on" (City of Davis v. William T. Coleman, Jr., Secretary of Transportation [1975]).

As stipulated under 23 U.S.C. 139(d): "(1) The lead agency shall be responsible for inviting and designating participating agencies in accordance with this subsection. (2) Invitation. - The lead agency shall identify, as early as practicable in the environmental review process for a project, any other Federal and non-Federal agencies that may have an interest in the project, and shall invite such agencies to become participating agencies in the environmental review process for the project. The invitation shall set a deadline for responses to be submitted. The deadline may be extended by the lead agency for good cause." As defined under NEPA, the term "participating agency" means "[a] Federal, State, local, or federally-recognized Indian tribal governmental unit that may have an interest in the proposed project and has accepted an invitation to be a participating agency, or, in the case of a Federal agency, has not declined the invitation in accordance with 23 U.S.C. 139(d)(3)" (23 C.F.R. 771.107[j]).

The City may be required to amend theSeal Beach General Plan is response to the project's potential impacts and, because the I-405 and I-605 Freeways traverse the City's corporate boundaries, possesses special expertise and information relevant to the project and its potential environmental effects. Since numerous publicly- and privately-owned properties located within City will be directly or indirectly affected by the proposed action, the City serves as an outspoken advocate for the interests and concerns of those parties.

Pursuant to Section 6002(d) of SAFETEA-LU (23 U.S.C. 139), the City requests designation as a non-Federal "participating agency." As specified in the FHWA's and Federal Transit Administration's (FTA) "SAFETEA-LU Environmental Review Process Final Guidance" (November 15, 2006) (SAFETEA-LU Guidelines): "The roles and responsibilities of participating agencies include, but are not limited to: [1] Participating in the NEPA process starting at the earliest possible time, especially with regard to the development of the purpose and need statement, range of alternatives, methodologies, and the level of detail for the analysis of alternatives. [2] Identifying, as early as practicable, any issues of concern regarding the project's potential environmental or socioeconomic impacts. Participating agencies also may participate in the issue resolution process described later in this guidance. [3] Providing meaningful and timely input on unresolved issues. [4] Participating in the scoping process. The scoping process should be designed so that agencies whose interest in the project comes to light as a result of initial scoping activities are invited to participate and still have an opportunity for involvement"

(Question 22) (see also 23 U.S.C. 139[h]). As further specified under the SAFETEA-LU Guidelines: “If initially an agency was unintentionally left out and now wants to participate, the agency should be extended an invitation to become a participating agency as soon as the oversight is realized. The lead agencies should request input and consider whether and how the new agency’s participation in the process affects previous decisions. It may be necessary to reconsider previous decisions if it is probable that the input of the new participating agency would substantially change the decision” (Question 26).

The DEIR/S states that Seal Beach is a “participating agency” (Table 5-2, p. 5-6). If not already assigned, the City formally requests “participating agency” status under NEPA. The comments presented herein are, therefore, those of “participating agency” (potentially invited late to the scoping process). As evidenced by the nature of these comments, the City believes that the Lead Agency should reconsider a number of its previous decisions, including those associated with the range of alternatives examined in the DEIR/S and the presence of additional feasible mitigation measures formulated in response to project-related and cumulative impacts within Seal Beach, its residents, and business community.

2.0 ENVIRONMENTAL CONCERNS

As noted in the “California Transportation Plan 2025” (Caltrans, April 2006) it is the State’s goal to “[r]eflect community values” and the State’s strategy to “[i]ncorporate community values and support context sensitive solutions for all transportation facilities and infrastructure” (pp. 54 and 57). Seal Beach interprets those policy declarations as a willingness, on the part of Caltrans, to design and development transportation facilities that protect local communities and neighborhoods from the intrusive effects of improvement to and expansion of the State’s transportation system.

Within the study area, the I-405 and I-605 Freeways traverse Seal Beach. Since lands, facilities, and a broad range of public and private uses abut those freeways, the City, its residents, and business community have the potential to be substantially impacted by any plans promulgated by Caltrans and the OCTA affecting the ROW, the use, the operation, the design, and the capacity of those freeways. Similarly, the arterial roadway system within Seal Beach, in combination with the City’s local street system, can be substantially affected by changes to those State highways. As such, any proposed actions affecting roadways under Caltrans’ jurisdiction cannot be viewed in isolation of their interrelated impacts upon those arterial and local streets under the jurisdiction of other agencies.

In Concerned Citizens of Costa Mesa v. 32nd District Agricultural Association (1986), the court emphasized the critical role of linking government decision making with public participation in the CEQA process. “CEQA compels an interactive process of assessment of environmental impacts and responsive project modifications which must be genuine. It must be open to the public, premised upon a full and meaningful disclosure of the scope, purposes and effect of a consistently described project, with flexibility to respond to unforeseen insights that emerge from the process [Citation]. In short, a project must be open for public discussion and subject to agency modification during the CEQA process [Citation]. This process helps demonstrate to the public that the agency has in fact analyzed and considered the environmental implications of its action.”

2.1 Specific Environmental Concerns

As illustrated in Figure 2-1 (Sensitive Receptor Locations) in the AQR (p. 39) and Figure 3.2.6-3 in the DEIR/S (p. 3.2.6-13), numerous "sensitive receptors" are located in Seal Beach directly adjacent to or in close proximity to the I-405 Freeway, including the Seal Beach Tennis Center, Blue Bell Park, Almond Park, and the College Park East (Almond Avenue), Leisure World (Beverly Manor Road), and College Park West (Harvard Lane, Park Drive, and College Park) and residential neighborhoods. In addition to any comments that other individuals and entities elect to submit, the City seeks to represent the interests of those areas (as well as its own facilities, infrastructure, and jurisdictional interests) as they may relate to the proposed action.

These comments are predicated, in part, on the policies of the City, as reflected in the Seal Beach General Plan. As indicated in the City's recently adopted Housing Element (April 9, 2012), it is Seal Beach's goal to "[m]aintain and enhance the quality of existing residential neighborhoods" (p. V-1). It is the policy of the City to "[p]rovide compatibility of residential uses with surrounding uses through the separation of incompatible uses, construction of adequate buffers, and other land use controls" (Policy 1e, p. V-2). Implementing Program 1b (Land Use Compatibility) states: "A goal of the City is to create and maintain desirable living areas for residents by physically separating or otherwise protecting residential neighborhoods from incompatible uses. This program will be implemented through the review of proposed amendments to the General Plan and zoning regulations, and through the review of discretionary permit applications" (p. V-3).

Based on its review of the DEIR/S, the City has identified a number of environmental issues (e.g., incompatible use issues) which, in the City's judgment, have neither been adequately addressed nor effectively mitigated by the Lead Agency. Those issues are briefly outlined below and more thoroughly described throughout these comments. In addition, there exists a substantially broader array of environmental concerns (e.g., air quality) which are separately addressed in later sections of these comments.

2.1.1 Almond Avenue

Within Seal Beach, Almond Avenue is listed as a "major collector" (FC Code 5) on Caltrans' California Road System (CRS) maps (Functional Classification System Maps, Map 13V55, August 5, 2011) for Orange-Los Angeles, California.

Implementation of the proposed action will result in both the need for additional real property within the City (as can be ascertained by differentiating between "Existing R/W" and "Proposed R/W," Appendix K, Utility U-24 and 2-25), necessitate the relocation of the existing soundwall along Almond Avenue from inset from the edge to either the edge or beyond the edge of the existing ROW, and predicate the need to relocate the existing overhead utility lines located in proximity to that soundwall. It is anticipated that those actions will result in the reduction in the pavement width of Almond Avenue, producing a substandard pavement width inconsistent with the City's adopted design and development policies.

On June 26, 2012, representatives of the OCTA and the City met along Almond Avenue for the purpose of clarifying and delineating the proposed soundwall relocation. At indicated "in the field" and illustrated on a series of exhibits disseminated by the OCTA at the June 26, 2012 meeting at the Seal Beach Community Center, based on the wall section and alternative under consideration, the existing soundwall will be moved northward either seven, eight, or ten feet.

That action would result in a diminishment of the existing pavement width (reducing pavement width to approximately 30.5 feet east of and 32.0 feet west of Almond Park assuming a 4-foot separation between the base of the new soundwall and the southern edge of curb) and necessitating the elimination of on-street parking on at least one side of Almond Avenue

The potential impacts of those actions upon the City and its residents (including College Park West) have not be examined in the DEIR/S or in any of the technical studies associated therewith, including, but not limited to: (1) "Traffic Study – San Diego Freeway (I-405) Improvement Project SR-73 to I-605, Orange and Los Angeles Counties" (Caltrans, May 2011) (Traffic Study); (2) "Community Impact Assessment – San Diego Freeway (I-405) Improvement Project SR-73 to I-605, Orange and Los Angeles Counties" (Caltrans, August 2011) (CIA); (3) "Ramp Closure Study" (Caltrans, June 2011) (RCS); (4) "Draft Relocation Impact Memorandum – San Diego Freeway (I-405) Improvement Project SR-73 to I-605, Orange and Los Angeles Counties" (Caltrans, February 2011) (RIM); (5) "Draft Transportation Management Plan for Interstate 405 Improvement Project" (Caltrans, August 2011) (TMP); or (6) "Visual Impact Assessment – San Diego Freeway (I-405) Improvement Project SR-73 to I-605, Orange and Los Angeles Counties" (Caltrans and Parsons, May 2011) (VIA).

As indicated in the "Final Environmental Impact Statement and Environmental Impact Report – State Route 22/West Orange County Connector, SCH No. 98064001" (OCTA/Caltrans/USDOT, March 2003) (WCC FEIR/S), prepared for the West County Connector Project (WCC), various actions were taken by Caltrans for the purpose of avoiding or minimizing environmental impacts. Those actions included, but were not limited to: (A) "The right-of-way impact at the City of Seal Beach's reservoir was avoided by tightening the curvature of the Seal Beach Boulevard off-ramp while shifting the exit nose further to the south"; and (B) "The full acquisition of six homes along Almond Avenue in the City of Seal Beach as well as the relocation of overhead power lines and reconstruction of existing soundwalls were avoided by: (1) shifting the I-405 freeway centerline toward the south; (2) tightening the curvature; and (3) shifting the southbound I-405 to eastbound SR-22 connector gore area (divergence point) further to the east. This was achieved without changing the impacts to the United States Naval Weapons Station (USNWS) utility easement or facility on the south side of I-405" (p. 2-28).

With regards to the WCC, in Seal Beach, Caltrans acknowledged and took great efforts to avoid project-related impacts along Almond Avenue, including avoidance of take of real property and retention of both the existing soundwall and existing overhead utilities. The City is appreciative of those impact avoidance efforts and would hope that similar efforts could be taken with regards to the proposed action.

The Lead Agency, nonetheless, misrepresents the existing soundwall located in proximity to Almond Avenue, suggesting that it was recently rebuilt and now includes decorative features (e.g., "The portion of SR-22 East within this unit was recently rebuilt as part of another project, and additional aesthetic elements were added to the soundwalls, along with the inclusion of vine plantings along the walls, p. 3.1.7-16). A segment of the existing soundwall, adjacent to Almond Avenue, is illustrated in "Typical View 57" in Figure 3.1.7-8 (Open Space-Residential Landscape Unit, Typical Views) in the DEIR/S (p. 3.1.7-21). It is noted that no discussion or analysis of the proposed changes to "Typical View 57" is, however, presented in the DEIR/S.

Now, in what appears to be either a case of short-term memory or application of a conflicting (double) environmental standard, as a result of the proposed action, Caltrans now fails to acknowledge the criticality of those same impacts and proposes to: (1) take public lands within the City along Almond Avenue; (2) encroach onto the existing Almond Avenue ROW; (3) remove and relocate the existing soundwall to the north; and (4) relocate the existing overhead utilities to an unspecified location (potentially to the north side of Almond Street and adjacent to existing single-family homes in the College Park East neighborhood), potentially creating unspecified but significant fiscal and environmental cost to the City and to the affected property owners.

Almond Avenue is identified as a “Principal” street in the Seal Beach General Plan (Figure 15-City of Seal Beach General Plan Circulation Element) and functions as a “residential collector street” serving the College Park East neighborhood. Within the College Park East area, Almond Avenue is also designated as a Class III bicycle route, such that motorists and bicyclists share the existing roadway. With the proposed relocation of the soundwall, bicyclists and motorists will need to share a narrower roadway, placing both parties at greater risk.

Pursuant to the provisions of Section 10.40.10 (Streetscape Standards and Design) in Chapter 10.40 (Streetscape) in Title 10 (Subdivisions) of the Seal Beach Municipal Code: “Each street’s design shall be based on its anticipated role within the city and within each neighborhood” (Section 10.40.10[A][1]). As specified in Table 10.40.010.A (Street Design Standards), “residential collector streets” shall have a total ROW width of 60 feet, a curb-to-curb width of between 36 and 40 feet, include two travel lanes each with a width of 10 feet, a parking lane with a width of 8 feet, and include a 12-foot wide pedestrian ROW.

Based on an independent traffic engineering analysis performed by W.G. Zimmerman Engineering, Inc. (WGZE), operating under contract to the City, a City-generated alternative lane configuration in the vicinity of Almond Avenue was presented to OCTA by representatives of the City on May 15 and June 12, 2012. At neither meeting did Seal Beach receive a commitment of OCTA’s support of the alternative design options presented therein.

NEPA requires that the federal agencies “[r]igorously explore and objectively evaluate all reasonable alternatives, and for alternatives which were eliminated from detailed study, briefly discuss the reasons for their having been eliminated” (40 C.F.R. 1502.14[a]). Although the range of alternatives that the agency must consider is not infinite, it does have an obligation to include all reasonable alternatives to the proposed action. As an alternative to the above-illustrated design alternative, the City would request that the Lead Agency also consider a narrower lane-width configuration in the vicinity of Almond Avenue so as not to require either the relocation of the existing soundwall or further encroachment into the College Park East neighborhood.

In order to maintain sufficient travel lane width along Almond Avenue, the loss of existing ROW would predicate the need to eliminate on-street parking and, with the wall face overtopping or extending beyond the existing curb edge, would create an undesirable streetscape and a hazardous road condition, resulting in a violation of Section 10.40.010(D) of the City’s Subdivision Ordinance (i.e., street edge design shall not compromise public safety or emergency vehicle access). The elimination of on-street parking is contrary to and in violation of Section 10.40.010(A)(3) of the City’s Subdivision Ordinance. In addition, the resulting roadway would not conform to the typical street section presented in Section 10.40.010(A)(5) and Figure 10.40.010.A (Typical Street Design) therein. Any reduction in street width and/or the presence of an intrusive soundwall would increase safety hazards to both bicyclists and pedestrians traveling along Almond Avenue.

Because Almond Avenue functions as an important "residential collector street" and provides the sole vehicular access road to a large number of existing single-family homes, the creation of substandard travel lanes is not a viable public safety and emergency access option for the City. Because Almond Avenue serves many short residential cul-de-sacs, the availability of on-street parking is critical to area residents, such that, in the City's estimation, the neighborhood cannot properly function without on-street parking being available for the area's residents and for use by service and emergency vehicles.

Because Almond Avenue is not addressed in the DEIR/S, the statement that "[u]p to 450 parking spaces out of the current inventory of 2,243 spaces associated with 17 potentially affected properties would be lost to accommodate freeway widening and associated roadway improvements" (p. 2-31) ignores the project's anticipated consequences along Almond Avenue and fails to accurately characterize the proposed action's potential impacts.

The Department's analysis of potential parking impacts is inconsistent throughout the DEIR/S. As indicated in the CIA, with regards to all three build alternatives, the Lead Agency states that "[u]p to <u>720 parking spaces</u> out of the current inventory of 2243 spaces from 17 potentially affected properties would be lost to accommodate freeway widening and associated roadway improvements. In addition, approximately 13 on-street parking spaces would be lost" (emphasis added) (CIA, Table S-1, p. S-5).

Although the Lead Agency states that sidewalks will be provided "on both sides of arterials within the proposed project limits (except on west side of Harbor Boulevard, west side of Euclid Street, south side of Edinger Avenue, west side of Bolsa Chica Road, and the eastside of Seal Beach Boulevard)" (DEIR/S, Table 2-1, p. 2-35), it does not appear the Department's intent is to provide a functional pedestrian sidewalk along the south side of Almond Avenue.

As specified in Section 10.40.010(F)(1) of the City's Subdivision Ordinance: "Pedestrian convenience and safety shall be considered in the design of sidewalks in the public right-of-way. Avoid encroaching light standards, above ground utility boxes, and other impediments where pedestrians are expected to pass." The relocation of overhead utilities to the north side of the roadway would impede pedestrian travel along the only remaining sidewalk along Almond Avenue, present a potential hazard to children and other non-motorists, introduce other potential safety hazards resulting from the proximity of those lines to existing homes, create an undesirable aesthetic impact to affected residents, and could negatively impact property valuation. None of these impacts have, however, been addressed or mitigated in the DEIR/S.

Based on the conflicts and inconsistencies identified herein, the City believes that substantial evidence refutes the Lead Agency's assumption that "[t]he build alternatives' proposed improvements, overall, do not conflict with applicable land use plans, policies, or regulations, and project effects would be less than significant" (p. 4-11) and "[t]he proposed project would not substantially increase hazards due to design features" (p. 4-18). Similarly, the City does not concur that the three build "alternatives would have a beneficial effect on the surrounding communities and their adopted plans" (p. 3.1.1-32).

The Lead Agency recognizes that "[r]esidents can be expected to have a high concern and a high degree of sensitivity to changes in the visual environment with regard to the project and its effect on views from their homes and neighborhoods" (p. 3.1.7-23); however, no analysis of the proposed relocation of the existing soundwall on the College Park East neighborhood and traffic operations along Almond Avenue has been provided.

2.1.2 College Park East

As indicated in the Seal Beach General Plan: "A 16-inch Long Beach Gas line follows the southerly right-of-way of the I-405 Freeway through its entire length in the City. Southern California Gas Company maintains a 34-inch gas line generally along Lampson Avenue, Seal Beach Boulevard, and the I-405 Freeway right-of-way" (Safety Element, pp. S-22 and S-23).

As indicated in the DEIR/S and as illustrated in Figure 3.1.5-1 (Proposed Relocation for Gas Lines Near NAVWPNSTA Seal Beach), the Department appears to be proposing (i.e., Options 2 and 3) the relocation of "two major gas lines, [including] a 14-inch high-pressure (HP) transmission and 16-inch HP distribution gas line, and a Verizon telecommunications facility located on the south side of I-405 within the Caltrans ROW" (p. 3.1.5-15) through the College Park East neighborhood. The DEIR/S notes that "[i]n 2010, the U.S. Navy granted a 20-ft utility corridor to Caltrans as a permanent highway easement to accommodate the SR-22 WCC Project Phase II with a condition that these facilities be relocated outside Caltrans ROW/easement by this I-405 project" (Ibid.). As a result, the Department has identified "three relocation options," including two that traverse the College Park East neighborhood in Seal Beach. As described in the DEIR/S:

- "Option 2: Relocate the gas lines from approximately 1,500 ft east of Seal Beach Boulevard to Bolsa Chica Road across I-405 to the north side, <u>along Almond Avenue</u> and Lampson Avenue. These gas lines would cross I-405 at two locations, on the Bolsa Chica Road overcrossing structure and through jacking and boring underneath I-405 east of Seal Beach Boulevard."
- "Option 3: Relocate the gas lines from Seal Beach Boulevard to Bolsa Chica Road across I-405 to the north side, <u>along Almond Avenue</u> and Lampson Avenue. These gas lines would cross I-405 at two locations by being carried inside the Seal Beach Boulevard and Bolsa Chica Road overcrossing structures" (emphasis added) (p. 3.1.5-15).

In what appears a contradiction, the DEIR/S also states that "[a] utility easement on the northern edge of the base for two underground gas pipelines has been discussed with the Navy. The gas pipelines are currently in Caltrans ROW and are proposed for relocation onto Navy property under each of the build alternatives. The Navy has indicated a preliminary willingness to grant the easement for this utility relocation" (p. 2-4). From the information provided by the Lead Agency, it is not possible to ascertain: (1) whether these "two underground gas pipelines" (p. 2-4) are the same as the "two major gas lines" (p. 3.1.5-15); (2) whether the Department, the operators of those pipelines, or any other party is contemplating the relocation of those lines to the north side of the I-405 Freeway (e.g., through College Park East); (3) whether the DEIR/S, once certified, is intended to serve as the environmental basis under CEQA and NEPA for that relocation. It is, however, immediately evident that insufficient analysis of those relocation plans is presently provided and that any plans to relocate potentially explosive and/or highly flammable transmission/distribution gas and/or petroleum pipeline directly adjacent to existing single-family homes would be folly.

The City cannot perceive any conditions where such actions would be acceptable nor does the City believe that a mitigation strategy could be formulated to reduce the potential environmental (e.g., health and safety) and socioeconomic impacts of relocating those lines through College Park East to a less-than-significant level. Is the Lead Agency asserting that the exemption specified under Section 21080.23 of CEQA is applicable to this pipeline relocation?

2.1.3 College Park West

Based on a review of the DEIR/S, it is the City's understanding that no further physical intrusion into the College Park West neighborhood is now proposed. However, particularly in light of the presence of children near Edison Park, the Lead Agency should clearly indicate: (1) to what extent construction traffic associated with the proposed action may need or choose to access the Caltrans ROW via College Park Drive; (2) whether any construction staging activities are planned or proposed within that portion of the City situated to the east of the San Gabriel River, north of the SR-22 Freeway, and west of the I-405/I-605 interchange; (3) whether and how resident and non-resident safety may be impacted both during construction and once operational and, if impacted, what actions will be taken to reduce or eliminate those hazards. Does Caltrans utilize any public or private access routes into or proximal to the College Park West neighborhood other than College Park Drive?

2.1.4 Leisure World

Based on a review of the DEIR/S, it is the City's understanding that no further physical intrusion into the Leisure World neighborhood is now proposed. However, particularly in light of the presence of elderly residents, the Lead Agency should clearly indicate: (1) to what extent construction traffic associated with the proposed action may need or choose to access the Caltrans ROW via Beverly Manor Road; (2) whether any construction staging activities are planned or proposed within that portion of the City situated to the east of the San Gabriel River, south of the SR-22 Freeway, and west of Seal Beach Boulevard; (3) whether and how resident and non-resident safety may be impacted both during construction and once operational and, if impacted, what actions will be taken to reduce or eliminate those hazards. Does Caltrans utilize any public or private access routes into or proximal to the Leisure World neighborhood other than Beverly Manor Road?

2.1.5 Seal Beach General Plan

Pursuant to Section 15125(d) of the State CEQA Guidelines, "[t]he EIR shall discuss any inconsistencies between the proposed project and applicable general plans and regional plans." Absent from the DEIR/S is an objective analysis of the proposed action's consistency with the Seal Beach General Plan. What the Lead Agency has sought to do is "cherry pick" among the policies presented therein in order to avoid a reasoned analysis of the project's consistency and/or inconsistency with the City's adopted public policy documents.

One of the four policies that the Department has highlighted states: "Provide a circulation/transportation system that enhances and minimizes response time needed for emergency vehicles" (DEIR/S, p. 3.1.1-16). As more thoroughly described herein, the "long-term closure of arterial overcrossings lasting up to 12 months" (DEIR/S, Table 2-1, p. 2-35), the absence of any evidence of direct consultation with emergency service providers, and the absence of any response-time analysis raised unanswered questions regarding project-related impacts on emergency response. Clearly absent from the DEIR/S is any evidence that the proposed action "enhances and minimizes response time," particularly during the extended construction period.

As indicated in the Seal Beach General Plan, it is the policy of the City that "Seal Beach should carefully consider the development of freeways, and/or rapid transit systems and endorse such proposals only when it is considered to be in the community's best interest. Efforts should be made to improve traffic circulation in the coastal section of the City and along major arterial streets, but not exclusively private auto vehicular traffic" (Land Use Element, p. LU-39). With regards to the "College Park East" neighborhood (served by Almond Avenue), it is the City's policy to "[p]rotect the existing population and character of older areas subject to rehabilitation and redevelopment" (p. LU-43). The proposed action serves to further neither land-use policy.

As further indicated in the Circulation Element, it is the objective of the City to "[e]nsure that the circulation system is in balance with the City's Land Use Element" and "[p]rovide adequate capacity for the City's circulation needs while minimizing negative impacts, including environmental impacts needing mitigation" (Circulation Element, pp. C-48 and 49). In furtherance of those objectives, City's policies include, but are not limited to: (1) "Review implementation programs that coordinate the transportation needs and requirements of the City with those of other public agencies in order to ensure that the overall circulation plan of the City is effective, efficient, and safe"; (2) "Maintain circulation system standards for roadways and intersection classifications, right-of-way width, pavement width, design speed, capacity, maximum grades, and associated features such as medians and bicycle lanes"; and (3) "Enhance street design standards to promote attractive circulation corridors" (pp. C-48 thru 50). In addition, it is Seal Beach's objective to "[p]ursue transportation management strategies that can maximize vehicle occupancy, minimize average trip length, and reduce the number of vehicle trips" (p. C-52). Supporting policies include, but are not limited to: (1) "Encourage the use of multiple-occupancy vehicle programs for shopping and other uses to reduce traffic"; (2) "Support national, state, and regional legislation directed at encouraging the use of carpools and vanpools"; and (3) "Require that proposals for major new non-residential developments that include submission of a TDM plan to the City" (p. C-53). The proposed action fails to fulfill and substantively hinders the City's attainment of those policies.

While also acknowledging that it is the City's policy to "[s]upport the addition of capacity and noise mitigation improvements such as high-occupancy vehicles (HOV) lanes, general purpose lanes, auxiliary lanes, and noise barriers to the I-405 Freeway" (p. C-52) and to "[e]ncourage the development, implementation, and use of new advanced technologies to optimize safe traffic flow and manage traffic congestion" (p. C-53), on balance and with regards to direct and indirect impacts upon Seal Beach, the short-term and long-term consequences of the proposed action appear to outweigh the project's possible short-range benefits.

In its own efforts to support the rejection of the No Build Alternative in favor of one of the build alternatives, the Lead Agency states that, "[w]ith the congestion along the I-405 Corridor and roadway network continues, residents and businesses that are dependent on the freeway and roadway network may <u>find alternate options</u> to reside and do business; thus affecting the local economy on a cumulative basis" (emphasis added) (CIA, Table S-1, p. S-6). It would appear that, unless one of the build alternatives is approved, residents of Orange County will move and businesses will relocate to other unspecified areas as a direct consequence of existing and future "congestion along the I-405 Corridor and roadway network." Absent any substantial evidence, the Lead Agency's broad generalization overly simplifies personal and business decisions relative to location selection and erroneously equates the construction of new lane-miles with habitation and business retention. Are there not other strategies available to public agencies that can be implemented to reduce congestion, improve accessibility and mobility, and promote residential and business retention or is Caltrans' asserting that it alone holds the key?

Alleging that the proverbial "sky is falling" (e.g., "residents and businesses that are dependent on the freeway and roadway network may find alternate options to reside and do business," CIA, p. S-6; "Emergency response times may increase under the No Build Alternative due to a projected increase in future traffic volumes and a corresponding increase in traffic congestion," p. 3.1.5-11) is both disingenuous and contrary to the informed and balanced requirements of CEQA.

Because the Lead Agency itself acknowledges that the proposed action is not a panacea for eliminating congestion (e.g., "it is not economically feasible to provide an improvement that would complete [sic] address traffic demand and provide an overall peak hour mainline LOS better than E/F, Traffic Study, p. 2.8-1; "none of the build alternatives completely satisfy predicted future mainline freeway demand," p. 2.8-3), peak-hour and incident-related congestion will continue to exist along both the referenced freeway segment and proximal arterials under both build and no-build scenarios.

As noted in University of California, Berkeley's "Determining the Effectiveness of HOV Lanes" (May, Adolf D., Leiman, Lannon, and Billheimer, John, California Path Research Report UCB-ITS-PRR-2007-17, November 2007), with regards to the HOT lane on the SR-91 Freeway, the authors note that "in his study on the SR-91 HOT lanes in Orange County, Ed Sullivan [Sullivan, Edward, Continuation Study to Evaluate the Impacts of the SR 91 Value-Priced Express Lanes, December 2000] noted a statistically significant increase in peak period accidents on the two mile stretch of Riverside SR-91 just east of the HOT lanes immediately after the opening of the HOT lanes in December 1995. He attributed the increase to 'the increased congestion on the highway section after the (SR-91 HOT lanes) opened.' The steady increase in accident rates on both segments of Riverside SR-91 undoubtedly reflects increasing congestion levels near the Orange County line. In its Annual HOV Report for 2000, Caltrans District Eight personnel noted that: 'The completion of the toll road facility (within the SR-91 Right of Way) in Orange County has not eliminated congestion within District 8. Continued monitoring has reflected no decrease in the westbound morning nor the eastbound afternoon congestion between the I-15/SR-91 Separation and the Orange/Riverside County line. There still exists a bottleneck in traffic for the westbound traffic at the County line'" (pp. 3-24 and 47). Because the SR-71 Freeway's HOT lane is routinely cited throughout the DEIR/S, any adverse impacts associated with that facility could be duplicated in Orange and Los Angeles Counties should Alternative 3 be selected.

Since adding new lane-miles is, at best, only a short-term solution, "find[ing] alternative options" for personal mobility should be perceived as a benefit. Similar, because the Lead Agency's unintended reference to the "the local economy on a cumulative basis" related to both individual household decisions concerning where to live and where to work and the regional southern California economy as a whole, both short-term and long-term environmental benefits are to be gained by governmental efforts to promote reductions in both total VMT and dependency on SOV trips. As indicated in the DEIR/S, each of the three build alternatives substantively increases VMT over the no-build scenario and, at least with regards to Alternative 3, the proposed action incentivize SOV travel and discourages the use of public transportation.

Quoting the "Statements of the Honorable Ray LaHood, Secretary of Transportation before the Committed on Environment and Public Works, U.S. Senate – Hearing on Clean Energy Jobs and American Power Act of 2009" (October 27, 2009), Secretary LaHood stated, in part:

> Currently, American adults travel a total of 25 million miles a day in trips of a half-mile or less and nearly 60 percent of these are motor vehicle trips. DOT, HUD [United States Department of Housing and Urban Development], and EPA [United States Environmental Protection Agency] are working together to support the building of

> more livable neighborhoods with 'complete' streets that increase safety and mobility for all users by giving Americans – whether they live in urban, suburban or rural communities - the choice of walking, biking, or riding transit instead of driving motor vehicles. If the presence of these alternatives promotes less driving, then that will reduce road congestion, reduce pollutants and greenhouse gases, and use land more efficiently. . .DOT has worked to ensure that livability and sustainability objectives are given significant weight in the new discretionary spending of the Department."

To the extend that the Department's goal is to "reduce congestion" and not merely build more freeway lane-miles, then the true goal of this and other transportation investment must be on promoting liveable and sustainable development and encouraging less driving (particularly as it relates to SOVs). As outlined below, the proposed action will have the opposite affect (e.g., add to congestion and hinder the development of liveable and sustainable development).

Under NEPA, a federal court (Maryland-National Capital Park and Planning Commission v. U.S. Postal Service [1973]) reaffirmed the requirement that agencies take a "hard look" at the environmental impacts of a project and not merely rest on "bald conclusions." Similarly, under CEQA, in Santiago County Water District v. County of Orange (1981), the court stated that "[t]he EIR must contain facts and analysis, not just the bare conclusions of a public agency. An agency's opinion concerning matters within its expertise is of obvious value, but the public and decision-makers, for whom the EIR is prepared, should also have before them the basis for that opinion so as to enable them to make an independent, reasoned judgment." As noted in Endangered Habitats League, Inc. v. County of Orange (2005), the court ruled to "defer to an agency's factual findings of consistency unless no reasonable person could have reached the same conclusion on the evidence before it." With regards to interpreting the Seal Beach General Plan, the City's opinion (and not the Department's opinion) should be given substantial credence.

The Lead Agency states that "[u]sage of the term 'significance' in this document is made pursuant to CEQA only, and the evaluation of environmental factors pursuant to CEQA significance thresholds is confined to Chapter 4 CEQA Evaluation, and Appendix A CEQA Checklist" (DEIR/S, p. 3.1.1-1). As indicated in Appendix A of the DEIR/S a project may produce a significant environmental effect is it were to "[c]onflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project (including, but not limited to the general plan, specific plan, local coastal program, or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect" (DEIR/S, Appendix A, Question X[b], p. 7). With regards to the proposed action, the Lead Agency erroneously marks "less than significant impact" (Ibid.).

At least with regards to the Seal Beach General Plan, the DEIR/S errors in stating that "Alternative 1 is consistent with the goals, objectives, and policies of all surrounding communities' General Plans" and that "it is expected to have a beneficial effect on all surrounding communities and their respective General Plans because it improves mobility and reduces congestion (p. 3.1.1-21). Tthe City concludes that the proposed action (inclusive of all build alternatives) is substantially inconsistent with the Seal Beach General Plan. Should a build alternative be selected, the City will need to prepare and process an amendment to the Seal Beach General Plan in order to bring that local policy document into substantial conformity.

Table 3.1.1-1 (Consistency Analysis with Adopted Local and Regional Plans for Build Alternatives) in the DEIR/S is quite telling with regards to the manner in which both "OCTA and

Caltrans" pursue improvement plans. In response to the City's policy to "[m]onitor and participate in applicable county, regional, state, and federal transportation plans and proposals," the Lead Agency's response is that "OCTA and Caltrans have developed an extensive outreach effort to ensure that all potentially affected jurisdictions and their residents are informed of the planning and implementation process and overall project schedule" (emphasis added) (p. 3.1.1-27). At least with regards to Seal Beach's concerns, absent is any evidence of the receptivity of those agencies to public comments and willingness to effectively response (through the formulation of new alternatives, design revisions, and mitigation measures) to those concerns.

2.2 Additional Information Requested

From the information presented in the DEIR/S, it is not possible for Seal Beach to fully understand the precise nature of the potential physical changes that may occur within the City's corporate boundaries as a result of the implementation of the three build alternatives. In order to assist the City in ascertaining the Department's current development plans, clarification is requested with regards to the following project-related components.

2.2.1 Existing and Replacement Soundwalls

Based on the City's examination of Sheets "Utility-24" (U-24) and "Utility-25" (U-25) in Appendix K of the DEIR/S, it appears that it is the Department's intent to remove and relocate the existing soundwall located in the vicinity of Almond Avenue in Seal Beach. Based on those drawings and the additional information presented therein, it further appears the Lead Agency's intent to remove and relocate one or more existing facilities located within or directly adjacent to Caltrans' ROW. To the extent that the City's interpretation of that material is correct, the following additional information is requested so that the full extend of the possible impacts of those actions can be independently determined.

How would the existing soundwall located in proximity to Almond Avenue be impacted under each of the three build alternatives? Would that soundwall be removed and relocated and, if so, relative to the existing wall's physical location, in what direction and how far would a new soundwall be constructed? If a new soundwall is contemplated, (a) what is the height of the existing wall, (b) what is the planned height of the new wall, (c) from where is wall height measured, and (d) will the new wall contain any decorative design features or landscape enhancements? Recognizing that the curb edge is not coterminous with the edge of Caltrans' ROW, under each of the build alternatives, relative to the existing curb edge along Almond Avenue, to what extent would the replacement soundwall encroach onto that existing roadway and would the pavement width along Almond Avenue be reduced? How far would the new soundwall be setback from the existing edge of curb? How would existing drainage facilities be impacted? How would existing utilities be impacted?

The DEIR/S states that "[w]here feasible, pedestrian facilities have been included in the project" (p. 3.1.6-103). Along Almond Avenue, are any "pedestrian facilities" proposed between the replacement soundwall and the existing and/or new edge of pavement (along the south side of Almond Avenue) and, if so, (a) what would be the width of that pedestrian area and (b) would it be paved or unpaved (pervious or impervious)? Is any wall-adjacent or wall-proximal landscaping and irrigation proposed? If irrigated, would potable or reclaimed water be utilized? Would the City or Caltrans be responsible for landscape planting, irrigation, and maintenance on the north side of the soundwall?

As illustrated in Sheets U-24 and U-25, which illustrates the area along Almond Avenue, the Department includes the following notation: “Relocate CN-4015” (Conflict Number 4015). “Utility-45” identifies CN-4015 as an existing Southern California Edison (SCE) 12-kilovolt (kV) overhead electrical line (i.e., “12 kV OH”) consisting of 2,800 linear feet. As specified therein, at an estimated cost of “$1,200,000,” it is the Department’s proposal to “relocate outside of conflicting area.” In accordance therewith, the “physical relocation responsibility” is “construction by utility owner”; the “party responsible for relocation costs” is “100% OCTA.”

What does “relocate outside of conflicting area” precisely mean? Would only SCE’s existing 12-kV overhead distribution line be impacted or would other above-ground and/or below-ground utilities also (1) be potentially impacted and (2) require relocation or other modification? It is the City’s policy that new and relocated utility lines be placed underground. If utility relocation is required, (1) to where would those utilities be relocated, (2) would overhead utilities be placed underground, and (3) is the City correct in assuming that OCTA would bear “100%” of the costs for that relocation and undergrounding?

In order to inform residents and street users, for each build alternative, the City requests that the Department provide: (1) existing and proposed soundwall details; and (2) pre-project and post-project section drawings showing Caltrans’ ROW (including freeway pavement, shoulder area, and landscaping), the existing and proposed configuration of Almond Avenue (including sidewalks, curb edges, pavement width and on-street parking), grade separation (including berm height) between existing and proposed freeway lanes and Almond Avenue, and soundwall height (designating the location from where height is measured).

2.2.2 Gas/Petroleum Pipeline Relocation

The DEIR/S notes that “[a] 14-inch high-pressure gas transmission line owned by the City of Long Beach and a 16-inch medium-pressure pipeline owned by SCG are located between the NAVWPNSTA [Naval Weapons Station] Seal Beach perimeter security access road and Caltrans I-405 ROW in Seal Beach” (p. 3.1.5-2). “Several of the utilities in the utility conflict matrix in Appendix K, Section K2, have been identified as <u>‘high risk’</u> under the Policy on High and Low Risk Underground Facilities within the Highway Rights-of-Way (Caltrans Right-of-Way Manual, January 1997). . .The Policy states that facilities transporting the following, whether encased or not, are considered high-risk facilities: [1] Petroleum products; [2] Oxygen; [3] Chlorine; [4] Toxic or flammable gases. Caltrans also considers the following additional types of utility facilities as high risk: [A] Natural gas in pipelines with a greater than 6-inch pipe diameter or in pipelines with normal operating pressures greater than 60 pounds per square inch gauge (psig)” (emphasis added) (pp. 3.1.5-12 and 13).

Although two of the three “options” with regards to the relocation the existing 14-inch and 16-inch HP gas/petroleum lines would place those lines in the backyard of a number of existing single-family homes within the College Park East neigbhorhood, absent from the DEIR/S is any description of: (1) the nature of those lines (other than their diameter); (2) the type, duration, frequency, and pressurization of materials transported (including source and destination); (3) characteristics of those materials (e.g., flammable, corrosive, and/or explosive); (4) right-of-way requirements; (5) associated land-use restrictions, including prohibitions concerning overtopping; (6) type of construction materials proposed; (7) depth of excavation and construction-term impacts (e.g., access, material delivery and handling, excavation); (8) federal, State, and local regulatory requirements relating to those lines and their placement; (9) consistency with local plans and policies; (10) risk of upset; (11) proximal land uses; and (12) potential health and safety implications to residents and others adjacent or proximal to those new alignments. Additionally, with regards to those facilities and/or utilities in general, no threshold of significance criteria have been identified, no determination of significance has been presented, and no avoidance, minimization, or mitigation measures have been formulated by the Lead Agency (see pp. 3.1.5-18 and 3.2.5-16 thru 18).

The Lead Agency states that the proposed relocation of these gas/petroleum lines results directly from the Department's approval of the "SR-22 WCC Project Phase II." Where in the WCC FEIR/S are the potential environmental impacts of the proposed relocation of these 14-inch and 16-inch diameter lines addressed? What is the precise language of the agreement between the Department and the United States Navy (Navy) with regards to the above referenced easement and those lines? Did the agreement between the Department and the Navy serve to further a specified mitigation measure or impact avoidance strategy presented in the WCC FEIR/S? If part of the WCC, why is the Lead Agency not pursing the preparation of a supplement to the WCC FEIR/S as the appropriate environmental documentation for the gas/petroleum pipeline relocation project? What planning study or other analyses was performed by Caltrans or by others involving the identification of those "three relocation options"? Is the Lead Agency seeking to utilize this DEIR/S, once certified, as the environmental basis for the gas/petroleum pipeline relocation?

If a ROW "easement" could be negotiated between the Department and the United States Navy as part of the WCC, why could a similar agreement not again be negotiated with regards to the proposed action, this shifting the alignment southward and away from the College Park East neighborhood and Almond Avenue?

The DEIR/S states that "ROW acquisition from Naval Weapons Station (NAVWPNSTA) Seal Beach was proposed early in the project development process. The Navy indicated that substantial impacts to the mission of the base would result from encroachment into the base" (p. 2-4). How would a more southerly alignment "substantially impact" the NAVWPNSTA? In what documentation did the United State Navy "indicate" its concerns and can copies of that material be provided for public review? Are there physical constraints that would prevent the expansion of Caltrans' ROW onto the NAVWPNSTA?

The DEIR/S further states that "NAVWPNSTA Seal Beach is a weapons and ammunition storage, disbursing, and reconditioning base for the United States Navy" (p. 3.2.5-11). Has any mapping been performed by the United States Navy or by others illustrating explosive, blast overpressure, or other public safety hazard radii with regards to stored munitions or other materials located on or associated with the NAVWPNSTA and where are those maps referenced and included in the DEIR/S? Are there are potential risks to NAVWPNSTA activities or operations attributable, either directly or indirectly, from the operation of the I-405 Freeway?

At the June 26, 2012 community meeting in Seal Beach, the OCTA represented referenced a "blast arch" associated with the NAVWPNSTA. What is a "blast arch" and what predicates its existence? How often is that mapping updated and does it accurately reflect existing safety hazards? Are safety risks reduced to a "non-existent" level beyond the specified distance or does the mapping reflect a different safety rating?

The Pipeline Safety Improvement Act of 2002 (H.R. 3609) imposes specific requirements on the natural gas industry designed to ensure the safety and integrity of its pipelines. The law places requirements on each pipeline operator to prepare and implement an "integrity management program" (IMP) that, among other things, requires operators to identify "high consequence areas" (HCA) on their systems. HCAs are areas within a specified distance from a pipeline meeting USDOT-defined human occupancy criteria.

As defined in 49 CFR 192.903: "High consequence area means an area established by one of the following methods described in paragraphs (1) or (2) as follows: (1) An areas defined as (i) A Class 3 location under §192.5; or (ii) A Class 4 location under §192.5; or (iii) Any area in a Class 1 or Class 2 location where the potential impact radius is greater than 660 feet (200 meters), and the area within a potential impact circle contains 20 or more buildings intended for human occupancy; or (iv) Any area in a Class 1 or Class 2 location where the potential impact circle containing (i) 20 or more buildings intended for human occupancy, unless the exception in paragraph (4) applies; or (ii) An identified site. Identified site means each of the following areas: (a) An outside area or open structure that is occupied by twenty (20) or more persons on at least 50 days in any twelve (12)-month period. (The days need not be consecutive.) Examples include but are not limited to, beaches, playgrounds, recreational facilities, camping grounds, outdoor theaters, stadiums, recreational areas near a body of water, or areas outside a rural building such as a religious facility; or (b) A building that is occupied by twenty (20) or more persons on at least five (5) days a week for ten (10) weeks in any twelve (12)-month period. (The days and weeks need not be consecutive.) Examples include, but are not limited to, religious facilities, office buildings, community centers, general stores, 4-H facilities, or roller skating rinks; or (c) A facility occupied by persons who are confined, are of impaired mobility, or would be difficult to evacuate. Examples include but are not limited to hospitals, prisons, schools, day-care facilities, retirement facilities or assisted-living facilities. Potential impact circle is a circle of radius equal to the potential impact radius (PIR). Potential impact radius (PIR) means the radius of a circle within which the potential failure of a pipeline could have significant impact on people or property. PIR is determined by the formula r = 0.69* (square root of p*d2)), where 'r' is the radius of a circular area in feet surrounding the point of failure, 'p' is the maximum allowable operating pressure (MAOP) in the pipeline segment in pounds per square inch and 'd' is the nominal diameter of the pipeline in inches. Note: 0.69 is the factor for natural gas. This number will vary for other gases depending upon their heat of combustion. An operator transporting gas other than natural gas must use section 3.2 of ASME/ANSI B31.8S-2001 (Supplement to ASME B31.8; ibr, see §192.7) to calculate the impact radius formula."

As reported in the Transportation Research Board's (TRB) "Transmission Pipelines and Land Use: A Risk-Informed Approach, , Committee for Pipeline and Public Safety: Scoping Study on the Feasibility of Developing Risk-Informed Land Use Guidance near Existing and Future Transmission Pipelines, Special Report 281 (2004): "There are many causes and contributors to pipeline failures, including construction errors, material defects, internal and external corrosion, operational errors, malfunctions of control systems or relief equipment, and outside force damage (e.g., by third parties during excavation). Of these, excavation and construction-related damage to pipelines are the leading causes of pipeline failure. Including operator excavation, third-party excavation, vandalism, and other outside forces, such failures in 2003 were estimated by USDOT to contribute 22 and 24 percent of hazardous liquids and natural gas transmission pipeline incidents, respectively. With increasing urbanization, land development activity near transmission pipelines, and the addition of new facilities to serve growing populations, the likelihood of construction-related pipeline damage may increase, and more people and property may be exposed to pipeline failures" (p. 19).

United States Geological Survey (USGS) reports that buried pipelines are vulnerable to permanent ground deformation and wave propagation (shaking). Ground deformation can include fault rupture, landslide, and liquefaction and associated lateral spreading and settlement. Pipe damage mechanisms include compression/ wrinkling, joint weld cracking/separation, bending/shear resulting from localized wrinkling, and tension. If a pipeline does fail, the consequences are dependent on its contents, diameter, and pressure of its contents. The two general categories of contents are "product" (including liquid fuels that could be gasoline, jet fuel, diesel fuel, or other liquid fuels) and natural gas. The operating pressure in natural gas pipelines can approach 1,000 pounds per square inch (psi). Gas released through failures in small diameter low-pressure gas mains (distribution mains) will generally dissipate quickly. Failure of large diameter high-pressure natural gas pipelines can result in an explosion that can blast a crater in the surrounding soil and damage nearby and overhead structures and facilities (such as power transmission lines). In any case, an ignition source is required to initiate the explosion (e.g., vehicle ignition system, cigarette lighter, or spark from a metal or stone impact). There is speculation that pipelines running parallel to overhead transmission lines carry an induced current that could cause a spark if the pipeline was ruptured. As such, there is a high probability that there will be an ignition source in the event of a rupture of a high-pressure pipeline. For some liquid fuels, such as diesel, the potential for fire is low but a rupture would result in environmental contamination (Source: USGS, The Shakeout Scenario, Supplemental Study – Oil and Gas Pipelines, Open File Report 2008-1150, May 2008, pp. 3-4).

With regards to liquid petroleum pipelines, a fire scenario could result from a pipeline spill and a nearby ignition source (e.g., vehicle fire). The risk of petroleum product fire is substantial because components of refined products, such as gasoline, evaporate quickly and can form flammable vapor clouds. In the event that a pipeline accident was to result in a rupture or large leak, there is a likelihood that the product could ignite should there be a high concentration of flammable hydrocarbons released and should an ignition source be present.

The failure of a high-pressure natural gas pipeline can lead to various outcomes, some of which can pose a significant threat to people and property in the immediate vicinity of the failure location. For a given pipeline, the type of hazard that develops and the damage or injury potential associated with the hazard will depend on the mode of failure (i.e., leak vs. rupture) the nature of the gas discharged (i.e., vertical vs. inclined jet, obstructed vs. unobstructed jet), and the time to ignition (i.e., immediate vs. delayed). The dominant hazard is thermal radiation from a sustained jet or trench fire, which may be preceded by a short-lived fireball.

Although a variety of analysis methodologies may be available, one often cited model (C-FER Model) examines isometric thermal radiation distances to determine a burn radius and a one percent fatality radius from a natural gas pipeline break. The C-FER Model calculates the degree of harm to people due to thermal radiation by using a mode that relates the potential for bury injury or fatality to the thermal load received. A 30-second exposure time is assumed for people exposed to the fire in the open. In this interval, it is assumed that an exposed person will remain in a fixed position for between 1-5 seconds and then run at 5 mph in the direction of shelter. It is further assumed that an exposed person would find a shelter located within 200 feet of their initial position. It is offered that the heat flux that will cause burn injury is between 1,000 and 2,000 Btu/h/ft^2, depending on the burn injury criteria. The threshold level of heat flux for fatal injury is determined when the chance of mortality is one percent. The heat flux is calculated to be 5,000 Btu/h/ft^2. On the basis of thermal radiation levels, C-FER calculates the radius of a hazard area as a function of pipeline size (diameter) and operating pressure.

The annual frequency of pipeline failure and product release is based on historic data from the Office of Pipeline Safety (OPS) Gas Pipeline Incident Database and Hazardous Liquid Pipeline

Accident data (available at www.phma.dot.gov). These failure rates are based on historic data for significant releases specific to pipelines in California. As Indicated in Table 1 (Normalized Pipeline Average Failure and Release Frequencies for California Pipelines [1984-2001 Period]), for refined product pipelines, the failure probability of pipelines is estimated to be 1.3×10^{-3} (1.3E-03) or 0.0013 releases per mile per year.

Table 1
Normalized Pipeline Average Failure and Release Frequencies for California Pipelines (1984-2001 Period)

Pipeline Product	Pipeline Service Type	Release Frequency (number of releases/mile/year)
Natural Gas	Transmission Line	1.2E-04 (0.00012)
Natural Gas	Gathering Line	2.1E-04 (0.00021)
Natural Gas	Distribution Main Line	4.6E-05 (0.000046)
Hazardous Liquids – All Commodity Types	Transmission Line	1.8E-03 (0.0018)
Crude Oil	Transmission Line	2.3E-03 (0.0023)
Refined Product	Transmission Line	1.3E-03 (0.0013)

Source: California Department of Education, Guidance Protocol for School Site Pipeline Risk Analysis, Volume I – User's Manual, February 2007, Table 4-3, p. 4-21

Would the College Park East neighborhood constitute a HCA within the meaning of Pipeline Safety Improvement Act of 2002? Where in the DEIR/S is the PIR illustrated? How many residential structures and other habitable buildings exist within the PIR? Was a C-FER analysis performed for each of the options and what were the findings of those analyses?

The Department's lack of disclosure concerning the relocation of the 14-inch and 16-inch diameter HP gas/petroleum pipelines raises the accompanying issue relating to the transport of hazardous materials and wastes. What types, forms, and quantities of hazardous materials and wastes (including petroleum products) are transported along the I-405 Freeway and at what volumes and frequencies? Along California's highway system, have there ever been accidents that resulted in the release of hazardous materials and/or wastes? Have those events ever resulted in fatalities or injuries to individuals not located within the Department's ROW or damage to real property?

Avoidance and minimization measure HAZ-6 notes: "Prior to construction, if still present, two 30-gallon open trash bins and two 5 gallon buckets that were dumped in the I-405 northbound shoulder just south of the I-605 interchange shall be removed and properly disposed of by the contractor" (p. 3.2.5-17). This measure suggests that hazardous materials and wastes may be periodically (albeit illegally) discarding within the Department's ROW. Has the Department ever experienced or made aware of such illegal disposal practices and what types of hazardous wastes and materials (including petroleum products) have been dumped along California' freeway system?

2.2.3 HOV/HOT Lane Access

The DEIR/S appears to include contradictory language concerning future access to the HOV lane by carpoolers, vanpoolers, and transit facilities. The DEIR/S states that "[t]he tolled Express Lane and the existing HOV lanes would be managed jointly as a tolled Express Facility with two lanes in each direction from SR-73 to I-605" (p. 2-3). As indicated in the Traffic Study: "To facilitate access to the Express Lane Facility, the following seven access points are currently under consideration on: (1) I-405 south of the SR-73 junction, by an at-grade access; (2) SR-73 south of the I-405 junction, by a direct connector; (3) I-405 in the Magnolia Street/Warner Avenue area, by an at-grade access; (4) I-405 in the Bolsa Avenue/Goldenwest Street area, by an at-grade access; (5) SR-22 east of the I-405 junction, by a direct connector; (6) I-605 north of the I-405 junction, by a direct connector; and (7) I-405 north of the I-605 junction, by an at-grade access" (p. 1-12). From those passages, because the HOV and toll lanes are closely linked (e.g., motorists can change lanes) it can be concluded that access to the HOV lane will be similarly restricted.

The Lead Agency states that the "existing condition" includes "Project EA 0J440K, which would provide continuous ingress and egress from the HOV lanes on the entire length of I-405 in Orange County" (S-10). As a result, among other things, the proposed action appears to negate the Department's recent approval of "Project EA 0J440K" and contradicts whatever rational was presented for its adoption. Since neither that rational nor further description of "Project EA 0J440K" is presented in the DEIR/S, the affected public is denied the ability to comment thereupon, including the apparent inconsistency between the early action and current proposal.

As indicated in the WCC FEIR/S: "The lack of HOV facilities on SR-22 and HOV direct connectors at crossing freeways causes a discontinuity for regional HOV traffic. Vehicles using the HOV lanes on the connecting freeways must exit the HOV facilities and use general-purpose lanes on SR-22, I-405 or I-605. There is little incentive or opportunity for individual drivers to switch from single-occupancy vehicles (SOVs) to carpooling or transit without dedicated facilities for this purpose. If SOV drivers cannot decrease their commute times because there are no dedicated lanes for HOVs or buses only, they are more likely to forego carpooling or using transit in favor of driving alone" (p. 1-9). Similarly, if MOUs are prevented from accessing the HOV lanes based on access restrictions, those vehicles will contribute to traffic volumes on the GP lanes as they await the next authorized "express lane" opening. With regards to both the WCC FEIR/S and this DEIR/S, how is the promotion of a lack of continuous access to the HOV lane on the I-405 Freeway consistent with the arguments espoused by the same Lead Agency and used to support of the direction connection at freeway crossings presented in the WCC FEIR/S?

As indicated in the DEIR/S: (1) "Alternative 1 would provide continuous access between the HOV and GP lanes. On July 31, 2007, the Department approved a Project Study Report (PSR) for a separate project (EA 0J440K) to provide continuous ingress and egress from the HOV lanes on the entire length of I-405 in Orange County. This separate project has not yet been programmed or funded; however, the proposed continuous access would be implemented as part of Alternative 1 of the proposed project for the segment of I-405 between Euclid Street and I-605" (p. S-4; see also 2-8); (2) "Alternative 2 would provide continuous access between the HOV and GP lanes. On July 31, 2007, the Department approved a PSR for a separate project (EA 0J440K) to provide continuous ingress and egress from the HOV lanes on the entire length of I-405 in Orange County. This separate project has not yet been programmed or funded; however, the proposed continuous access would be implemented as part of Alternative 2 of the proposed project for the segment of I-405 between Euclid Street and I-605. Transit vehicles and HOV2+ would continue to be eligible to utilize the HOV lanes" (pp. S-5 and 6; see also 2-9); and (3) "Compared to the existing condition, as recorded in the Notice of Preparation (NOP) (issued August 31, 2009) and the Notice of Intent (NOI) (issued September 1, 2009), the future No Build Alternative includes the future completion of the following two projects: [1] The SR-22 West

County Connectors (WCC) Project (currently in the construction phase), which has received environmental document approval and is proceeding through the design and construction phases; and [2] Project EA 0J440K, which would provide continuous ingress and egress from the HOV lanes on the entire length of I-405 in Orange County. This separate project has not yet been programmed or funded" (pp. S-9 and 10; see also p. 2-23).

Although clearly specified with regards to all other build and no build alternatives, the application of "Project EA 0J440K" is left intentionally vague with regards to Alternative 3. This is likely because, under Alternative 3, access to the "express lanes" (including both the HOV and HOT lanes) would be substantially restricted. The DEIR/S notes that, as proposed, "[a]ll vehicles in the express lanes, tolled or free, will be able to use both lanes of the Express Lane Facility" (VIA, p. 18). As such, with the exception of the "seven access points," non-toll paying HOVs would be prevented from accessing the "express lanes," requiring those vehicles to travel in the GP lanes greater distances than they would now travel and, thereby, adding to congestion (including air pollutants) in the GP lanes.

What was the Department's rational for the approval of "Project EA 0J440K"? Where in the DEIR/S is there a discussion of the proposed action's lack of consistency with "Project EA 0J440K"? How will restrictions on access to the HOT lane affect access to the HOV lane? Can qualifying and/or toll-paying motorists travel freely between the HOT and HOV lanes? Is the imposition of restriction on HOV lane access consistent with "Project EA 0J440K"?

How does lack of access to the HOV lane serve to encourage carpool formation for short-length and/or long-length travel distances? Was lack of continuous access to the "express lanes" by both MOVs and HOVs explicitly considered in accessing travel time and, if so, what assumptions were utilized regarding restricted access (e.g., how many miles did motorists need to travel before accessing the "express lanes")? Where assessments of travel time based solely on vehicles passing the northern and southern ends of the designated "corridor" or were trips originating and ending from ramps internal to that "corridor" also considered? Once fully implemented, from point of ingress onto the freeway, what is the longest distance a vehicle has to travel to access the HOV lane under "Project EA 0J440k"? Under the proposed action, from point on ingress onto the freeway, what is the longest distance a vehicle has to travel before accessing the "express lanes"?

2.3 City-Nominated Mitigation Measures

As specified under Section 21081.6(c) of CEQA, prior to the close of the comment period on a draft EIR, "a responsible agency, or a public agency having jurisdiction over natural resources affected by the project, shall either submit to the lead agency complete and detailed performance objectives for mitigation measures which would address the significant effects on the environment identified by the responsible agency or agency having jurisdiction over natural resources affected by the project, or refer the lead agency to appropriate, readily available guidelines or reference documents." Although the full scope of project-related and cumulative impacts (e.g., air quality and human health risks) cannot be entirely known based on the inadequacies of the DEIR/S, without excluding the subsequent introduction of other City-identified actions, the following project modifications have been identified and, if implemented, would address some of Seal Beach's concerns:

(1) **Seal Beach Mitigation Measure No. 1**. Along the northbound segment of the I-405 Freeway, between Bolsa Chica Road/Valley View Street and Seal Beach Boulevard,

modify the proposed freeway configuration to reflect the alternative design plans prepared by W.G. Zimmerman Engineering, Inc., as illustrated in Attachment A (Alternative Design Configurations) herein, or such alternative design as may accommodate the approved freeway improvements without resulting in the further encroachment of the existing or replacement soundwalls (S1116, S1132, and S1162) into the College Park East neighborhood.

(2) **Seal Beach Mitigation Measure No. 2**. The existing soundwalls (S1116, S1132, and S1162) situated in proximity to Almond Avenue in the City of Seal Beach (between Seal Beach Boulevard on the west and Bolsa Chica Road/Valley View Street on the east) shall not be relocated northward so to further encroach into or toward the College Park East neighborhood. Proposed freeway improvements shall be confined to the area south of the existing soundwalls, thus (a) allowing for the retention of the existing landscaping located between the soundwall and Almond Avenue, (b) preserving the existing street pavement width and availability of on-street parking, (c) avoiding the take, loss, or forfeiture of any public and/or private property interests within that area, and (d) avoiding the need to relocate any existing overhead or underground utilities.

(3) **Seal Beach Mitigation Measure No. 3**. To the extent that further noise mitigation benefitting the College Park East neighborhood can be demonstrated, a new or replacement soundwall shall be provided in proximity but not necessarily coterminous with the edge of Caltrans' right-of-way, encroaching into the neighborhood no further than the existing soundwall's outer edge. The new or replacement soundwall shall: (a) be of a height and configuration that measurably improves (i.e., 5-dBA or greater noise reduction) noise mitigation over existing conditions, (b) fully conforms to or exceeds existing seismic safety standards, (c) contains decorative elements and/or outward (northern) facing landscaping and associated irrigation improvements for the aesthetic benefit of the adjoining residential area, (d) be designed and constructed so as to reduce potential visual impacts resulting from graffiti and other vandalism, and (e) the proposed said wall shall be constructed to a minimum of the same existing elevation of the existing soundwall.

(4) **Seal Beach Mitigation Measure No. 4**. Caltrans shall construct a new 14-foot or taller soundwall (S1162) in the vicinity of the Seal Beach Tennis Center. Soundwall S1162 shall align with the existing soundwall to the east and extend approximately 700 feet to the west, from east of Aster Street to the parking area located on the west side of the Seal Beach Tennis Center. In accordance with Caltrans' own analysis, the soundwall shall be of a height and configuration sufficient to produce a minimal 5 decibel (dBA) noise reduction at the tennis center's administrative facilities.

(5) **Seal Beach Mitigation Measure No. 5**. Contract or other documentation shall stipulate that construction activities do not impede traffic along Almond Avenue or result in the temporary or permanent loss of parking opportunities along that roadway.

(6) **Seal Beach Mitigation Measure No. 6**. The existing 14-inch high-pressure (HP) transmission, the existing 16-inch HP distribution gas line, and the existing Verizon telecommunications facility presently located on the south side of I-405 Freeway within Caltrans' current right-of-way and planned for relocation shall not be relocated to the north side of the I-405 Freeway and/or placed in proximity to the College Park East neighborhood. Any plans for the relocation of those facilities to an alternative location

with the City of Seal Beach shall be subject to approval and conditioning by the Seal Beach City Council.

(7) **Seal Beach Mitigation Measure No. 7**. Except through written authorization from the City of Seal Beach Director of Public Works and subject to reasonable City-imposed conditions, no construction-related traffic shall be authorized along College Park Drive, Beverly Manor Road, and Almond Avenue and no construction staging activities, including, but not limited to, equipment and worker parking, maintenance operations, and material storage or stockpiling, shall be performed within the College Park West Leisure World, and College Park East neighborhoods.

The inclusion of these City-nominated mitigation measures herein should neither be construed as a declaration of Seal Beach's support of the proposed action nor concurrence that adoption of these measures would reduce significant environmental effects to a less-than-significant level; rather, with regards to certain topical issues, these measures are proposed for the sole purpose of further minimizing the potential environmental impacts that are anticipated to result from the project's implementation.

3.0 FALLACIES REGARDING THE PROPOSED ACTION

Any structure build on a shaky foundation will not support its eventual weight. With respect to the proposed action, there exist substantive erroneous foundational assumptions in the DEIR/S that serve to negate both the resulting environmental analysis and the Lead Agency's findings. The following inherent problems are not merely those expressed by a minority opinion but constitute the conclusions of the majority of the scientific community. Since these fallacies drive at the heart of the Lead Agency's analysis (and the foundations upon which the DEIR/S' assumptions and conclusions rest), there representation as fact rather than merely conjecture presents a singular focus intended solely to support the conclusion that building more freeway lane-miles is the obvious and only rationale course of action.

CEQA stipulates that "the sufficiency of an EIR is to be reviewed in light of what is reasonably feasible. Disagreement among experts does not make an EIR inadequate, but the EIR should summarize the main points of disagreement among the experts" (14 CCR 15151). Absent from the DEIR/S is any consideration of divergent viewpoints (supported by substantial evidence) allowing the project to be examined from a perspective not resulting in the selection between three inherently similar lane-mile expansion plans for the I-405 freeway.

3.1 Freeway Traffic Growth Projections

There exists something inherently deceptive in the extrapolation of traffic forecasts. Just as a pipeline has a finite capacity to transport fluids, regulated by diameter and pressure, those same laws of physics are assumed not to apply to the I-405 Freeway. Unlike a pipeline, within its confines, the number of vehicles attempting to flow past two fixed points (traffic demand) is not uniform but varies based on the time of day and the day of week. In either conduit, however, there exists a finite conveyance volume that cannot be increased without a corresponding increase in design capacity. In reality, actual traffic volumes cannot exceed available capacity. As a result, projections that traffic volumes will increase by nearly 50 percent only serve as "scare tactics" presently for the sole purpose of promoting a predetermined agenda.

If the freeway is considered a "closed system," traffic volumes cannot grow without added capacity. If the network of freeway, arterials, secondary, and local streets constitutes an "open system" (e.g., traffic diverting to the path of least resistance), traffic growth otherwise assignable to the freeway might be diverted onto other arterial highways. Congestion on arterials may then push automobiles only secondary streets and ultimately onto local streets. At each link of that chain, particularly when presented with choices and options, driving habits can be altered. Employees can petition employers for more flexible hours. Wage earners may seek alternative employment opportunities closer to home. New carpools and vanpools will be formed. More commuters will seek alternative forms of transportation. Most certainly, fewer SOVs will be on the road during peak periods.

As reported in the Traffic Study and presented in Table 4 (Freeway Average Daily Traffic (ADT) Volumes – Existing and Future) herein, within the Seal Beach area, traffic volumes along the I-405 Freeway are projected to increase from 370,260 average vehicles per day (ADT) in 2009 to 453,580 ADT in 2020 to 508,780 ADT in 2040. Traffic growth between 2009 and 2020 is reported to be "based on interpolation of Year 2009 and Year 2040 traffic forecasts weighted for expected land use growth" (Traffic Study, p. 2.2-1). Traffic forecasts for Year 2040 conditions are "based on the OCTAM 2035 traffic forecasts increased by 1% to Year 2040" (Ibid).

Independent whether freeway improvements are instituted, the Lead Agency is representing that these traffic volumes will exist on the freeway under both the No Build Alternative and any of the three build scenarios. As indicated in the DEIR/S, the build alternatives "would not accommodate additional traffic beyond what is currently projected with or without the project" (p. 3.1.2-8). If the proposed improvements are not implemented, will traffic volumes in the Seal Beach area on the I-405 Freeway still approach 508,780 ADT?

In what appears to be an internal contradiction, the Lead Agency's assertion that, although "expected land use growth" (Traffic Study, p. 2.1-1) translate into a substantial increase in ADT, "the project area is highly urbanized and built out, containing few vacant or underdeveloped parcels" (p. 3.1.2-6) and "the amount of vacant land or land ready for development within the study area is extremely limited [e.g., 213 acres within Costa Mesa, 472 acres within Huntington Beach], representing 2 to 5 percent" (3.1.2-9). The Department appears to be arguing that no induced-growth is expected (i.e., "the project is not growth inducing," p. 3.1.2-9) because there remains no additional areas for grow while at the same time basing its arguments for the need for new lane-miles on a nearly 50 percent increase in traffic volumes between 2009 and 2040.

To the extent that the Lead Agency seeks to argue that the annual growth of "1% to Year 2040" is the result of development which is occurring outside the boundaries of the designated "corridor," then a more regional assessment of traffic and cumulative impacts (beyond that now presented) is called for.

As indicated in the DEIR/S: "Data contained in the SCAG RTP Growth Forecast, adopted March 2008, provides information on current and forecasted (through year 2035) population and employment totals and growth trends" (emphasis added) (p. 3.1.2-3). The Department notes that "[t]he 2008 RTP presents the transportation vision for the SCAG region through the year 2035 and provides a long-term investment framework for addressing the region's transportation and related challenges" (emphasis added) (p. 3.1.1-19). Absent from the DEIR/S is any reference the Southern California Association of Government's (SCAG) "2012-2035 Regional Transportation Plan/Sustainable Communities Strategy" (2012 RTP/SCS), as adopted on April

4, 2012. As such, the totality of the Lead Agency's analysis is based on out-dated "current and forecasted population and employment totals and growth trends."

As noted in SCAG's "Economic Recession and Population Projects in a Regional Context" (January 7, 2010): "Economic recession of Orange County will bottom out in 2010 or 2011. The job growth in 2010 and 2020 will be much lower than what is currently projected. The economy will rebound but not to the same levels as 3 years ago. The 2020/2035 targets will be pushed out to later years. The numbers forecast for 2020 might happen in 2035" (p. 10). As further noted in SCAG's "Projecting Regional Population in the Middle of an Economic Recession: Case of Southern California" (November 7, 2010, v.3):

> Population projections play a key role in determining the future community needs including housing and transportation in a regional planning context. Regional demographers and planners efficiently and regularly develop and update the future population growth using diverse data sources including US Census Bureau, State Statistical Agency, and private vendors. Those federal and state agencies do not frequently update their demographic assumptions, and sometimes might not maintain currency and reasonableness of population projections. We recently have experienced the unexpected economic recession beginning in December 2007 across the nation, which would affect the regional population growth, in particular, migration, in the near future. The assumption of existing population projections quickly becomes questionable due to the economic uncertainty in the near future. The traditional long term perspective, which might not reflect the on-going economic trends and the frequently updated short term economic forecast, might result in the serious bias of the short term and long term population projections (p. 3)

Substantial population deviations can be identified when comparing the Lead Agency's 2008-based population projections, as presented in Table 3.1.2-1 (Population Growth Forecast within Cities/Communities Covering Project Study Area) in the DEIR/S (p. 3.1.2-3), and the SCAG's "Growth Forecast Appendix, Proposed Final" (April 2012). As indicted therein: "The region currently faces serious challenges caused by the recent economic recession that began in December 2007. The region lost approximately 800,000 jobs from 2007 to 2010. Although the economic recession officially ended in 2009, the region is still struggling to bring its economy back to the pre-recession level" (p. 5) and during this period, for every 100 jobs lost in the United States, 17 were in California, and of those, 9 were lost in the SCAG region" (p. 21).

Presented in <u>Table 2</u> (Comparative Population Growth Forecasts), Year 2035 population projections for each of the city and county areas identified by the Lead Agency are compared against the most recent SCAG projections. As indicated, the Department's projected population increase exceeds current SCAG projections by up to 125.3 percent. From that, it would have to be assumed that projected traffic volumes would reflect a similar overestimation.

As indicated in SCAG's "Growth Forecast Appendix, Proposed Final," "[t]he regional growth forecast is used as a key guide for future transportation investments in the SCAG region" (p. 10). Although the project's sole objective is to be "[t]o be consistent with regional plans" (DEIR/S, p. 1-5), the Department does not even look to the regional planning agency's current growth forecasts as the basis for its planning efforts. Since they serve as the fundamental basis upon which the Lead Agency's entire analysis is derived, rely upon outdated 2008 data, are inconsistent with current SCAG 2012 RTP/SCS projections, and fail to reflect the region's current economic environment, the Lead Agency's population, housing, employment, and ADT projections constitute an "area of controversy" (14 CCR 15123[b]).

Table 2
Comparative Population Growth Projections (Year 2035)

County of City	DEIR/S[1]	2012 RTP/SCS[2]	Difference	
	Year 2035	Year 2035	Number	% Overestimated
Orange County	3,653,990	3,421,000	232,990	106.8
Costa Mesa	126,958	114,000	12,958	111.4
Fountain Valley	64,525	59,500	5,025	108.4
Garden Grove	192,532	180,300	12,232	106.8
Huntington Beach	225,815	205,500	20,315	109.9
Los Alamitos	13,312	12,000	1,312	110.9
Unincorporated Orange County	237,211	189,300	47,911	125.3
Seal Beach	27,871	24,800	3,071	111.2
Westminster	102,017	92,600	9,607	110.2

Footnotes:
1. California Department of Transportation, Draft Environmental Impact Report/Environmental Impact Statement – San Diego Freeway Improvement Project, Orange and Los Angeles Counties, California, SCH #2009091001, May 2012, Table 3.1.2-1, p. 3.1.2-3.
2. Southern California Association of Governments, Growth Forecast Appendix, Proposed Final, April 2012, pp. 33-34.

Source: City of Seal Beach

If it can be assumed that each travel lane has a finite ability to facilitate the conveyance of vehicles (based on a specified vehicle mix and optimal LOS), there must exist a "cap" on the number of vehicles physically able to utilize the freeway. Since the Lead Agency purports that peak-hour traffic already exceeds LOS "E" both in the HOV and GP lanes, then it can be surmised that Year 2009 conditions closely replicate the existing freeway's carrying capacity without alterations in the time that motorists choose to travel. If presently at or nearing capacity, then the Lead Agency's assumptions concerning increased ADT is highly suspect.

If land-use intensification is the prime contributor to increased VMT, then he Lead Agency itself appears to be the major contributor to traffic growth. As indicated in Table 7 (Induced Travel Demand in Increased Vehicle Miles Traveled), the Lead Agency acknowledges that the proposed freeway improvements will increase VMT by 1,013,000 miles/year. In addition, the DEIR/S states that Alternative 1 will "result in approximately 32,000 direct/indirect/induced jobs," Alternative 2 will result in "approximately 34,000 direct/indirect/induced jobs," and Alternative 3 will result in "approximately 42,000 direct/indirect/induced jobs" (CIA, p. .6-2).

In its single focus to build more lane-miles, the Lead Agency ignores national trends, including changing travel behavior. For example, unaddressed are the affects of gasoline prices on travel. As reported in the Congressional Budget Office's (CBO) "Effects of Gasoline Prices on Driving Behavior and Vehicle Markets" (January 2008):

> The 100 percent increase in real U.S. gasoline prices since 2003, which is larger even than the record increases of the early 1980s, has induced motorists to adjust their driving habits and the types of vehicles they purchase. Those responses have important implications for the future fuel efficiency of the passenger vehicle fleet, for the way vehicles are driven, and for the use of the nation's highway and mass transit networks should higher gasoline prices persist. . .Freeway motorists have adjusted to

> higher prices by making fewer trips and by driving more slowly. CBO analyzed data collected at a dozen metropolitan highway locations in California, along with data on gasoline prices in California, to identify changes in driving patterns. On weekdays in the study period, for every 50 cent increase in the price of gasoline, the number of freeway trips declined by about 0.7 percent in areas where rail transit is a nearby substitute for driving; transit ridership on the corresponding rail systems increased by a commensurate amount. Median speeds on uncongested freeways declined by about three-quarters of a mile per hour for every 50 cents the price of gasoline has increased since 2003 (pp. ix and x).
>
> The research suggests that a 10 percent increase in the retail price of gasoline would reduce consumption by about 0.6 percent in the short run.5 Over a longer period, consumers would be much more responsive to an increase in the price of gasoline (should the higher price persist) because they would have more time to make choices that took longer to put in place, such as buying an automobile that gets better gasoline mileage. Estimates of the long-run elasticity of demand for gasoline indicate that a sustained increase of 10 percent in price eventually would reduce gasoline consumption by about 4 percent. That effect is as much as seven times larger than the estimated short-run response, but it would not be fully realized unless prices remained high long enough for the entire stock of passenger vehicles to be replaced by new vehicles purchased under the effect of higher gasoline prices - or about 15 years. Over that time, consumers also might adjust to higher gasoline prices by moving or by changing jobs to reduce their commutes - actions they might take if the savings in transportation costs were sufficiently compelling. Those long-term effects would be in addition to consumption savings from short-run behavioral adjustments attributable to higher fuel prices (p. xi).

As further reported by the FHWA's "Innovations for Tomorrow's Transportation" (Issue 1, May 2009), in "Impacts of Higher Fuel Costs," the author (Dan Brand) reported: "We know from traffic engineering that <u>small changes in traffic volumes on congested highways make a big difference</u> in travel speeds. An indication of this is given above in the data section in which the average gas price increase of 28% over the first half of 2008 over 2007 resulting in about a 3% reduction in VMT over 2007 "influenced a 3% reduction in the Travel Time Index for the nation as a whole. This one-to-one correspondence of VMT reduction to travel time reduction is an important finding" (emphasis added) (p. 55).

In contrast, when comparing any of the three build options the No Build Alternative, VMT will substantially increase. Based on the connectivity between VMT and travel time reductions, to the extent that the Lead Agency's purpose and need declaration includes "improve trip reliability, maximize throughput, and optimize operations" (DEIR/S, p. S-1), a wide range of alternatives based on reductions in VMT should have been considered by the Lead Agency. In what appears contrary to federal and State policies relating to GHG emission reductions, VMT reduction strategies, however, were never considered.

3.2 Acceptance of Substandard Conditions

As specified in the OCTA's "2011 Orange County Congestion Management Program": "During subsequent LOS monitoring, CMP statute requires that CMPHS intersections maintain a LOS grade of 'E' or better, unless the baseline is lower than 'E'; in which case, the ICU rating cannot increase by more than 0.1" (p. 5).

As specified in the Seal Beach General Plan, it is the adopted goal of the City to "provide a circulation system that supports existing, approved, and planned land uses throughout the City while maintaining a desired Level of Service on all streets and at all intersections" (Circulation Element, p. C-50). As a policy, the City strives to "maintain a citywide Level of Service not exceeding LOS D for roadway segments and intersections during the peak hour" (p. C-50). Recognizing that the maintenance of LOS "D" during peak-hour constitutes a lofty goal, as a target, the City does not accept LOS "E" or "F" conditions as constituting the foundation for its planning and transportation engineering efforts.

Is indicated in the MIS, completed in 2006, the foundational steps upon which that analysis (and arguably everything that follows) was based included: "(1) Identifying travel needs and mobility issues within the study area; (2) Establishing goals and objectives; [and] (3) Developing a broad range of possible alternative transportation concepts" (p. 10). As that information has been translated and reinterpreted in the DEIR/S, the fundamental error is the Lead Agency's acceptance of substandard traffic conditions (LOS "F") for the overwhelming majority of freeway users as a goal toward which Caltrans and the OCTA now strive. Rather than accepting the status quo and saying "maybe we can do just a little better for some drivers," a broader acceptance of the planning process and its resulting environmental documentation would be developed if the two agencies' vision was the formulation of alternatives and mitigation strategies designed to promote the attainment of acceptable transportation operations (LOS "D" or better conditions), not only on the I-405 Freeway but throughout the region based on a multiple modal solution (asking "what do we want to accomplish and how do we get there?").

The MIS and all the well-intended but misguided efforts that followed are founded on the acceptance and/or perpetuation of a deficient and defective transportation system (e.g., LOS "F" conditions) as the "goal and objective" upon which the Lead Agency's alternatives (and vision) are based. By artificially constraining the analysis to a narrowly defined "corridor" and limiting the debate to the number and type of new lane-miles, a multitude of potential transportation solutions were effectively eliminated from the start or were never considered. At best, rather than "recovery," what is being offered is only a "band-aid" for a terminally ill patient. With nearly $6 billion dollars at stake, the public looks to its elected officials and governmental entities for meaningful solutions and sound public investments with a shelf-life extending beyond the retirement of those in office or sitting behind bureaucratic desks. With regards to the proposed project, it appears that the sponsoring agencies lack vision, seemingly content with the adage that "something is better than nothing" (e.g., "Alternative 2 is considered a viable project alternative because it will achieve. . .Relief of congestion compared to future conditions under the No Build Alternative" and "Alternative 3 is considered a viable project alternative because it will achieve. . .Reduction of congestion compared to future conditions under the No Build Alternative," VIA, pp. 18 and 22).

It is a fallacy to assume, at the outset, that: (1) workable and far-reaching solutions to the region's and/or subregion's traffic conditions cannot be formulated; (2) functional transportation conveyance systems cannot be devised and developed; and (3) substandard conditions are the best that Californians can hope to achieve. The proposed alternatives now being foisted on the public do not even strive to solve or remedy the region's transportation impacts. Presented with three virtually identical variations of the same alternative, it is not acceptable to only compare one failed strategy to another," ignoring in that comparison the standard of acceptable versus unacceptable (with regards to workable transportation system operations) and accepting the imposition of self-imposed blinders which only serve to prevent meaningful public dialogue and discourse. Anyone who remembers driving the freeways during the Los Angeles Olympics knows feasible solutions can be developed to the area's transportation problems, allowing for acceptable traffic operations on the freeways even during peak periods (absent freeway widening). What is required is an overall transportation approach woefully absent from that now presented. The Los Angeles Olympics experience proved that mitigation of freeway traffic impacts is, in fact, possible with strong agency leadership, a common vision, and broad public participation.

3.3 Avoidance, Minimization, and Mitigation Measures

As a preface to the presentation of any comments on "mitigation measures," it is important to note that, from the DEIR/S, it is not possible determine what is being represented by the Lead Agency as "mitigation measures," as that term is defined under CEQA. As indicated in the DEIR/S" "Table S-1 summarizes project impacts by alternative and identifies avoidance and minimization measures. Where applicable, these measures are sometimes also mitigation measures, as discussed in Chapter 4 of this Draft EIR/EIS" (p. S-12). For example, Table S-1 (Project Impact Summary Table) (pp. S-13 thru S-35) contains a single column labeled "avoidance, minimization and/or mitigation measures." In that table, with the exception of the column heading, the only time the term "mitigation measure" is mentioned is with regards to the following two "measures": (1) "CUL-1: "Work shall be halted in the vicinity of any previously known or unknown buried cultural materials unearthed during construction until a qualified archaeologist can assess the significance of the materials. Any further mitigation measures required will be developed in accordance with the requirements of Caltrans Section 106 PA – Stipulation XV in accordance with 36 CFR 800.13. Any mitigation measures required by the archaeologist will be implemented, including, if necessary, supplemental environmental documentation" (pp. S-24 and 25); and (2) "CUL-2: If human remains and associated artifacts are encountered during ground-disturbing activities, then the provisions of Public Law 101-601, Section 5097.98 and .99 of the PRC, and Section 7050 of the Health and Safety Code, will be followed. Any further mitigation measures required shall be developed in accordance with the requirements of 36 CFR 800.13, the post review discovery provision of the regulations implementing Section 106 of the NHP" (p. S-25). Both of those references refer to the impermissible deferral of mitigation measure and include no explicit requirements or performance measures and are, therefore, unenforceable.

In order to identify the Lead Agency's recommended mitigation measures, stakeholders are directed to "Chapter 4 of the Draft EIR/EIS" (p. S-12). In Chapter 4 (California Environmental Quality Act Evaluation), only a limited number of "measures" are referenced as "mitigation measures" therein. The DEIR/S states that "mitigation measures pursuant to CEQA were identified for each significant effect of the project, described above in Section 4.2.3" (p. 4-64). In accordance with the Lead Agency's declarations, recommended mitigation measures are limited to the following: (1) "Mitigation Measures GEO-1 through GEO-7" (p. 4-21); (2) "Mitigation Measures T-1 through T-9" (p. 4-22); (3) T-1, UT-2, and COM-1 through COM-11" (p. 4-23); and (4) "Mitigation Measure PAL-1" (pp. 4-21 and 47).

Since the term "avoidance and minimization measures" is not of CEQA derivation, it is assumed that it is intended to have application under NEPA. Because "some impacts determined to be significant under CEQA may not lead to a determination of significance under NEPA" (pp. S-1 and 4-1), it must be assumed that, with the limited exception of those identified "mitigation measures," all other actions constitute "avoidance and minimization measures" under NEPA.

The Lead Agency describes the following actions as “avoidance and minimization efforts”: (1) “Avoidance and minimization measures AQ-1 through AQ-14” (p. 4-6): (2) “minimization measures BIO-1 through BIO-9” (p. 4-8); (3) “minimization measure CUL-1” (p. 4-8), “Minimization Measure CUL-2” (p. 4-9), and “Minimization Measure CUL-3” (p. 4-8); (4) “Minimization Measures GEO-1 through GEO-7” (p. 4-9); (5) “Minimization Measures WQ-1 through WQ-6” (p. 4-10); (6) “Minimization Measures LU-1 and LU-2” (p. 4-11); (7) “minimization measures NOI-2 and NOI-3” (p. 4-12); (8) “Minimization Measures COM-13 and LU-3 through LU-6” (p. 4-18); and (9) “Minimization Measures HAZ-1 through HAZ-11” (p. 4-22). Because GEO-1 through GEO-7 are identified as both “mitigation measures” (p. 4-21) and “minimization measures” (p. 4-9), it is not possible to know the Lead Agency’s intent with regards to those actions. Additionally, with regards to every other “effort” and/or “measure,” since the DEIR/S contains no explicit categorization of those other actions, it is not possible to ascertain whether the Lead Agency has categorized them as “mitigation measures (under CEQA) or “avoidance and minimization measures” (under NEPA).

The Lead Agency notes that “all measures to avoid, minimize, and mitigate these potential significant effects have been incorporated into the project” (pp. 4-9 and 4-49). To the extent that the “avoidance and minimization measures” are already a part of the proposed action, then those measures do not impose any addition obligation other than directing OCTA and Caltrans the implement the project that they already propose.

Although never explicitly stated, it can be surmised that the Lead Agency’s efforts to differentiate between “avoidance and minimization efforts” and “mitigation measures” is intended to segregate those actions with regards not only to applicability and monitoring but also compliance and enforceability. As specified under the CEQ’s “Appropriate Use of Mitigation and Monitoring and Clarifying the Appropriate Use of Mitigated Findings of No Significant Impact” (January 14, 2011) (NEPA Mitigation Guidelines) (Attachment B). As indicated therein, citing Robertson v. Methow Valley Citizens Council (1989), the CEQ “acknowledges that NEPA itself does not create a general substantive duty on Federal agencies to mitigate adverse environmental effects” (p. 3).

In Robertson v. Methow Valley Citizens Council, the federal court noted that NEPA requires “that mitigation be discussed in sufficient detail to ensure that environmental consequences have been fairly evaluated,” but does not require that “a complete mitigation plan be actually formulated and adopted.” CEQ Regulations recommend but do not mandate the monitoring occur in order to verify implementation of mitigation measures (40 C.F.R. 1502.2[c]).

The Lead Agency is, however, reminded of the provisions of 23 U.S.C. 139(c)(4) which states: “The Secretary shall ensure that the project sponsor complies with all design and mitigation commitments made jointly by the Secretary and the project sponsor in any environmental document prepared by the project sponsor in accordance with this subsection and that such document is appropriately supplemented if project changes become necessary.”

3.4 Feasibility of Project Alternatives

As defined in Section 15364 of the State CEQA Guidelines, “’[f]easibility’ means capable of being accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, legal, social, and technological factors” (emphasis added). Under NEPA, as described in “Forty Most Asked Questions Concerning CEQ's NEPA Regulations” (March 23, 1981) (CEQ Questions), "reasonable alternatives" warranting detailed study are described as "those that are practical or feasible from the technical and economic standpoint and using common sense" (Question 2[a]).

Because the Lead Agency cannot demonstrate that it has the ability to effectuate any of the three build alternatives examined in the DEIR/S (e.g., "Full funding has not been identified for any of the proposed build alternatives and remains an unresolved issue," p. S-39) and because the Department has sought to utilize cost considerations as one of the key factors in eliminating otherwise feasible implementation options for further consideration therein, the Lead Agency has failed to present a legally adequate environmental analysis conforming to NEPA and CEQA.

As indicated in correspondence from William Kempton, OCTA's CEO to OCTA's Regional Planning and Highway Committee (Subject: Update on the Interstate 405 Improvement Project Alternatives, Business Models, and Delivery Option), dated April 16, 2012, which is neither included in nor referenced in the DEIR/S, current project cost estimates and funding options are described below:

> For Alternatives 1 and 2, the total estimated project cost is $1.3 billion and $1.4 billion, respectively. As the M2 revenues for this project are currently estimated to be $600 million over the life of the M2 program, this leaves an estimated funding need of $700 million for Alternative 1 and $800 million for Alternative 2.
>
> For Alternative 3, the express lanes alternative, the total estimated project cost is $1.7 billion. Alternative 3 is approximately two miles longer than the other two alternatives and includes an Express Lanes direct connector between the I-405 and the SR-73, and would require additional Intelligent Transportation System components to operate the Express Lanes facility. Alternative 3 delivers congestion management via tolling to provide the public with the option of a guaranteed speed and travel time through the corridor. Alternative 3 provides for greater vehicle throughput, as vehicles travelling at or near the speed limit in the Express Lanes will move through the corridor in greater numbers than vehicles in slower moving general purpose lanes. With the same M2 revenues of $600 million for the Express Lanes Alternative, the funding need is approximately $1.1 billion.
>
> For Alternative 3, three separate project finance options were modeled - Self Finance [SF], the use of Availability Payments [AP], and a P3 [public-private partnership] Concession. In all cases, the project cost is $1.7 billion. For the Self Finance option, approximately $300 million dollars could be raised from non-recourse future toll revenue bonds, leaving a funding need of $800 million. This funding need could be met by the sale of future M2 revenue bonds. This option would ensure that revenue generated would be controlled by OCTA, with these revenues projected to be approximately $1.4 billion over the next 30 years. With the Availability Payments option, approximately $1.2 billion could be raised, although the repayment cost of $5.8 billion exceeds the future toll revenue projections of $4.9 billion, leaving a deficit of $900 million. Performance based repayments would be made by OCTA regardless of toll revenues. With the P3 Concession option, approximately $800 million could be raised, leaving a funding need of $200 million. All toll revenues would go to the P3 Concessionaire, and there would be no debt costs associated with this option.

As indicated in Table I-10 (Proposed Funding and Shortfall) in the DEIR/S, the "funding shortfall" for Alternative 1 is $700 million, the "funding shortfall" for Alternative 2 is $800 million, and the “funding shortfall” for Alternative 3 is $800 million (p. I-18). However, at the June 26, 2012 community meeting in Seal Beach, William Kempton, OCTA’s CEO stated that that “$1.3 billion” in Measure M/M2 funds are presently available to the OCTA. Although inconsistent with the information presented in the DEIR/S and other documentation available from the OCTA, to the extent that Mr. Kempton’s statement is an accurate characterization of available funding, Alternative 1 could be implemented based on existing funding. Why is information concerning the amount of available Measure M/M2 funding inconsistently represented?

Based on the information presented in the DEIR/S, inclusive of all materials that existed in the administrative record up to prior to the release of the DEIR/S, none of the three build alternatives can be demonstrated to be feasible. Because none of the funding options can, as of yet, be demonstrated to provide OCTA with the resources needed to implement any of the three build alternatives, the Lead Agency cannot demonstrate that the use of non-toll road financing is infeasible. Even when toll road revenues are considered, assuming a design-building structure and conveyance of all toll revenues to a future P3 concessionaire, OCTA still falls “$200 million” short of currently estimated project costs (without adjustments for future cost escalations).

Although not readily apparent, as indicated in correspondence from William Kempton, OCTA’s CEO to OCTA’s Regional Planning and Highway Committee (Subject: Outline of the Proposed Project Delivery Organizational Approach for the Interstate 405 Improvement Project), dated June 4, 2012, the CEO stated that “Alternative 3 self finance option is the most financially feasible and provides some return to the M2 Freeway Program” (p. 2).

As indicated in OCTA’s “Measure M2 Triennial Performance Assessment Status Report, Staff Report” (November 15, 2010) (Triennial Report): “The OCTA‘s efforts on Interstate 405 in west Orange County illustrate both the challenges facing the OCTA in delivering M2. Listed in the Voter‘s Pamphlet as Freeway Project K, the improvements between the I-605 in Los Alamitos and the Costa Mesa Freeway (SR-55) has a Measure M budget of $500 million, making it one of M2‘s premier freeway projects. However, as the project has been more fully developed and has moved into environmental review, the <u>costs of the 405 west project have increased to the $1.7 to $2.2 billion range</u>, a far more expensive project than can be built in the next few years with a mix of state, federal, and M2 funds. Even with board direction to minimize all right-of-way takes by exploring narrower than standard lane widths and non-standard shoulders, building Project K may require innovative funding methods, including toll lanes or Express Lanes to aid in overall project funding. Without additional funding from non-traditional sources, the <u>OCTA cannot fund promised improvements on the western portion of Interstate 405</u>” (emphasis added) (p. 20). From this, it can be concluded that the Lead Agency’s efforts to minimize ROW acquisition (e.g., “Minimize environmental impacts and ROW acquisition,” DEIR/S, p. S-5) were not necessarily founded on benevolence but on more fundamental cost considerations.

As noted, the projected cost of Alternative 3 is identified as “$5.8 billion” and not the “$1.7 billion” identified in the DEIR/S (p. 2-10) or “$2.2 billion” identified in the Triennial Report (p. 20). For example, although the estimated cost of each is less than associated with Alternative 3, the following options were eliminated by the Lead Agency, in whole or in part, for economic reasons: (1) “Alternative M3 was estimated at $2.781 billion” (p. 2-41); (2) “Alternative M5 was estimated at $2.377 billion” (p. 2-42); (3) “Alternative M6 was estimated at $2.351 billion” (p. 2-43); (4) “Alternative M7 was estimated at $1.290 billion” (p. 2-43); (5) “Alternative M8 was estimated at $1.504 billion” (p. 2-44); (6) “Alternative M8a was estimated at $2 billion” (p. 2-45); (7) “Alternative M9 was estimated at $3.212 billion” (2. 46); (8) “Alternative M11 was estimated at $2.840 billion" (2-47); (9) "The total capital cost of Alternative M12 was not estimated but would likely be similar to Alternative M13 or $2.231 billion" (p. 2-48); and (10) "Alternative M13 was estimated at $3.231 billion" (p. 2-49). As noted, the estimated cost of both "Alternative M7" and "Alternative M8" are even less than the "$1.7 billion" identified in the DEIR/S for Alternative 3 but were subsequently rejected based on cost considerations (e.g., "The high cost of Alternative M8a also contributes to the determination that the alternative is not viable," p. 2-45).

"CEQA does not authorize an agency to proceed with a project that will have significant, unmitigated effects on the environment, based simply on a weighing of those effects against the project's benefits, unless the measures necessary to mitigate those effects are truly infeasible" (City of Marina v. Board of Trustees of California State University [2006]). As required under Section 15126.4(a) of the State CEQA Guidelines: "An EIR shall describe <u>feasible mitigation measures</u>" (emphasis added). Notwithstanding that requirement, a substantial portion of the Lead Agency's analysis is based on the tenet of "feasibility" and many of the "efforts" and/or "measures" are so vague (e.g., absent any means of quantification or assessment of performance) as to be enforceable. As such, feasibility cannot be used as a nebulous concept (that can be utilized when it serves the Department's interests and ignored when it does not) but must find form and substance in the DEIR/S (e.g., "The EIR serves not only to protect the environment but also to demonstrate to the public that it is being protected," 14 CCR 15003[b]). For example, with regard to the feasibility of implementing a broad range of "measures," the Department states: (1) "Beginning with preliminary design and continuing through final design and construction, plan, save, and protect as much existing vegetation in the corridor, especially eucalyptus and other skyline trees, <u>as feasible</u>" (Mitigation Measure VIS-1) (p. 4-64); (2) Beginning with preliminary design, and continuing through final design and construction, landscape and re-vegetate disturbed areas <u>to the greatest extent feasible</u> (Measure VIS-6) (p. 4-64); (3) "Provide vine planting on sound walls and retaining walls <u>where feasible</u> and appropriate" (Measure VIS-18) (pp. 4-65 and 66); (4) "The construction contractor shall establish Environmentally Sensitive Areas (ESAs) or their equivalent near sensitive air receptors within which construction activities involving extended idling of diesel equipment would be prohibited, <u>to the extent that is feasible</u> (Measure AQ-9); and (5) "To avoid impacts to raptors, all new highway lighting adjacent to NAVWPNSTA Seal Beach shall not contain features that allow for raptor perches, <u>as feasible</u> (Measure BIO-6) (emphasis added).

In addition, the DEIR/S notes: (1) "Each and every significant effect on the environment must be disclosed in the EIR and mitigated <u>if feasible</u>" (p. 4-1); (2) "<u>where feasible</u>, additional minimization measures have been identified to further reduce project effects, as applicable" (p. 4-5); (3) "The project permitting process and associated permit conditions would require avoidance <u>where feasible</u>" (p. 4-7); (4) "Caltrans/OCTA has a robust public outreach process for this project, which will continue through completion of the project, and additional <u>feasible</u> measures that are identified during the public outreach process and circulation of the Draft EIR/EIS, and agreed to by Caltrans/OCTA, will be incorporated <u>where feasible</u> to further reduce the significant effects on community character" (p. 4-49); (5) "To the extent that it is applicable or <u>feasible</u> for the project and through coordination with the project development team, the following measures will also be included in the project to reduce the GHG emissions and potential climate change impacts from the proposed project" (p. 4-59). Since the OCTA cannot demonstrate that it even has a plan to pay for the capital costs of any of the three build alternatives examined in the DEIR/S (much less on-going maintenance costs and debt service), no substantial evidence exists that any of the identified "efforts" and/or "measures" will be implemented and, if implemented, to what degree and efficacy.

In Gray v. County of Madera (2008), the court ruled that mitigation measures must both be specific as to their performance or contain specific performance standards offering assurance that implementation will remedy the effect or provide a compensatory environment which is "substantially similar" to that which existed prior to the degradation attributable to the proposed action and that the feasibility of those measure to accomplish their intended purpose be sufficiently demonstrated. Citing that case:

> While we generally agree that CEQA permits a lead agency to defer specifically detailing mitigation measures as long as the lead agency commits itself to mitigation and to specific performance standards, we conclude that here the County has not committed itself to a specific performance standard. Instead, the County has committed itself to a specific mitigation goal – the replacement of water lost by neighboring landowners because of mine operations. However, this goal is not a specific performance standard such as the creation of a water supply mechanism that would place neighboring landowners in a situation substantially similar to their situation prior to the decline in the water levels of their private wells because of the mining operations, including allowing the landowners to use water in a substantially similar fashion to how they were previously using water. Moreover, the listed mitigation alternatives must be able to remedy the environmental problem. We have concluded that the listed mitigation alternatives, except for the building of a new water system, cannot remedy the water problems because they would not place neighboring landowners into a situation substantially similar to what the landowners experienced prior to the operation of the mine. And the option to build a water system, which is the only effective mitigation measure that was proposed if it was feasible, was never studied or examined. Thus, the County is improperly deferring the study of whether building such a system is feasible until the significant environmental impact occurs.

Additionally, based on the absence of a viable funding plan, there likely will need to be other undisclosed changes, concessions, and/or public costs required to implement any of the three build alternatives. Because those changes, concessions, and costs may not be finalized until after the close of the environmental process, the potential environmental implications of those actions may never be fully addressed and may occur outside any opportunity for stakeholder participation. Since the proposed action involves the long-term commitment of public funds (and the opportunity costs associated therewith), OCTA's commitment of those funds and/or ability to demonstrate a viable implementation strategy is an integral part of the project and, for the purpose of environmental compliance, cannot be separated therefrom.

Existing environmental conditions and anticipated impacts can increase or decrease over time, scheduling considerations (including the anticipated commencement/completion dates) and the existence of internal and extraneous factors influencing that schedule (e.g., absence of money) are integral elements in assessing project-related and cumulative environmental effects. As indicated in the DEIR/S, facility construction is expected to commence in 2015 (e.g., "Construction of the proposed project is planned to commence in 2015," p. 2-26); however, since the Department has not demonstrated its ability to fund the identified improvements, that schedule could have substantial slippage. Alternatively, attainment could require substantial concessions (e.g., "All toll revenues would go to the P3 Concessionaire") which could potentially have a bearing on the proposed action and its environmental implications.

The Lead Agency states that "[f]urther financial planning to identify full funding for the alternative selected for construction will be required to prepare the Financial Plan required by the Federal Highway Administration prior to approval of the Final EIR/EIS" (DEIR/S, p. S-40). Since too much is riding on the existence of and effectiveness of that future "financial plan" (e.g., selection and rejection of alternatives, existence and substance of identified "efforts" and/or "measures"), failure to include that information in the DEIR/S has deprived the affected public of meaningful opportunities to comment on the document, prematurely eliminated other potentially feasible alternatives based on premature and non-evidentiary rationalization, resulted in the deferral of critical analyses to a later time and date (outside opportunities for public participation), and appears to now predicate a single course of action (e.g., generation of toll revenues and conveyance of those revenues to a P3 concessionaire. Although its intended inclusion was presaged in both the "Notice of Preparation" (NOP) and "Notice of Intent" (NOI) but promptly eliminated from the DEIR/S (e.g., "Alternative 4 proposed to provide localized improvements within the I-405 corridor that could be fully funded and implemented with available revenue from Orange County's Renewed Measure M transportation sales tax initiative," pp. 2-3 and 4) and although the single stated objective of the proposed action is "[t]o be consistent with regional plans and find a <u>cost-effective early</u> project solution for delivery" (emphasis added) (p. 1-5), the one viable and feasible build alternative identified in the DEIR/S (i.e., Alternative 4 is a lower-cost option to provide localized improvements within the I-405 corridor that could be fully funded and implemented with available revenue from Orange County's Renewed Measure M transportation sales tax initiative," p. 2-28) was never seriously considered.

What does "cost-effective" even mean and what criteria will be used in its assessment and comparative analysis? The proposal to convey all future toll revenues to a private operator may reduce "up-front" costs but results in the forfeiture of any "opportunity costs" associated with the use of future revenues. Since the criteria are not specified in the DEIR/S and information concerning any alleged economic benefits (e.g., equating time savings to economic productivity), how will stakeholders be able to participate in the formulation of that criteria, in the comparative evaluation of alternatives (e.g., "Alternative 4" and "TSM/TDM/Mass Transit Alternative"), and in the determinations concerning the expenditure of public funds? Although consisting of literally thousands of page of text, the DEIR/S appears merely to be a house of cards whose structure is dependent on a yet to be determined, unknown, undisclosed, and unproven financing structure. Pending its release, with the exception of "Alternative 4" (and potentially the "TSM/TDM/Mass Transit Alternative") the Lead Agency cannot demonstrate the feasibility of any of the three build alternatives or defend the elimination of other alternatives based, in whole or in part, on financial considerations.

The DEIR/S notes: "Alternative 4 would neither provide additional capacity along the entire corridor nor enhance interchange operations. It would not meet the project purpose and was eliminated from further consideration in this Draft EIR/EIS" (p. 2-4); however, neither "additional capacity" nor "enhanced interchange operations"' were identified in the Lead Agency's declared P&N and single objective. As a result, the Lead Agency seeks to reject otherwise feasible alternatives based on criteria substantively different from those articulated by the Department for the proposed action.

3.5 Congestion Relief

As indicated in "San Diego Freeway (I-405) Frequently Asked Questions" (USDOT, Caltrans, and OCTA, undated) (http://www.octa.net/pdf/405/faq.pdf): "It has been estimated that the width of the I-405 would need to be doubled from the existing ten lanes to twenty lanes to serve the traffic demand expected by year 2035. For a number of reasons, including right-of-way constraints and operational limitations of widening, none of the proposed improvements are expected to completely eliminate congestion" (Question 4). Acknowledging the existence of induced or latent demand, it is noted that "none of the proposed alternatives would completely eliminate congestion in the I-405 corridor. Additional general purpose lanes would fill up and become congested very quickly after they open" (emphasis added) (Question 12).

As reported in a report prepared by the Brookings Institute and University of California Berkeley, entitled "The Effect of Government Highway Spending on Road Users' Congestion Costs, Final Report to the Federal Highway Administration" (October 2004), the authors (Clifford Winston and Ashley Langer) concluded:

> [W]e estimate that one dollar of highway spending in the last year of our sample, 1996, reduced motorists' congestion costs only 3.3 cents in that year (2000 dollars). Note that this benefit is not an ongoing return, but only applies to the year in which spending occurred. Although highway spending serves many purposes, policymakers frequently cite reducing congestion as among the most important. Thus, our estimate seriously questions the cost-effectiveness of current spending priorities if policymakers wish to achieve this goal. As noted, we did not include several variables in the model that affected congestion costs but were arguably affected to some extent by highway spending. If we included any of these variables in the model, the effect of highway spending on congestion costs would be even lower (pp. 13-14).
>
> It could be argued that highway spending in 1996 would reduce congestion costs in future years by adding to the value of the capital stock. But such spending supplemented the value of each state's capital stock only six percent on average. In addition, any benefits from this modest improvement in the capital stock would be reduced significantly by depreciation in just a few years. Given that we found that spending reduced motorists' congestion costs only three cents in the year that spending occurred and that additional cost savings in the future would be much [less] (pp. 14-15).

"Each of the build alternatives is viable with each providing incremental throughput increase; however, none will totally alleviate congestion" (emphasis added) (Traffic Study, p. ES-4). "Each of the proposed alternatives project improves freeway capacity but does not totally satisfy projected future demand [b]ased on the fact that oversaturation is predicted under future expected traffic conditions (i.e., LOS F) for the I-405 in the study area" (emphasis added) (Traffic Study, p. 2.1-3). The Lead Agency acknowledges that the existence of congestion is a "fact" now and into the foreseeable future. With regards to each of the three build alternatives:

- Under the No Build Alternative, "[i]n general, under both 2020 and 2040 conditions for the No Build Alternative, the freeway mainline (including both general purpose lanes and HOV lanes) is expected to operate at LOS F in both the AM and PM peak hours in both the southbound and northbound directions. (emphasis added) (p. 2.4-1). "LOS F during AM and PM peak times is expected to occur on nearly all segments in 2020 and on all segments in 2040" (emphasis added) (p. 2.4.3). "The speed index ranges from 5 to 21 depending upon segment, direction of travel, and peak hour" (p. 2.4-3).
- "Under Alternative 1 conditions for Opening Year (2020), the freeway mainline (including both general purpose and HOV lanes) is expected to operate at LOS F during the AM and PM peak hours in both directions with few exceptions. Under Design Year (2040)

traffic conditions, all lanes are expected to operate at LOS F during both AM and PM peak hours for both directions of travel (emphasis added) (Traffic Study, p. 2.5-1). "[A]ll segments are expected to operate at LOS F during peak hours" (emphasis added) (p. 2.5-2). "The speed index ranges from 6 to 38 depending upon segment, direction of travel, and peak hour" (p. 2.5-3).

- "[U]nder Alternative 2 conditions for 2020, the freeway mainline general purpose lanes and HOV lanes are expected to operate at LOS D to F in the AM and PM peak hours in the southbound and northbound directions, with LOS D more prevalent in the northern section of I-405. Under Design Year (2040) conditions, all general purpose lanes and HOV lanes are expected to operate at LOS F during both AM and PM peak hours" (emphasis added) (Traffic Study, p. 2.6-1). "[A]ll segments are expected to operate at LOS F during peak hours" (emphasis added) (p. 2.6-2). "The speed index ranges from 7 to 50 depending upon segment, direction of travel, and peak hour" (p. 2.6-3).
- "[U]nder Alternative 3 conditions, the freeway mainline general purpose lanes are expected to operate at LOS F in the AM and PM peak hours in both the southbound and northbound directions under 2020 and 2040 conditions. The express lanes are expected to operate generally at LOS C to D under 2020 and 2040 conditions" (emphasis added) (Traffic Study, p. 2.7-1). "LOS F is expected to occur in the general purpose lanes during the AM and PM peak hours on nearly all links in 2020 and on all links in 2040" (emphasis added) (p. 2.7-3). "The speed index ranges from 14 to 53 in the general purpose lanes and 65 in the express lanes whose speeds and volumes are managed through the imposition of tolls" (p. 2.7-3).

As indicated in the Traffic Study: "Whenever density exceeds 45 pc/mi/ln [passenger cars/mile/lane], the Level of Service category is "F", or very congested (i.e., traffic jams). The general purpose lanes in every alternative, and the HOV lanes in the No Build alternative and in Alternatives 1 and 2, are expected to operate at LOS F during the peak hours, except for spot locations. Under projected future traffic conditions for Year 2040, the express lanes in Alternative 3 are expected to operate at LOS C/D. . .Management of the express lanes in Alternative 3 through tolling will be targeted to minimizing congestion in the express lanes during peak periods; this will maximize their speeds" (pp. ES-3 and ES-4). By the Lead Agency's own admission, everything will remain at gridlock with the limited exception of the express (HOT) lanes in Alternative 3. The Traffic Study demonstrates that congestion (as measured in vehicular throughput and relative speed) will be reduced for only those able to pay the toll; however, traffic in all the GP lanes will remain at LOS "F."

As noted in Caltrans' "Route Concept Report – Interstate 405, San Diego Freeway, 12-ORA P.M. 0.23/24.18" (November 1999) (RCR), LOS "F" is defined as "congestion" (e.g., "With these improvements the LOS would be at 'F' [congestion] in the year 2020 for the entire length of the route," Summary). As further defined in the Traffic Study, "LOS 'F' is used to define breakdowns in vehicular flow. Breakdowns occur when traffic incidents cause a temporary reduction in the capacity, at merge or weaving segments that result in a greater number of vehicles arriving than the number of vehicles discharged and when the projected peak hour flow rate exceeds the estimated capacity of the location" (emphasis added) (p. 2.1-2).

With regards to projected level of service conditions and vehicular throughput projections, presented in Table 3 (Level of Service and Vehicle Throughput) below is information extracted from the Traffic Study. As indicated therein, in general terms, with regards to level of service conditions, excluding the proposed "express lanes" under Alternative 3 where improved LOS conditions may exist through the active management of those lanes (i.e., controlling the number of vehicles through increasing tolls and changing occupancy requirements), either doing something (adding more lane miles) or doing nothing (not adding more lane miles) produces the relatively same LOS conditions (LOS "F"). In the "best case" freeway segment, vehicle throughput increases by only 1,200 vehicle per hour (vph) under Alternative 1, by only 2,400 vph under Alternative 2, and by only 3,000 vph under Alternative 3. If the old adage is true, "the more things change, the more they stay the same," it is unclear how massive public expenditures for the apparent benefit of a relatively few drivers (those willing to pay the toll) will substantially improve conditions for the overwhelming majority of the area's residents.

Table 3
Level of Service and Vehicle Throughput

Study Segment	No Build Alternative				Alternative 1				Alternative 2				Alternative 3			
	NB		SB		NB		SB		NB		SB		NB		SB	
	GP	HOV	SG	HOV	GP	HOV	GP	HOV	GP	HOV	GP	HOV	GP	HOV	GP	HOV
Level of Service																
SR-73 to Brookhurst	F	F	F	F	F	F	F	F	F	F	F	F	F	C	F	C
Brookhurst to SR-33 East	F	F	F	F	F	F	F	F	F	F	F	F	F	C	F	C
SR-22 East to I-605	F	F	F	F	F	F	F	F	F	F	F	F	F	D	F	D
Vehicle Throughput																
SR-73 to Brookhurst	7200	1200	7200	1200	7200	1200	7200	1200	7200	1200	7200	1200	7200	3200	7200	3200
		8400		8400		8400		8400		8400		8400		10400		10400
Change from No Build		-		-		0		0		0		0		2000		2000
Brookhurst to SR-33 East	4800	1200	4800	1200	4800	1200	6000	1200	7200	1200	7200	1200	6000	3000	6000	3000
		6000		6000		6000		7200		8400		8400		9000		9000
Change from No Build		-		-		0		1200		2400		2400		3000		3000
SR-22 East to I-605	7200	2400	7200	2400	7200	2400	7200	2400	9600	2400	9600	2400	8400	3400	8400	3400
		9600		9600		9600		9600		12000		12000		11800		11800
Change from No Build		-		-		0		0		2400		2400		2200		2200

Source: Albert Grover & Associates, Traffic Study – San Diego Freeway (I-405) Improvement Project SR-73 to I-605, Orange and Los Angeles Counties. May 2011, Tables 2.5.9, 2.6.9, and 2.7-9, pp. 2.5-24, 2.6-24, and 2.7-29.

The information in Table 4 (Freeway Average Daily Traffic [ADT] Volumes – Existing and Future) is extracted from the Traffic Study (see Table 2.2.1, p. 2.2-1) and indicates that traffic volumes, as measured in average daily traffic (ADT), even without the proposed action, will increase substantially between "existing conditions" (Year 2009), "opening day" (Year 2020), and the project's "design year" (Year 2040). Ignoring traffic spikes that occur during the morning (AM) and evening (PM) peak hours, assuming that traffic volumes are consistent throughout the day (which itself is a false assumption) and the anticipated traffic diversion from arterial and secondary streets onto the freeway as a result of the proposed improvements, the projected increase in ADT that Caltrans expects to occur (absent the proposed action) exceeds the added capacity identified in Table 3 (Level of Service and Vehicle Throughput), even under the best-case scenario As a result, even with the proposed action: (1) traffic conditions (e.g., congestion) will worsen over existing conditions; (2) projected demand increases at a faster rate than projected supply; and (3) on "opening date," the improvements will prove obsolete.

Despite assertions of the purported intent of its endeavors (e.g. reduce congestion), undisclosed in the DEIR/S is the reality that the viability of both HOV and HOT lanes is, in fact, dependent on the perpetuation of congestion (e.g., "express lanes specifically do not suffer from reduced flow as general purpose lane congestion increases," Traffic Study, p. 2.1-3). The formation of carpools and the payment of tolls by motorists are both predicated on the existence of clear choices regarding travel time (i.e., congested GP lanes or free-flowing "express lanes"). Based on the resulting dependencies they engender and the decentralization of a diverse labor pool, in the absence of congestion, there exists little motivation for non-family members to form unions to travel to work or to pay the added travel costs when the HOT lane and the adjoining GP lane allow arrival at the appointed destination at generally the same time.

Table 4
Freeway Average Daily Traffic (ADT) Volumes – Existing and Future

Location	Existing Condition (Year 2009)	Opening Day (Year 2020)	Design Year (Year 2040)
SR-22 East – I-605	370,260	453,580	508,780
Projected Increase over Existing Conditions	-	83,320	138,520
Brookhurst Street – SR-22 East	257,400	309,270	343,640
Projected Increase over Existing Conditions	-	51,870	86,240
SR-73 – Brookhurst Street	306,900	374,300	418,960
Projected Increase over Existing Conditions	-	67,400	112,060

Source: Albert Grover & Associates, Traffic Study – San Diego Freeway (I-405) Improvement Project SR-73 to I-605, Orange and Los Angeles Counties. May 2011, Tables 2.2.1, p. 2.2-1.

The Lead Agency alleges that the proposed action's "[l]ong-term benefits would include improvement to the transportation network in the area, reduction of congestion, and improved intersection circulation (emphasis added) (p. 3.4-1). The following two items are noticeably absent from that statement: (1) a definition as to what constitutes "congestion"; and (2) any linkage between "congestion" and "capacity" (either as an isolated variable or in combination with demand). Similarly, as used in the DEIR/S, "congestion" is spoken of as if it were a new concept (rather than one that pre-dating the automobile), that it is an isolated phenomenon and can be solved in small incremental stretches of roadway (somehow unique to each segment), and that a single and universally held perception (rather than multiple perspectives) of its existence can be defined. In reality, congestion is a persistent problem and not a condition of recent origin or unique to the southern California area.

Historic accounts of congestion can be traced back to Julius Caesar who banned wheeled traffic from Rome during the daytime. Leonardo da Vinci proposed the separation of wheeled traffic from pedestrian traffic (Encyclopedia Britannica, Traffic Control, online). Congestion exists in all metropolitan areas (including many in southern California) and perceptions regarding congestion (including tolerance) may be both societal and geographically diverse.

In "2010 Status of the Nation's Highways, Bridges, and Transit: Conditions and Performance, Report to Congress" (March 30, 2012), the FHWA states: "There is no universally accepted definition or measurement of exactly what constitutes a congestion "problem." The public's perception seems to be that congestion is getting worse, and it is by many measures. However, the perception of what constitutes a congestion problem varies from place to place. Traffic conditions that may be considered a congestion problem in a city of 300,000 may be perceived differently in a city of 3 million, based on differing congestion histories and driver expectations. These differences of opinion make it difficult to arrive at a consensus of what congestion means, the effect it has on the public, its costs, how to measure it, and how best to correct or reduce it. Because of this uncertainty, transportation professionals examine congestion from several perspectives. Three key aspects of congestion are severity, extent, and duration. The severity of congestion refers to the magnitude of the problem or the degree of congestion experienced by drivers. The extent of congestion is defined by the geographic area or number of people affected. The duration of congestion is the length of time that the roadway is congested, often referred to as the "peak period" of traffic flow" (p. 4-2).

In the "City in History" (1961), Lewis Mumford wrote:

> The facts of metropolitan congestion are undeniable; they are visible in every phase of the city's life. One encounters congestion in the constant stoppages of traffic, resulting from the massing of vehicles in centres that can be kept in free movement only by utilizing human legs. One encounters it in the crowded office elevator or in the even more tightly packed subway train, rank with the odors of human bodies. Lack of office room, lack of school room, lack of house room, even lack of space in the cemeteries for the dead. Such form as the metropolis achieves its crowd-form: the swarming bathing beach by the sea or the body of spectators in the boxing areas or the football stadium. With the increase of private motor cars, the streets and avenues become parking lots, and to move traffic at all, vast expressways gouge through the city and increase the demand for further parking lots and garages. In the act of making the core of the metropolis accessible, the planners of congestion have already almost made it uninhabitable.
>
> The costs of congestion itself, in impeding the essential economic activities of the metropolitan area, are augmented by the costs of the purely mechanical methods of overcoming this congestion. These costs, even if they were humanly tolerated, would long age have been rejected because of their financial extravagance, if rational economic standards had played any part in forming the metropolitan myth (p. 624).

As indicated in the FHWA's "Consideration for High Occupancy Vehicle (HOV) Lane to High Occupancy Toll (HOT) Lane Conversions Guidebook" (June 2007): "Traffic congestion on U.S. highways serving our largest metropolitan regions have reached unprecedented levels despite our heroic but, ultimately, failed efforts to build more highways in response to the nation's insatiable demand for travel. With the benefit of several decades' worth of hindsight, the U.S. transportation policy community has pledged a renewed commitment to attacking the urban transportation problem through a <u>combination of demand and system management strategies</u> focused on managing our existing transportation supply more effectively and efficiently" (emphasis added) (p. 1-1). Similarly, as indicated on the FHWA's website: "Congestion results when traffic demand approaches or exceeds the available capacity of the system" (http://www.fhwa.dot.gov/congestion/).

To the extent that "congestion" can be fundamentally defined as the imbalance between supply and demand (excess demand and insufficient supply), then congestion has two separate constituents (supply and demand). Absent a singular focus on "capacity, public effort to "reduce congestion" must, therefore, be approached from both perspectives. Because that has not occurred in the DEIR/S, decision makers are being asked to choose between "three of the same things" rather than "two or more different remedies" (e.g., the FHWA's "combination of demand and system management strategies").

In order to assess performance and compare the only alternatives (excluding the No Build Alternative), the Traffic Study states: "For the proposed project which improves freeway capacity but does not totally satisfy projected future demand, the following measures of effectiveness (MOE) were selected to either quantitatively and/or qualitatively compare improvement alternatives: [1] Peak hour throughput (throughput being the number of vehicles able to pass a fixed point along the project route). [2] <u>Relative</u> speed, and conversely, the vehicle travel time to traverse the project length during the peak hour" (emphasis added) (Traffic Study, p. ES-3). "[B]ecause speed is more easily understood than throughput, it has been shown as a <u>relative</u> measure of improvement associated with providing added freeway capacity" (emphasis added) (p. 2.1-5). With only those two indices, as with "relative" speed, it is possible to compare the "relative" merits of the three build alternatives.

Without commenting on the validity of the measures cited, in contrast, the FHWA's "2011 Urban Congestion Trends – Improving Travel Reliability with Operations, FHWAQ-HOP-12-019" (undated) identifies the following measures of congestion: (1) hours of congestion (amount of time when freeways operate below 50 mph; (2) travel time index (TTI) (time penalty for trip on an average day (e.g., a TTI of 1.30 indicates a 20-minute free-flow trip takes 26 minutes [20 x 1.30] during peak); and (3) planning time index (PTI) (time penalty for a trip to be on time for 95 percent of trips (e.g., a PTI of 1.60 indicates a 20-minute free-flow trip takes 32 minutes [20 x 1.60]). None of these factors are even referenced in the DEIR/S.

The deck is now stacked. Because the only two variables to be analyzed are peak-hour throughput and relative speed, the only range of solutions posited is the number and type of additional lane-miles to be added to the specified freeway segment. Never asked is the more fundamental questions: (1) What is the root cause of traffic congestion? (2) If an issue of supply and demand, what actions can be taken to reduce the existing imbalance? (3) If a manner of too many automobiles and trucks, what can be done to take automobiles and trucks off the road? (4) If a matter of accessibility, how can access opportunities be enhanced?

The DEIR/S states that "[t]he purpose of the proposed action is to: [1] Reduce congestion; [2] Enhance operations; [3] Increase mobility, improve trip reliability, maximize throughput, and optimize operations; and [4] Minimize environmental impacts and right-of-way acquisition" (p. S-1). "Relative speed" is not, however, identified as among the project's purposes. It is evident that "congestion" is not actually being measures but that broad and ill-defined concept is, because it is "more easily understood," examined in the context of "relative speed." In that it may be a factor in calculating vehicle throughput, relative speed is, at best, one of the components that could be used in describing available supply (e.g., on the supply side, congestion is primarily a function of the physical characteristics of the facility and events that limit the availability of this capacity). Because "relative speed" is being measured and not "congestion," there is a substantial disconnect between the Lead Agency's P&N and both how "congestion" is defined and how it is being quantitatively expressed. How fast (or slow) an average vehicle traverses a set distance during a peak hour period is not a valid measure of congestion. Similarly, since no optimal or ideal relative speed exists or has been documented in the DEIR/S (e.g., number of vehicles per hour per lane that maintain a specified LOS), any incremental difference between one alternative and another is both meaningless and, in the absence of a set goal, fails to yield a determination of whether the resulting increase (or decrease) is worth the added (or lesser) cost (e.g., how should a one mph increase in average peak-hour speed valued?).

As speeds diminish and the frustration of SOVs mount, motorists may feel compelled to investigate other forms of transportation, employers may be forced to consider other working arrangements (e.g., telecommuting and flexible work hours), and individuals may alter or consider different life-style choices (e.g., increased attraction of transit-oriented developments). Although the Lead Agency seeks to portray those considerations in negative light, shorter or less frequent commutes and increased bus and train ridership may, in fact, not be bad things.

Moviegoers are familiar with the adage from "Field of Dreams": "Build it, and they will come." The traffic corollary is "don't build it and they will still come." Absent from the DEIR/S is any discussion of latent demand (defined as pent-up [dormant] demand for travel; travel that is desired but unrealized because of constraints) and induced demand (defined as realized demand that is generated [induced] because of improvements to the transportation system) and the consequences of that demand on traffic conditions once the improvements are completed.

As indicated in the United States Environmental Protection Agency's (USEPA or EPA) "Our Built and Natural Environments: A Technical Review of the Interactions between Land Use, Transportation, and Environmental Quality" (2001) (OBNE): "Over the past several decades, improvements in automobile-related infrastructure (highways, roads, parking lots), greater separation between jobs and housing, greater distances between destinations, and induced traffic (or additional travel prompted by road capacity expansions) have led to increases in vehicle travel" (p. 33). As documentation supporting the federally recognized linkage between increased road capacity and congestion, the USEPA stated:

> Probably the best-known quantification of induced travel using U.S. data is a study by a University of California-Berkeley team led by Mark Hansen. Using time-series data and multiple regression, Hansen et al. estimated the auto traffic effects of changes in road capacity. Hansen studied relatively long-run time-series data - up to 16 years - and cross-sectional data to overcome difficulties in other studies that used only cross-sectional data and limited time periods. The peer-reviewed results are statistically robust and quite clear: induced travel can occur and can absorb all new capacity. According to the study, vehicle miles traveled on state highways increase, on average, by 0.6 to 0.7 percent at the county level for each 1 percent increase in highway miles, and by 0.9 percent at the metropolitan level. The full increase in VMT materializes within five years of the change in road supply. New road capacity does not simply affect travel on the new road or new lanes. It may also affect traffic outside its own corridor. People might use the new road rather than an older, more congested route. People may choose new destinations. A decision to use the new road probably means a decision to use a road connecting to it. Thus, capacity increase can lead to travel growth on other roads as well as on new roads highway lanes.
>
> Hansen found that: "adding lane miles in a given county increases VMT throughout the wider region. This will occur if, for example, increasing the capacity of a highway in a given county induces commuting to or through that county from other counties in the region." Hansen found that capacity additions have different impacts in different metropolitan areas. An additional lane mile in San Francisco, Los Angeles, or San Diego metro areas produces roughly 12,000 additional daily VMT (pp. 22-23).

As further indicated in the United States Transportation Research Board's (TRB) "Expanding Metropolitan Highways: Implications for Air Quality and Energy Use, Special Report 245" (1995), the TRB concluded that "[t]he evidence from the studies reviewed here supports the view that highway capacity additions can induce new trips, longer trips, and diversions from transit" (p. 162).

3.6 Additional VMT Equates to Reduced GHG

On December 7, 2009, the USEPA signed the following two findings regarding GHGs under Section 202(a) of the Federal Clean Air Act (CAA): (1) Endangerment finding - the USEPA finds that the current and projected concentrations of the following six "well-mixed greenhouse gases" in the atmosphere threaten the public health and welfare of current and future generations: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6); and (2) Cause or contribute finding - the USEPA finds that the combined emissions of these well-mixed greenhouse gases from new motor vehicles and new motor vehicle engines contribute to the GHG pollution which threatens public health and welfare (USEPA, Docket No. EPA-HQ-OAR-2009-0171, December 7, 2009).

As reported in the California Department of Public Health's (CDPH) "Health Co-Benefits and Transportation-Related Reductions in Greenhouse Gas Emissions in the Bay Area" (November 11, 2011): "Climate change associated with the emission of greenhouse gases is the most significant threat confronting public health during the 21st century. In California, the transportation sector accounts for 38% of these emissions, outpacing all other sectors, including energy production. Within transportation, personal passenger vehicles account for 79% of greenhouse gas (GHG) emissions, and strategies to reduce carbon dioxide (CO_2) and other greenhouse gases include reducing both CO_2 emitted per mile and the <u>overall miles traveled</u>" (emphasis added) (p. 1).

As indicated in Caltrans' "Prioritization of Transportation Projects for Economic Stimulus with Respect to Greenhouse Gases, Final" (June 20, 2009), the Department states that "projects that increase capacity may or may not affect GHG emissions depending on the type of project. In general, projects that alleviate existing delays may reduce short-term GHG emissions but will likely have very little long-term GHG benefit since they do not decrease VMT in the long run. It is important to note that projects in currently approved RTP's [regional transportation plan] have primarily been selected and designed to address declines in travel mobility measures (e.g., reducing delay) that are projected to result from long-term population growth. Consequently, t<u>hose projects that add capacity without reducing real VMT (i.e., resulting in shorter or fewer SOV trips) will not contribute to meeting mid-term and long-term GHG targets</u>" (emphasis added) (pp. 6-7).

As indicated in <u>Table 5</u> (Project Categories and their Anticipated Long-Term Relationship to GHG Emissions), Caltrans qualitatively organized typical projects into "added capacity projects" (those projects that improve operational efficiency, thus indirectly adding capacity, as well as those projects that directly add capacity though lane or transit/HOV improvements) and "non-capacity added projects" (projects that rehabilitate, maintain, or preserve conditions of pavement). For added-capacity projects, the likelihood of GHG reductions declines and the likelihood of increased GHG emissions rises as mixed-flow solutions are implemented. Based on Caltrans own analysis, of all the transportation improvement projects identified, the proposed action has the greatest likelihood of increasing GHG emissions and the least likelihood of reducing GHG emissions.

Table 5
Project Categories and their Anticipated Long-Term Relationship to GHG Emissions

Added-Capacity Projects	Example Projects (in no particular order)	GHGs	
Mixed Flow Capacity Addition	Additional lanes (incl certain types of auxiliary) Tolled roads (mixed use)	Increasing likelihood of GHG increases →	← Increasing likelihood of GHG reductions
Traffic Operations	Operational improvements (ramp metering, signal improvements, turn lanes, auxiliary lanes) Traffic management systems Truck lanes (climbing, separated flow) Elimination of at-grade rail crossings		
Enhancement and Capacity Additions for Alternative Modes	Bike facilities Pedestrian facilities Park & Ride (carpool) Tolled lanes (high occupancy restricted) HOV lane additions/enhancements		
Transit	Rail Bus Ferry Transit infrastructure (stops, waiting areas) Bus rapid transit Park & Ride (transit)		
Non-Capacity Added Projects	Example Projects (in no particular order)	GHGs	
Maintenance, Rehabilitation, Preservation	Pavement preservation Pavement rehabilitation and maintenance Stormwater/drainage	Long-term neutral Impacts without innovation	
Neutral/Other	Bridge preservation Bridge rehabilitation Bridge replacement Facilities preservation Facilities rehabilitation Facilities replacement Damage restoration Safety improvements Landscaping, Sound Walls		

Source: California Department of Transportation, Prioritization of Transportation Projects for Economic Stimulus with Respect to Greenhouse Gases, Final, June 20, 2009, Table 1 (Project Categories and their Anticipated Long-Term Relationship to GHG Emissions), p. 8.

Information from Caltrans' independent analysis serves to refute other statements presented in the DEIR/S, namely that "[t]o the extent that a project relieves congestion by enhancing operations and improving travel times in high-congestion travel corridors, GHG emissions, particularly CO_2, may be reduced" (p. 4-55). In support of that statement, the Lead Agency includes a graph (Figure 4.2) extracted from a single-page article (i.e., "Traffic Congestion and Greenhouse Gases: Matthew Barth and Konok Boriboonsomsin," p. 4-55) and included a web-link to that article. Noticeably absent from the DEIR/S analysis and the referenced graphic are the authors' own admonition. The cited study notes that different traffic management techniques (i.e., congestion mitigation increasing average traffic speeds from those under heavily congested conditions; speed management reducing high speeds to safer speeds; and traffic smoothing reducing the number and intensity of accelerations and decelerations) could affect CO_2 emissions "as long as travel demand does not increase because of the improved traffic flow." The Lead Agency's own analysis (e.g., "the proposed project is intended to add capacity ", p. 3.6-10) refutes any emission reduction benefits.

In its substantially broader analysis of GHG emissions, Caltrans concluded: "Traditional transportation-related air quality assessments focus on several principles, some of which remain applicable in the GHG context. A key concept is the relationship, for a given point in time, between vehicle emissions and travel speeds. In general, stop-and-go traffic produces high emission rates for virtually all vehicle types and traditional urban-scale pollutants such as hydrocarbons (HC), carbon monoxide (CO), and oxides of nitrogen (NOx). Per-vehicle emissions of urban-scale pollutants decline as traffic flow improves until, at very high speeds (e.g., 60+ mph), emission rates increase again. Vehicular CO_2 emissions follow a similar pattern. Road congestion that significantly reduces speeds or increases engine loads will also increase emissions. A key disconnect between traditional urban-scale pollutants and CO_2, however, lies in the understanding that although emissions of traditional pollutants of interest (HC, CO, and NOx) have declined substantially in recent decades as vehicle technology has improved, CO_2 emissions are governed by fuel economy, which has remained static over time. Thus, holding fuel consumption per mile driven as a constant, any increase in VMT results in increased CO_2" (p. 9).

The above referenced study further notes that "[t]he literature separates short and long-term impacts, and identifies factors that influence how new capacity alters travel speeds, trip generation, mode choice, travel distance, and time-of-day travel choices. The National Research Council [NRC] found major highway capacity additions increase emissions over the long run, particularly in growing, less developed areas where capacity increases attract further development. NRC noted that in developed areas, traffic flow improvements such as left turn lanes and signal timing may reduce emissions without risking related traffic growth. More recent literature reviews also document a positive correlation between increased lane-miles of capacity and increased daily VMT; California-based analyses corroborate this link.[Footnote] Increased travel activity contradicts the AB 32 Scoping Plan, which envisions that by year 2030, control strategies will achieve an eight percent reduction in per-capita VMT from BAU [business as usual] conditions" (Project Category Description, Mixed Flow Capacity Addition).

The "footnote" cited by Caltrans is to Robert Cervero's and Mark Hansen's "Induced Travel Demand and Induced Road Investment, A Simultaneous Equation Analysis" (Journal of Transport Economics and Policy, Volume 36, Part 3, September 2002, pp. 469-490) (Attachment C). In that article Professor Cervero (Institute of Transportation Studies, Department of City and Regional Planning, University of California, Berkeley) and Professor Hansen (Institute of Transportation Studies, Department of Civil and Environmental Engineering, University of California, Berkeley) present simultaneous models predicting induced travel demand and induced road investment.

Based on a review of the literature, the accredited authors concluded that recent research is "broadly consistent with the assertions, made several decades ago, of two noted transport policy analysts, Anthony Downs and Wilfred Owen. Downs, argued that expanding congested freeways triggers a phenomenon he termed 'triple convergence' in which drivers shift their routes, times of travel, and modes in order to exploit the new capacity, thereby generating similar levels of congestion (at least during peak periods) as before. Downs' interpretation led Owen to conclude: 'Meeting the ever-growing needs for transport capacity has often proved to be a fruitless task, as the persistence in urban traffic jams attest.' In the United States, the contention that 'you can't build your way out of traffic congestion' has become the rallying cry of the Surface Transportation Policy Project (STPP). In a recent report based on 15 years of data across 70 US metropolitan areas, STPP concluded that regions that invested heavily in expanding road capacity fared no better in easing congestion than areas that did not" (p. 470).

As defined therein, "'induced travel' reflect[s] all changes in trip-making that are unleashed by a road improvement: (1) newly generated trips (that is, latent demand); (2) longer journeys; (3) changes in modal splits; (4) route diversions; and (5) time-of-day shifts. 'Induced demand' is more restrictive, encompassing only the first three of these components, thereby representing only newly added VMT within a region" (p. 470). Based on their empirical findings, the authors found that modeling results were "consistent with theory and much of the empirical literature to date. Notably, a strong short-term travel induced demand effect was uncovered from the 22 years of county-level California data: from the elasticity estimate, every 10 per cent increase in lane-mile capacity was associated with a 5.9 per cent increase in VMT, controlling for other factors including the simultaneous influences of road supply and demand. However, the results also reveal a significant induced-investment effect, with lane-mile additions significantly explained by VMT: a 10 per cent increase in VMT was associated with a 3.3 per cent increase in lane-mile additions, all else being equal and simultaneous influences accounted for. Thus, 'induced demand' effects were found to be stronger than 'induced investment' effects, although not overwhelmingly so. Regarding the polarized debate that swirls around induced travel demand, as often is the case with ideological differences, there is some truth in both sides of the argument. That is, California experiences suggest that <u>road investments induce travel demand</u> and traffic growth induces road investments. The former dynamic appears to be stronger than the latter; however, both sets of relationships are statistically significant" (emphasis added) (pp 478-481).

In Environmental Council of Sacramento v. California Department of Transportation, Case No. 07CS00967 (July 15, 2008) (<u>Attachment D</u>), in a case involving highway improvements similar to those now being proposed, the court stated that "'[i]nduced demand is broader than a project's 'growth inducing impacts' in that a highway project's 'growth inducing impacts' may contribute to 'induced demand,' but 'induced demand' also may occur even if the project will not have an 'growth inducing impacts'" (Minute Order, p. 9). As noted in the court record "Will Kempton" (Caltrans Director) was expressly named in the suit (e.g., "A peremptory of writ of mandate directed to Respondents California Department 12 of Transportation and Director <u>Will Kempton</u> shall issue under seal of this Court, ordering Respondents to do all of the following: (a) Within 30 days from service of this writ of mandate, Respondents shall vacate and set aside the June 21, 2007, certification of the Final Environmental Impact Report. . .(b) Respondents shall not reapprove the Project unless and until Respondents have certified an environmental impact report that complies with CEQA and the CEQA Guidelines, and otherwise complied with CEQA," emphasis added, p. 2). Since that same "Will Kempton" is now the OCTA's Chief Executive Officer, clearly the OCTA was intimately familiar with the case, the court's admonishment, and the requirements for a legally adequate CEQA document. Since the issues and defects raised in the above case are directly applicable to the proposed actions and its CEQA compliance obligations, each of the assertions and allegations raised by the Environmental Council of Sacramento, as presented therein, are incorporated herein by reference.

As specified in CEQ's "Memorandum to Heads of Agencies on the Application of the National Environmental Policy Act to Proposed Federal Actions in the United States with Transboundary Effects" (Council on Environmental Quality, Chair, July 1, 1997) (CEQ Memorandum): "Neither NEPA nor the Council on Environmental Quality's regulations implementing the procedural provisions of NEPA define agencies' obligations to analyze effects of actions by administrative boundaries. Rather, the entire body of NEPA law directs federal agencies to analyze the effects of proposed actions to the extent they are reasonably foreseeable consequences of the proposed action, regardless of where those impacts might occur. Agencies must analyze indirect effects, which are caused by the action, are later in time or farther removed in distance, but are still reasonably foreseeable, including growth-inducing effects and related effects on the ecosystem, as well as cumulative effects" (pp. 3-4).

Despite the Department's claim that the proposed action will decrease congestion, there exists substantial evidence that the proposed improvements will actually increase the number of vehicles (as measured, indirectly, by increased total VMT), thus increasing congestion. As indicated in Tables 3.1.6-3 (I-405 Mainline Estimated Daily Vehicle Miles of Travel) and 3.2.6-4 (Vehicle Miles Traveled) in the DEIR/S, increased daily VMT attributable to each of the three build alternatives is presented in Table 6 (I-405 Mainline Estimated Daily Vehicle Miles of Travel). From this, it becomes evident that the proposed action does not get motorists out of their vehicles and onto public transportation. In fact, the proposed action would appears to have the oppose affect. Similarly, because each of the three build alternatives increase VMT over the No Build Alternative, the DEIR/S own evidence (e.g., total VMT is not the same under the No Build Alternative and the three build alternatives under both 2020 and 2040 conditions), as summarized in Table 7 (Induced Travel Demand in Increased Vehicle Miles Traveled), demonstrates that the proposed action both diverts traffic and induces travel demand (e.g., growth inducing).

Table 6
I-405 Mainline Estimated Daily Vehicle Miles of Travel

Segment	2009	2020				2040			
		No Build	Alt 1	Alt 2	Alt 3	No Build	Alt 1	Alt 2	Alt 3
SR-73 to Brookhurst	1,053,000	1,142,000	1,225,000	1,283,000	1,314,000	1,204,000	1,341,000	1,437,000	1,492,000
Brookhurst to SR-22 East	1,796,000	1,929,000	2,069,000	2,167,000	2,195,000	2,013,000	2,244,000	2,405,000	2,460,000
SR-22 East to I-605	1,214,000	1,325,000	1,420,000	1,486,000	1,492,000	1,401,000	1,558,000	1,670,000	1,679,000
Total	4,063,000	4,396,000	4,714,000	4,936,000	5,001,000	4,618,000	5,143,000	5,512,000	5,631,000

Source: California Department of Transportation, Draft Environmental Impact Report/Environmental Impact Statement – San Diego Freeway Improvement Project, Orange and Los Angeles Counties, California, SCH #2009091001, Table 3.1.6-3 (I-405 Mainline Estimated Daily Vehicle Miles of Travel), p. 3.1.6-22)

Table 7
Induced Travel Demand in Increased Vehicle Miles Traveled

Total	4,063,000	4,396,000	4,714,000	4,936,000	5,001,000	4,618,000	5,143,000	5,512,000	5,631,000
Induced Demand			+318,000	+540,000	+605,000		+525,000	+894,000	+1,013,000

Source: California Department of Transportation, Draft Environmental Impact Report/Environmental Impact Statement – San Diego Freeway Improvement Project, Orange and Los Angeles Counties, California, SCH #2009091001, Table 3.1.6-3 (I-405 Mainline Estimated Daily Vehicle Miles of Travel), p. 3.1.6-22)

As indicated therein, when compared to the No Build Alternative, Alternative 1 will add 525,000 VMT, Alternative 2 will add 894,000 VMT, and Alternative 3 will add 1,013,000 VMT. As indicated in the PSR, with regards to automobile accidents and severity, the "average rate Statewide," as measured per million vehicle miles, is reported to be "0.006 fatal," "0.38 fatal plus injury," and "1.24 total" (Table 4, p. 17). Based on a projected daily increase of 1,013,000 vehicle miles, undisclosed is the projection that the three build alternatives will produce an estimated 2.2 annual fatalities, 140.6 annual fatalities plus injuries, and 458.8 annual accidents.

Although representing a large projected increase in total vehicle miles traveled, the estimates appear unrealistically low in light of the USEPA's projection that between 2007 and 2030, VMT will increase by 45.6 percent within the Los Angeles-Riverside-Orange Metropolitan Statistical Area (MSA) (http://www.epa.gov/ttn/naaqs/ozone/areas/vmt/vmtcagf.htm). The reasons for any substantial deviation should be fully explained.

As indicated by the FHWA's "Multi-Pollutant Emissions Benefits of Transportation Strategies, Final Report" (November 14, 2006): "Transportation is a major source of air pollutant emissions. Nationally, on-road transportation sources are responsible for 27 percent of VOCs [volatile organic compounds] emissions, 35 percent of NOx [nitrogen oxides] emissions, and 55 percent of CO [carbon monoxide] emissions" (p. 1-1). The FHWA further noted:

> Strategies that reduce vehicle miles traveled (assuming no other effects) will reduce emissions of all pollutants. Each mile that a vehicle travels, it emits more pollution, so reducing vehicle travel mileage will reduce emissions of all seven gases [CO, particulate matter (PM_{10} and $PM_{2.5}$), NO_X, VOCs, sulfur oxides (SO_X), and ammonia (NH_3)]. However, in conducting emissions analysis, it is important to examine not only the reduction in vehicle miles traveled (VMT), but also the reduction in the number of vehicle trips. During the first portion of a vehicle trip, when the vehicle engine starts cold, the vehicle emits some pollutants at a much higher rate than during the remainder of the trip, since emissions control technology does not operate as efficiently as when the vehicle is warm. Some strategies reduce VMT by shortening vehicle trip lengths but do not reduce the number of vehicle trips. For instance, development of a park-and-ride lot may reduce VMT by encouraging carpools, but the park-and-ride lot generally does not reduce vehicle cold starts, only running emissions, since individuals must drive to the lot in the morning. On the other hand, most bicycle/pedestrian projects reduce vehicle trips entirely, and will eliminate both cold start and running emissions. Consequently, VMT-reducing strategies may result in different percentage reductions in different pollutants, depending on whether or not vehicle trip cold starts are reduced (p. 2-1).

The proposed action produces the "double whammy" of both increasing VMT and, by promoting SOVs, increasing the number of total vehicle trips. In addition, the projected increase of VMT under each of the three build alternatives results in increased consumption of gasoline and other petroleum products. As reported in the USEPA's "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2010" (April 15, 2012), the USEPA conclude:

> The transportation end-use sector accounted for 1,772.5 Tg CO_2 Eq. [teragrams of CO_2 equivalent] in 2010, which represented 33 percent of CO_2 emissions, 23 percent of CH_4 emissions, and 48 percent of N_2O emissions from fossil fuel combustion, respectively. . .Among domestic transportation sources, light duty vehicles (including passenger cars and light-duty trucks) represented 61 percent of CO_2 emissions, medium-and heavy-duty trucks 22 percent, commercial aircraft 7 percent, and other sources 10 percent. Passenger car CO_2 emissions increased by 20 percent from 1990 to 2010, light-duty truck. . . From 1990 to 2010, transportation emissions rose by 19 percent due, in large part, to increased demand for travel and the stagnation of fuel efficiency across the U.S. vehicle fleet. The number of vehicle miles traveled by light-duty motor vehicles (passenger cars and light-duty trucks) increased 34 percent from 1990 to 2010, as a result of a confluence of factors including population growth, economic growth, urban sprawl, and low fuel prices over much of this period. . .

> Almost all of the energy consumed for transportation was supplied by petroleum-based products, with more than half being related to gasoline consumption in automobiles and other highway vehicles. Other fuel uses, especially diesel fuel for freight trucks and jet fuel for aircraft, accounted for the remainder. The primary driver of transportation-related emissions was CO_2 from fossil fuel combustion, which increased by 20 percent from 1990 to 2010 (p. 3-13).

As indicated in the DEIR/S, "all three build alternatives would result in increased energy usage" (p. 3.2.8-9). Specifically: (1) "Alternative 1 would result in the annual consumption of approximately 167,069 barrels more crude oil than the No Build Alternative" (p. 3.2.8-5); (2) "Alternative 2 would result in the consumption of approximately 284,212 barrels more crude oil than the No Build Alternative" (p. 3.2.8-6); and (3) "Alternative 3 would result in the consumption of approximately 322,589 barrels more crude oil than the No Build Alternative" (p. 3.2.8-6).

The DEIR/S further states: (1) "The future amount of crude oil use associated with the construction and maintenance of Alternative 1 is estimated to be approximately 15.05 million barrels. Compared to the No Build Alternative, there would be no indirect energy savings. This demand would be partially offset by long-term per-vehicle energy savings in the corridor due to improved traffic flows under Alternative 1" (p. 3.2.8-8); (2) "The future crude oil consumption for Alternative 2 is estimated to be approximately 16.12 million barrels. Compared to the No Build Alternative, there would be no indirect energy savings. This demand would be partially offset by long-term per-vehicle energy savings in the corridor due to improved traffic flows under Alternative 2." (p. 3.2.8-8); and (3) "The future crude oil consumption for Alternative 3 is estimated to be approximately 16.45 million barrels. The overall energy consumption for Alternative 3 would be the highest of all three build alternatives. Compared to the No Build Alternative, there would be no indirect energy savings. This demand would be partially offset by long-term per-vehicle energy savings in the corridor due to improved traffic flows under Alternative 3" (p. 3.2.8-8).

By even inferring the unproven existence of "long-term per-vehicle energy savings," the Lead Agency seeks to skew the more salient point that, under all build alternatives, a substantial increase in "future crude oil consumption" will occur and, with it, a corresponding increase in GHG emissions. Similarly, with the exception of the limited increase in the total number of vehicles utilizing the HOV/HOT lanes, "improved traffic flow" is a myth. Under all scenarios and both pre-project and post-project conditions, LOS "F" conditions will remain in all GP lanes during peak-hour periods.

4.0 I-405 IMPROVEMENT PROJECT

As indicated in Caltrans' RCR, "Interstate 405 (I-405) also known as the San Diego Freeway has 24.18 miles located in Orange County and 48.2 miles located in Los Angeles County" (RCR, Summary). In contrast, the DEIR/S states that "[t]he San Diego Freeway (I-405) is generally a north-south route with 24 miles in Orange County and 48 miles in Los Angeles County" (p. 2-1). As such, it is unclear as to the precise and level of accuracy with which the DEIR/S analyzes or describes the proposed action and its potential environmental effects.

As indicated in the NOI, "The proposed project covers approximately 14 miles" (p. 2). Similarly, the DEIR/S notes that the "entire" length of the "express lanes" is only 14 miles (e.g., "It is anticipated that toll amounts to use the entire 14 miles of the proposed I-405 Express Lanes from SR-73 to I-605 would be similar," p. 2-20). Also, the Traffic Study states that "[t]he proposed project covers a distance of approximately 14 miles along I-405 between SR-73 and I-605" (p. 1-3). In an apparent contradiction, the DEIR/S states that the project covers "approximately 16 miles" (pp. title page and 1-23). In further contradiction, the AQR described the project as either consisting of a "15-mile corridor length" (AQR, p. 51) or "cover[ing] a distance of approximately 14 miles" (AQR, PM Conformity HOT Spot Analysis, August 1, 2007, unpaginated). Although not a large distinction, these glaring difference regarding a fundamental aspect of the proposed action points to a lack of internal inconsistency with regards to the manner in which the project is described and suggests the existence of an inconsistency in which the project is analyzed.

Of more significance, however, is the possible misrepresentation of the three build alternatives. For example, as indicated in correspondence from Will Kempton, OCTA's Chief Executive Officer to OCTA's Regional Planning and Highway Committee (Subject: Update on the Interstate 405 Improvement Project Alternatives, Business Models, and Delivery Option), dated April 16, 2012, the CEO noted that "Alternative 3 is approximately two miles longer than the other two alternatives" (p. 2). That difference is neither identified nor analyzed in the DEIR/S. From all these conflicting statements, it is not possible to accurately determine the length of any of the three build alternatives.

In addition, internal inconsistencies have been identified throughout the DEIR/S. For example, the AQR states that "Alternative 1 is fully funded and is in the 2008 Regional Transportation Plan" (p. 73). Conversely, the DEIR/S notes that "[f]ull funding has not been identified for any of the proposed build alternatives and remains an <u>unresolved issue</u>" (emphasis added) (p. S-39).

As stipulated under Section 15123(b) of the State CEQA Guidelines, EIRs must include "[a]reas of controversy known to the lead agency including issues raised by agencies and the public" and "[i]ssues to be resolved including the choice among alternatives and whether or how to mitigate the significant effects." Since neither Caltrans nor the OCTA have presented a viable financing structure demonstrating the feasibility of any of the three build alternatives (thus allowing for public discussion and debate) and/or demonstrating the ability of either agency to effectuate any of the build alternatives or fund the "efforts" and/or "measures" identified therein, the Lead Agency has presented a legally inadequate CEQA analysis.

4.1 Orange County Transportation Authority Measure M/M2

As indicated in the DEIR/S: "A large portion of the funding for the proposed project is included in Orange County's Renewed Measure M transportation sales tax initiative (countywide half-cent sales tax) funding program. The Renewed Measure M (Measure M2) Program was authorized by Orange County voters in November 2006, and it began in 2011. The Measure M2 Program allocates sales tax revenues to specific Orange County, transportation improvement projects in three major areas – freeways, street, and roads, and transit. The Measure M2 Program, which is a 30-year $11.8 billion investment program designed to improve Orange County transportation, contains language that commits funding for improvements to the I-405 corridor and requires any arterial overcrossing replacements associated with widening I-405 to meet OCTA's "Master Plan of Arterial Highways" (MPAH) standards. Project K [San Diego Freeway (I-405) Improvements between the I-605 Freeway in Los Alamitos area and Costa Mesa Freeway (SR-55)] in Attachment A of the ordinance establishing the Measure M2 Program provides for improvements on I-405 that would "add new lanes to the San Diego Freeway [I-405] between I-605 and SR-55, generally within the existing right-of-way. The project will make best use of available freeway property, update interchanges and widen all local overcrossings according to city and regional master plans" (p. 1-17 and 18).

4.1.1 Measure M

As indicated in the "Orange County Local Transportation Authority Ordinance No. 2" (Amended September 23, 1991, November 25, 1991, May 23, 1994, May 13, 1996, June 9, 1997, December 10, 2001, September 13, 2004), as signed on August 2, 1990: "The purpose of this measure is to <u>improve the quality of life</u>, relieve traffic congestion, and <u>improve air quality</u> in Orange County" (emphasis added) (p. 9). Absent from the DEIR/S is any indication that the "purpose" of the proposed action includes improving the "quality of life" and "air quality." Why was that stated purpose not explicitly included in the project description?

As specified therein, the "Ordinance No. 2" stipulates that the OCTA shall accomplish that stated purpose by, among other things, "[e]xpanding the present Los Angeles to San Diego commuter rail service throughout Orange County," by "[i]ncreasing transit service and providing discount fares for senior citizens and the disabled," and by "[r]equiring that any proposed change in the amount of funds for rail transit, freeway, regional and local street improvement expenditures be brought back to the voters for their approval" (p. 10). How does imposing a toll on freeway use reduce transportation costs for senior citizens and the disabled? Based on that language, does the Lead Agency concede that any expenditure about the "$500 million dollars" specified therein requires voters' consent?

Included in "Ordinance No. 2" was the "Orange County Division, League of California Cities Countywide Traffic Improvement and Growth Management Program: Countywide Growth Management Plan Component" (Revised June 15, 1989, Amended September 23, 1991, Amended May 23, 1994). As stipulated therein, "[t]he goals of the Traffic Improvement and Growth Management Program shall be to: [1] Outline each agency's plans and efforts to develop multi-jurisdictional traffic solutions through well-defined cooperative planning process; [2] Specify traffic level of service standards; [3] Promote alternative forms of transportation and overall system efficiency by maximizing use of the existing transportation network through Transportation Demand Management (TDM); [4] Provide funding for construction and maintenance of street, road and highway facilities; [5] Require a locally collected and administered traffic mitigation fee to guarantee that new development pays its fair share toward dealing with traffic generated by the new development; [6] Foster a better balance of jobs and housing and attempt to reduce the length of commuter trips through careful planning; [7] Provide that local jurisdictions, where applicable, establish performance standards for fire, police, library, flood control, and other infrastructure services based on local criteria; [8] Require the phasing of new development to insure that service level goals are achieved; [9] Envisions the creation of a deficient intersections program to promote funding matches between local fees and proceeds from the sales tax corrected deficiencies."

How does the Lead Agency's designation of the project "corridor" and failure to consider the adjoining segment of the I-405 Freeway in Los Angeles County fulfill the goal of promoting "multi-jurisdictional traffic solutions"? How does the DEIR/S failure to consider any performance-based alternatives allow specificity of "traffic level of service standards"? How does the Lead Agency's rejection of the "TSM/TDM/Mass Transit Alternative" serve to "promote alternative forms of transportation"?

With the exception of "Santa Ana Freeway Improvements for the San Diego Freeway (I-405) to the Los Angeles County Line," "San Diego Freeway (I-5) from the I-5/I-405 Confluence to San Clemente," and "I-4/I-405 Interchange," the proposed action does not appear to be a part of the "Orange County Freeway Project Descriptions" presented in Measure M. Excluding reference to any subsequent inclusion in Measure M2, where in Measure M is the "I-405 Improvement Project" identified and described?

4.1.2 Measure M2

As indicated in the OCTA's "Renewed Measure M Transportation Investment Plan," accompanying OCTA's "Ordinance No. 3," as adopted on July 24, 2006: "The Ordinance is not intended to modify, repeal or alter the provisions of Ordinance No. 1, and shall not be read to supersede Ordinance No. 2. The provisions of the Ordinance shall apply solely to the transactions and use tax adopted herein" (p. 8). The following description of "Project K (San Diego Freeway [I-405] Improvements between the I-605 Freeway in Los Alamitos area and Costa Mesa Freeway [SR-55])" was provided therein:

> Add new lanes to the San Diego Freeway between I-605 and SR-55, generally within the existing right-of-way. The project will make best use of available freeway property, update interchanges and widen all local overcrossings according to city and regional plans. The improvements will be coordinated with other planned I-405 improvements in the I-405/SR-22/I-605 interchange area to the north and the I-405/SR-73 improvements to the south. The improvements shall adhere to recommendations of the Interstate 405 Major Investment Study (as adopted by the Orange County Transportation Authority Board on October 14, 2005) and will be developed in cooperation with local jurisdictions and affected communities. Today, I-405 carries about 430,000 vehicles daily. The volume is expected to increase by nearly 23 percent, bringing it up to 528,000 vehicles daily by 2030. The project will increase freeway capacity and reduce congestion. Near-term regional plans also include the improvements to the I-405/SR-73 interchange as well as a new carpool interchange at Bear Street using federal and state funds. The estimated cost for these improvements to the I-405 is $500.0 million (emphasis added) (p. 13).
>
> Freeway Projects will be built largely within existing rights of way using the latest highway design and safety requirements. However, to the greatest extent possible within available budget, Freeway Projects shall be implemented using Context Sensitive Design, as described in the nationally recognized Federal Highway Administration (FHWA) Principles of Context Sensitive Design. Freeway projects will also be planned, designed and constructed with consideration for their aesthetic, historic and environmental impacts on nearby properties and communities using such elements as parkway style designs, locally native landscaping, sound reduction and aesthetic treatments that complement the surroundings. . .At least five percent (5%) of the Net Revenues allocated for Freeway Projects shall fund Programmatic Mitigation for Freeway Projects (emphasis added) (p. 4-5).

Ordinance 3 further noted that "Freeway Projects will be planned, designed and constructed using a flexible community-responsive and collaborative approach to balance aesthetics, historic and environmental values with transportation safety, mobility, maintenance and performance goals" (p. B-5). Absent from the DEIR/S are any statements of OCTA's adherence to the recommendations of the "Interstate 405 Major Investment Study," evidence of receptivity to Seal Beach's expressed concerns, or funding commitments to environmental mitigation within the City. Although "Alternative 4 is a lower-cost option to provide localized improvements within the I-405 corridor that could be fully funded and implemented with available revenue from Orange County's Renewed Measure M transportation sales tax initiative" (p. 2-28), absent from the DEIR/S is the analysis of any alternative designed "within [the] available budget."

What is "Context Specific Design" and how would the principles exposed therein relate to the planned relocation of the existing soundwalls along Almond Avenue? What is mean by "designed and constructed with consideration for their aesthetic, historic and environmental impacts on nearby properties and communities" in the proposed relocation of the existing soundwalls along Almond Avenue? How does the Lead Agency's self-imposed "independent utility and logical termini," excluding consideration of those freeway segments located to the north and south of the proposed action, conform to the mandate that "improvements will be coordinated with other planned I-405 improvements in the I-405/SR-22/I-605 interchange area to the north and the I-405/SR-73 improvements to the south"?

Measure R was approved by Los Angeles County voters in November 2008 and increased sales taxes in Los Angeles County by one-half cent for 30 years in order to fund transportation projects and improvements. The ballot measure created the "Traffic Relief and Rail Expansion Ordinance" (effective January 2, 2009) (http://www.metro.net/measurer/images/ordinance.pdf) which included an expenditure plan, defined specific projects for funding, established a timeframe for the availability of funds, and expected level of funding.

Absent from the DEIR/S is any reference to or discussion of the Gateway Cities Council of Governments' "I-605 Congestion 'Hot Spots' Feasibility Analysis," as funded under Los Angeles County Measure R. That study is analyzing congestion improvement alternatives for various "hot spots" along the I-605, SR-91, I-405 and I-105 Freeways in Los Angeles County, as well as the surrounding arterial street network and includes improvements to freeway-to-freeway interchanges, additional freeway GP lanes, and arterial street improvements. How is the Lead Agency's failure to even identify the existence of that study and that ordinance consistent with Measure M2's requirement that freeway improvements be coordinated?

To the extent that Caltrans and/or the OCTA assert that the project is publicly mandated (as a result of the passage of Measures M/M2), then, at a minimum, the Lead Agency must: (1) define the project's P&N and objectives as the fulfillment of that mandate; (2) include "Project K" as one of the alternatives examined in detail in the DEIR/S; and (3) identify "Project K" as the "preferred" alternative. The fact that none of those actions in fact occurred negates any assertion of alleged connectivity between the proposed action and the voters' directive. By defining the proposed action's P&N and objective as something other than the voters' directive and by subsequently eliminating "Project K" (i.e., Alternative 4) because it "would not meet the project purpose and was eliminated from further consideration" (p. 2-4) appear to suggest that a State bureaucracy believes that it is not bound by the majority of the will of the County's voters.

Numerous City's residents have stated that the introduction of HOT lanes along the I-405 Freeway is inconsistent with the provisions of Measures M/M2. While Ordinance Nos. 2 and 3 include extensive references to "freeways," there is not a single reference to "toll" roads, to "HOT lanes," or to "express lanes." The City has reviewed those ordinances and concurs that no such references exist therein. Is the Lead Agency asserting that "HOT lanes" and/or "express lanes" are either explicitly or implicitly authorized thereunder and that Measures M/M2 funds can be used for the development of any form of pay-for-use roadway system?

4.2 Department-Specified Purpose and Need

Although purportedly the basis for the initiation of improvements to the I-405 Freeway, absent from the Lead Agency's declared P&N is any reference to Measures M/M2.

As indicated in FHWA's "NEPA and Transportation Decisionmaking – The Importance of Purpose and Need in Environmental Documents" (September 18, 1990): "The purpose and need section is in many ways the most important chapter of an environmental impact statement (EIS). It establishes why the agency is proposing to spend large amounts of taxpayers' money while at the same time causing significant environmental impacts. A clear, well-justified purpose and need section explains to the public and decision makers that the expenditure of funds is necessary and worthwhile and that the priority the project is being given relative to other needed highway projects is warranted. In addition, although significant environmental impacts are expected to be caused by the project, the purpose and need section should justify why impacts are acceptable based on the project's importance. As importantly, the project purpose and need drives the process for alternatives consideration, in-depth analysis, and ultimate selection. The Council on Environmental Quality (CEQ) regulations require that the EIS address the 'no-action' alternative and 'rigorously explore and objectively evaluate all reasonable alternatives'" (emphasis added).

On May 12, 2003, the CEQ issued a guidance letter to The Honorable Norman Y. Mineta, Secretary of the Department of Transportation concerning the role that the P&N plays in the context of compliance with CEQ's regulations under NEPA. As indicated therein: "The requirement for a discussion of 'purpose and need' in an environmental impact statement under the CEQ regulations is to 'briefly specify the underlying purpose and need to which the agency is responding in proposing the alternatives including the proposed action' (40 C.F.R. §1502.13). This discussion is important for general context and understanding as well as to provide the framework in which 'reasonable alternatives' to the proposed action will be identified. The lead agency - the federal agency proposing to take an action - has the authority for and responsibility to define the 'purpose and need' for purposes of NEPA analysis. This is consistent with the lead agency's responsibilities throughout the NEPA process for the 'scope, objectivity, and content of the entire statement or of any other responsibility' under NEPA" (p. 1).

With regards to CEQA, a project description shall include a "statement of objectives sought by the proposed project. A clearly written statement of objectives will help the lead agency develop a reasonable range of alternatives to evaluate in the EIR. . .The statement of objectives should include the underlying purpose of the project" (14 CCR 15124[b]).

Section 6002 of SAFETEA-LU established an "environmental review process" that is required to be followed for all environmental impact statements prepared for highway or transit projects that require approval of the USDOT. The FHWA's and the FTA's SAFETEA-LU Guidance contains detailed guidance regarding implementation of Section 6002. As defined therein, the term "transportation project" means any highway project, any public transportation capital project, and any multi-modal project that requires an approval from FHWA or FTA. As indicated in the DEIR/S: "Authority to operate a toll facility on the Interstate Highway System would be required from FHWA" (p. 1-19). In addition, as specified under Section 6002(f) therein, "[t]he statement of purpose and need shall include a clear statement of the objectives that the proposed action is intended to achieve, which may include - (A) achieving a transportation objective identified in an applicable statewide or metropolitan transportation plan; (B) supporting land use, economic development, or growth objectives established in applicable Federal, State, local, or tribal plans;

and (C) serving national defense, national security, or other national objectives, as established in Federal laws, plans, or policies."

As indicated in the NOI, "Caltrans, as the delegated National Environmental Policy Act (NEPA) agency, in cooperation with the Orange County Transportation Authority (OCTA), will prepare an environmental impact statement (EIS) on a proposal for a highway improvement project in Orange County, California" (p. 2) and "[t]he purpose of the project, as currently defined, is to increase capacity, improve traffic and interchange operations, and enhance safety on 1-405 between SR-73 and 1-605" (pp. 2-3). As indicated in the NOP, Caltrans "will act as the lead agency and will prepare an environmental impact report [EIR] for the project" and "Caltrans, in cooperation with the OCTA, proposes to increase capacity, improve traffic and interchange operations, and enhance safety by widening the segment of the I-405 from SR-73 to I-605" (p. 1). The "Public Scoping Notice" states that "Caltrans is the California Environmental Quality Act (CEQA) and the National Environmental Policy Act (NEPA) Lead Agency and the OCTA is the Funding Agency and a Responsible Agency under CEQA" (p. 1).

From those notices, it would appear that the purpose of the project is consistently defined and that the resulting DEIR/S would consistently replicate that purpose. However, as indicated in the DEIR/S, the Department subsequently states that "[t]he project purpose is a set of objectives the project is intended to meet. The project need is the range of transportation deficiencies that the project was initiated to address. The purpose of the proposed action is to: [1] Reduce congestion; [2] Enhance operations; [3] Increase mobility, improve trip reliability, maximize throughput, and optimize operations; and [4] Minimize environmental impacts and right-of-way acquisition. In furtherance of the project's purpose, the following objective is then established by the Lead Agency: "To be consistent with regional plans and find a cost-effective early project solution for delivery" (p. S-1). Absent from the DEIR/S' list of project purposes and objectives is any reference to "increase capacity, improve traffic and interchange operations, and enhance safety." For some inexplicable reason, the purpose and objectives of the proposed action, as described in the Department's scoping documents, are substantially different from the purpose and objectives of the proposed action described in the DEIR/S (indicating a lack of continuity and consistency between the NOP/NOI and DEIR/S).

The P&N statement presented in the DEIR/S neither identifies the need for a specific funding source nor limited the range of design and development alternatives that could be formulated by the Department in response thereto (e.g., cost and other financial considerations are not included in the P&N). Similarly, absent from the P&N is any reference to Measure M/M2 and/or the representations that were make to the County's voters at the time of there passage.

As indicated in the Lead Agency's technical studies, the proposed action's purpose and objectives further differ from those presented in either the NOP/NOI and DEIR/S. For example, a similar but not totally consistent purpose statement is present in the "Traffic Study – San Diego Freeway (I-405) Improvement Project SR-73 to I-605, Orange and Los Angeles Counties" (Caltrans, May 2011). As stated therein, "[t]he purpose of the project is to <u>add capacity and reduce congestion on the general purpose and High Occupancy Vehicle (HOV) lanes</u> along the entire I-405 corridor from SR-73 to I-605; enhance interchange operations; increase mobility, improve trip reliability, maximize throughput, and optimize operations; and enhance safety, all while minimizing right-of-way (ROW) acquisition <u>and ensuring the financial viability of proposed improvements</u>" (emphasis added) (p. 1-1).

In contrast, the CIA states that "[t]he purpose of the proposed action is to: [1] Add capacity and reduce congestion on the General Purpose (GP) and High Occupancy Vehicle (HOV) lanes along the entire I-405 corridor from SR-73 to I-605; [2] Enhance interchange operations; [3] Increase mobility, improve trip reliability, maximize throughput, and optimize operations; [4] Implement strategies that ensure the earliest project delivery; and [5] Enhance safety" (p. S-1). Also, "[t]he following objectives have been established to successfully complete the project while minimizing environmental impacts: [1] Minimize ROW acquisition; [2] Ensure financial viability; [3] Meet, at a minimum, the commitments of Orange County's Renewed Measure M transportation sales tax initiative to add capacity to the I-405 within the project area; [4] Maintain or improve future traffic performance within the corridor; and [5] Improve the corridor so as to ensure the facility is maintained as an effective link in the National Strategic Highway Network" (p. S-1 and 2).

As presented in the DEIR/S, a similar set of "purposes" and "objectives" is presented in the NSR (p. 2) and a similar "purpose" statement is presented in the "Initial Site Assessment – San Diego Freeway (I-405) Improvement Project SR-73 to I-605, Orange and Los Angeles Counties" (Caltrans, March 2011) (ISA) (p. 8).

As illustrated in Table 8 (Lack of Consistencies in the Proposed Action's Stated Purpose and Objectives), ignoring the additional substantial differences presented in the "Interstate 405 Major Investment Study, Final Report" (OCTA, February 2006) (MIS) and in the "Project Study Report/Project Development Support" (Caltrans/OCTA, July 2008) (PSR/PDS), the NOI/NOP, DEIR/S, and accompanying technical studies are inconsistent with regards to the stated "purpose" and "objectives" of the proposed action. As a result, since there exists no single set of objectives that the project seeks to accomplish, under CEQA, it is not possible to formulate a "range of reasonable alternatives to the project, or to the location of the project, which would feasibly attain most of the basic objectives of the project" (14 CCR 15126.6[a]). Instead, although entirely within the Lead Agency's control, what is presented is a "moving target" which is provided without explanation why the project's stated "purpose" and "objectives" remain constantly in flux. Presented below is a summary of the constantly changing P&N and objectives of the proposed action.

In addition, absent from the project's stated purposes and objective is any reference to "safety"; however, the DEIR/S subsequently states that "the proposed project is a transportation project within an urbanized transportation corridor designed to enhance public safety and relieve congestion" (pp. 4-4, 4-5, 4-10). As such, the DEIR/S is not even internally consistent as to what the proposed project seeks to achieve.

Assuming that "goals" and "objectives" are synonymous for the purpose of environmental compliance, in comparison, the "goals" formulated for the West County Connector (WCC), as presented in the WCC FEIR/S included: "[1] Improve mobility and reduce congestion in the SR-22/WOCC study area; [2] Maximize cost-effectiveness of the SR-22/WOCC improvements; [3] Minimize adverse and maximize beneficial environmental impacts to SR-22/WOCC communities; [4] Minimize negative and maximize positive economic impacts to SR-22/WOCC communities" (p. v). The substantive deviation among the two adjoining and interconnected projects is never explained.

Table 8
Lack of Consistencies in the Proposed Action's Stated Purpose and Objectives

	NOI/NOP	DEIR/S	Technical Studies[1]
Purpose	Increase capacity Improve traffic and interchange operations Enhance safety on 1-405 between SR-73 and 1-605	Reduce congestion Enhance operations Increase mobility, improve trip reliability, maximize throughput, and optimize operations Minimize environmental impacts and right-of-way acquisition	Add capacity and reduce congestion on the General Purpose and High Occupancy Vehicle lanes along the entire I-405 corridor from SR-73 to I-605 Enhance interchange operations Increase mobility, improve trip reliability, maximize throughput, and optimize operations Implement strategies that ensure the earliest project delivery Enhance safety
Objectives	None stated	To be consistent with regional plans and find a cost-effective early project solution for delivery	Minimize ROW acquisition Ensure financial viability Meet, at a minimum, the commitments of Orange County's Renewed Measure M transportation sales tax initiative to add capacity to the I-405 within the project area Maintain or improve future traffic performance within the corridor Improve the corridor so as to ensure the facility is maintained as an effective link in the National Strategic Highway Network

Footnotes:
1. California Department of Transportation and Parsons, Visual Impact Assessment – San Diego Freeway (I-405) Improvement Project SR-73 to I-605, Orange and Los Angeles Counties, May 2011, p. 3.

Source: City of Seal Beach

In defining meaning, the court (California Oak Foundation v. Regents of the University of California [2010]) stated that "[t]he primary goal in interpreting any statute is to 'determine the Legislature's intent so as to effectuate the law's purpose' [Citation]. To this end, we 'give meaning to every word and phrase in the statute to accomplish a result consistent with the legislative purpose, i.e., the object to be achieved and the evil to be prevented by the legislation' [Citation]. If the statutory language is clear, we follow its plain meaning so long as an absurd or unintended consequence does not result [Citation]" (emphasis added). A plain reading of the Lead Agency's objective indicates that the "objective to be achieved" is consistency with regional plans and that the "evils to be prevented" are cost inefficiencies and delayed implementation.

If so defined, by failing to present a factual analysis of the proposed action's consistency with regional plans (e.g., Southern California Association of Governments, 2012-2035 Regional Transportation Plan/Sustainable Communities Strategy, April 4, 2012), the Lead Agency has not provided its decision makers and other stakeholders with sufficient information to demonstrate compliance. By pursuing an implementation plan far in excess of available funding (e.g., "[f]ull funding has not been identified for any of the proposed build alternatives and remains an unresolved issue," p. S-39) rather than focusing on improvements that could be built for the currently available funding (e.g., "Alternative 4 proposed to provide localized improvements within the I-405 corridor that could be fully funded and implemented with available revenue from Orange County's Renewed Measure M transportation sales tax initiative," pp. 2-3 and 4), the Lead Agency has pursued a path that prevents attainment of its own self-described objective (i.e., "early project solution for delivery).

It is noted that “Alternative 4,” as referenced above, is not the same project as “MIS Alternative 4” identified in the MIS [405 Major Investment Study, Final Report] and purportedly carried forward by the Lead Agency as “Alternative 1” in the DEIR/S (e.g., “Only one build alternative, Alternative 1, which was MIS Alternative 4, has been retained as a viable alternative and is fully evaluated in this document,” p. 2-3).

Because the Lead Agency concludes that new “Alternative 4 would neither provide additional capacity along the entire corridor nor enhance interchange operations,” it would thus “not meet the project purpose and was eliminated from further consideration in this Draft EIR/EIS” (p. 2-4). Since it is the single objective of the proposed action “[t]o be consistent with regional plans and find a cost-effective early solution for delivery” (p. S-1), it is evident that the proposed actions and stated objective are misaligned and that the environmental analysis has been artificially manipulated toward another predetermined outcome.

Alternatively, since “consistency” (or conformity) with regional plans constitutes a pre-existing obligation for the commitment of Federal funds (e.g., 40 C.F.R. 93.104[d], 40 C.F.R. 93.109), to paraphrase the DEIR/S, the Lead Agency’s sole objective is to “pursue the implementation of the proposed action or pursue the implementation of the proposed action faster.”

Referencing SCAG’s 2012 RTP/SCS: “A successful RTP creates opportunities for business, investment, and employment in Southern California. This plan does so by proposing over $500 billion of investment in the next 25 years” (p. 12).

Recognizing that these are austere economic times, it must be realistically assumed that the identified level of investment is unattainable. In order to assist in prioritization, the 2012 RTP/SCS contain key “guiding policies,” including: (1) “Policy 1: Transportation investments shall be based on SCAG’s adopted regional performance indicators”; (2) “Policy 4: Transportation demand management (TDM) and non-motorized transportation will be focus areas, subject to Policy 1”; and (3) “Policy 5: HOV gap closures that significantly increase transit and rideshare usage will be supported and encouraged, subject to Policy 1” (p. 15). Identified performance outcomes include: (1) “Maximize <u>mobility and accessibility</u> for all people and goods in the region”; (2) “Preserve and ensure a sustainable regional transportation system”; (3) “Actively encourage and create incentives for energy efficiency, where possible”; and (4) “Encourage land use and growth patterns that facilitate transit and non-motorized transportation” (emphasis added) (p. 15). The proposed action fulfills none of these guiding policies and does not promote the achievement of any of those performance outcomes. As such, in the larger policy framework, the proposed action cannot be found consistent with the 2012 RTP/SCS.

As indicated in the California Transportation Commission’s (CTC) “Statewide Transportation Needs Assessment, Final Report” (November 2011) (CTC Needs Assessment), Statewide, “[t]he total estimated revenue from all sources during the ten-year study period is $242.4 billion. This represents about 45 percent of the overall estimated costs of projects and programs that were identified in the needs analysis, and leads to a shortfall of about $295.7 billion over the ten-year period. If it is assumed that revenues for preservation (rehabilitation and maintenance) are provided at historical levels (43.4%), then the amount of revenue available for system expansion and system management projects during this period is $94.7 billion, or only about 48 percent of the estimated costs of needed projects” (p. 1-2). As evidence by those figures, the State is in desperate need for supplemental transportation funds and/or belt tightening.

The OCTA has already tipped its hand with regards to its predetermination of the CEQA and NEPA processes ultimate outcome. As indicated in correspondence from Arthur T. Leahy, OCTA's CEO to OCTA's Highway Committee (Subject: Consideration of the San Diego Freeway Improvement Project for Future High-Occupancy Toll Land and Design-Build Authority), dated January 19, 2009, the CEO stated: (1) "The current estimated cost from the project study report to add one or two general purpose lanes ranges from $1.1 billion to $1.85 billion, but only $500 million is available in Renewed Measure M for this project. Implementing a HOT lane system on Interstate 405 would generate additional revenues to help fund these improvements and facilitate an early implementation of a more comprehensive traffic congestion relief project in the corridor" (emphasis added) (p. 3); and (2) "OCTA is ready to compete with other counties to implement HOT lanes as a public-private partnership project using design-build and to compete for anticipated federal economic stimulus funding" (p. 4). As such, based on the disparity between projected costs and available funding, only a revenue-generating alternative will be deemed feasible.

In addition, the "Draft Transportation Management Plan" (Caltrans/OCTA, August 2011) (Draft TDM), as included in Appendix D of the CIA, states that "[t]he construction of this project is expected to take approximately 54 months" (Draft TDM, p. 8) or five years (e.g., "The five-year construction period would begin in 2015," AQR, p. 1). Only Alternative 3 is expected to require 54 months (DEIR/S, Table S-1, p. S-19) to complete. As such, the CIA (and by extent the DEIR/S in its entirely) focuses primarily on the implementation of Alternative 3.

The DEIR/S indicates that Alternative 3 "was included in the project development process because it has revenue-generating potential and because it provides a congestion management element not present in the other build alternatives" (p. S-39). In addition, "[b]ecause of the tolling component of Alternative 3, there are additional options available to address the shortfall of Alternative 3 (e.g., a public private partnership and a TIFIA loan) that would not be available for Alternatives 1 and 2" (p. 1-18) and "[i]t is anticipated that construction of the tolled and GP lanes in each direction could be partially funded by the toll revenue anticipation bonds" (p. 2-3). As such, although no definitions are provided, it appears that the Lead Agency has artificially structured its sole objective to promote the subsequent selection of Alternative 3 in that the Lead Agency it will seek to argue that a toll-generating facility will best support a "cost-effective early project solution for delivery" (p. S-1).

In suggesting that no preferential project has yet to be identified, it is disingenuous for the DEIR/S to state that "[a]fter the public circulation period for the Draft EIR/EIS, all comments will be considered, and the Project Development Team (PDT) will select a preferred alternative" (p. 2-27). Evidence of predetermination can be found in OCTA's 2010 LRTP. Presented therein is a "list of freeway projects included in the Year 2035 Preferred Plan" (p. 74). The following project is included on that list: "Interstate 405: From the SR-73 to the San Gabriel River Freeway (I-605), provide two High Occupancy Toll (HOT) lanes in each direction, converting existing HOV lanes, and adding one new HOT lane in each direction" and "[f]rom SR-73 to the San Gabriel River Freeway (I-605), add one mixed-flow lane in each direction" (emphasis added) (p. 74). Even though the CEQA/NEPA process has yet to be completed, the proposed action (i.e., see 2010 LRTP, p. B3) has already been included in the OCTA's "detailed Year 2035 Preferred Plan Project List" with a $2.2 billion budget and a Year 2022 completion date (emphasis added) (p. B3).

As described in the DEIR/S, Alternative 3 includes "one GP lane between Euclid Street and I-605 and one tolled Express Lane in each direction between State Route 73 (SR-73) and State

Route 22 (SR-22) each of I-405 to be managed jointly as a tolled Express Facility with two lanes in each direction between SR-73 and I-605" (Abstract). Since the objective of the proposed action is be "consistent with regional plans" (p. S-1), it is now overly convenient to merely look to OCTA's recently adopted long-range plan to demonstrate consistency.

Based on that declared purpose and objective, with regards to both describing the proposed action and limiting the range of alternatives under consideration, the DEIR/S states that "[t]he project proposes to improve the mainline freeway and interchanges on I-405 in Orange and Los Angeles counties" (emphasis added) (p. S-2). The Department states that the project "proposes" certain actions not that the project's "purpose" is specific actions. Neither the stated "purpose" nor singular "objective" specify or limit the range of solutions to mainline freeway improvements, specify an increase in lane-miles, or place revenue generation above mobility and throughput. The Lead Agency nonetheless elects to limit the environmental analysis to the following "three build alternatives": "Alternative 1 – Add One GP Lane in Each Direction; Alternative 2 – Add Two GP Lanes in Each Direction; and Alternative 3 – Express Lanes (Tolled) and Add One GP Lane in Each Direction" (p. S-3). Each of those alternatives examine only mainline freeway improvements and increased lane-miles.

As previously indicated, the project's declared purpose and objective is moving target, such that at each step in the process a new set of rationale is formulated in order to artificially narrow the range of alternatives without any attempt to reflect back in time to see: (1) what criteria had been previously applied and how new alternatives might promote the attainment of those foundational objectives; or (2) how previously discounted options might fair when examined from an evolving purpose statement. For example, as indicated, in part, in the MIS: "The need for improvements in the I-405 corridor stems from the mobility problems found in the corridor. The purpose of improvements is to address those problems. Four key points were identified that represent the most significant mobility problems within the study area: (1) Demand already exceeds current capacity, resulting in significant travel delays during peak and some off-peak periods. . .(2) Diversion of traffic is taking place onto arterials because the freeway is too congested during peak periods. . .(3) Operational problems occur on the freeway, primarily because of physical bottlenecks. . .(4) The corridor has a lack of public transportation options (pp. 11-13). Thirteen conceptual alternatives were identified in the MIS and subjected to a screening process in order to identify those alternatives most responsive to those identified mobility problems and transportation needs. With regards to each of those key issues, specific evaluation measures were identified. As indicated in Table 9 (Major Investment Study - Initial Screening Evaluation Measures) and Table 10 (Major Investment Study - Measures Used to Evaluate the Final Alternatives) terms like "mobility" were defined in a manner which allowed for objective (quantitative or qualitative) evaluation and comparative analysis.

As noted, bottlenecks (number of breaks in lane continuity), lane drops (completeness of auxiliary lanes), arterial VMT, trips diverted to transit, and environmental justice impacts were all factors that were used to identify and evaluate possible project alternatives in the MIS. As noted therein, the "TSM Alternative" resulted in a reduction of VMT (MIS, Table 4-5, pp. 45-46). In contrast, none of those criteria have been retained or considered in the DEIR/S. From that, it can be concluded that the purpose and objective of the project examined in the MIS is different from the purpose and objective of the project addressed in the DEIR/S. As a result of that change, contrary to what is inferred by the Lead Agency, there is no clear or direct continuity between the MIS and DEIR/S (e.g., the OCTA cannot throw out its old planning criteria and apply new criteria and then assert that the two are the same).

Table 9
Major Investment Study - Initial Screening Evaluation Measures

Issue	Measure
Freeway mobility	Person (in vehicle) hours of delay in study area Percent change in peak period travel times on I-405 Volume-to-capacity ratios on I-405
Arterial mobility	Reduction in arterial VMT
Travel choices	Daily transit trips Daily HOV trips
Land use/Economic development	Value of time saved by commercial vehicles
Implementation	Total capital cost (of project) Cost effectiveness (cost per person hour of travel saved) Right-of-way impacted Visual impacts (from elevation)

Source: Orange County Transportation Authority, Interstate 405 Major Investment Study, Final Report, February 2006, Table 2-2 (Initial Screening Evaluation Measures), p. 17.

Table 10
Major Investment Study - Measures Used to Evaluate the Final Alternatives

Issue	Measure
Freeway mobility	Person (in vehicle) hours of delay in study area Percent change in peak period travel times on I-405 Volume-to-capacity ratios on I-405 Flexibility to increase capacity and manage demand Number of breaks in lane continuity (bottlenecks) Completeness of auxiliary lanes
Arterial mobility	Reduction in arterial vehicle miles (VMT) and hours (VHT) of travel Number of signalized intersections operating at LOS E or F Total delay at signalized arterial/freeway-ramp intersections Volume-to-capacity ratios of arterial mid-block intersections Volume-to-capacity ratios of freeway crossings not at interchanges
Operations	Number of freeway entrances and exits ramps requiring more than one lane
Travel choices	Daily transit trips HOV lane travel time improvements Transit service to transit-dependent areas
Land use/Economic development	Peak period travel times to major activity centers Value of time saved by commercial vehicles
Implementation	Total capital cost (of project) Cost effectiveness Right-of-way acquisition impacts to residential and commercial buildings and property Environmental justice impacts Archaeological sites impacted Public facilities impacted Parka and recreation impacts Acquisition of sites with hazardous materials

Source: Orange County Transportation Authority, Interstate 405 Major Investment Study, Final Report, February 2006, Table 4-1 (Measures Used to Evaluate the Final Alternatives), p. 41.

As indicated in the DEIR/S: "Project studies for the I-405 Improvement Project were initiated in 2003 under an MIS process to develop viable alternatives for the I-405 corridor from SR-73 to I-605 (proposed project). Under the MIS process, 13 conceptual project alternatives were originally developed in consultation with the Department and OCTA and are documented in a Conceptual Alternatives Report (dated May 2004). The 13 conceptual alternatives were subjected to an initial screening process to identify the alternatives most responsive to the mobility problems and transportation needs of the I-405 corridor. The 13 conceptual alternatives included 4 alternatives that added travel lanes, as well as 4 alternatives that included fixed guideway transit in the median of the freeway and 2 that included bus-rapid-transit (BRT) operating on proposed dual HOV lanes along the freeway in each direction with median station stops similar to those currently in use on Interstate 110 (I-110) in Los Angeles. All of the alternatives included park-and-ride facilities, as well as either enhanced local bus service, express bus service, or both. Freeway and arterial mobility, travel choices, land use, economic development, and implementation measures were taken into consideration in the initial screening analysis" (p. 2-2).

With the possible single exception of "mobility" (a turn which should be considered distinct from "accessibility") none of the screening criteria against which those "13 conceptual alternatives" were evaluated (i.e., mobility, travel choices, land use, economic development, and implementation measures) relate to the stated purpose of the proposed action (i.e., reduce congestion, enhance operations, mobility, improve trip reliability, maximize throughput, and optimize operations, and minimize environmental impacts and right-of-way acquisition) and its singular objective (i.e., consistency with regional plans and cost-effective early project solution for delivery) or the criteria upon which the project's current list of alternatives have been based.

As subsequently indicated in the "Project Study Report/Project Development Support" (Caltrans/OCTA, July 2008) (PSR/PDS), the Department states that "[t]he purpose of the proposed project is to meet four primary objectives and one secondary objective. The four primary objectives are to: (1) increase the capacity of the freeway to meet more of the existing and forecasted demand, increase peak period corridor speeds, and reduce peak period corridor travel times; (2) improve traffic operations on the freeway mainline; (3) enhance interchange operations; and (4) enhance safety" (p. 7).

The project's current objective does not appear to comply with the requirements of Section 6002(f) of SAFETEA-LU. As specified therein: "Purpose and Need - (1) Participation - As early as practicable during the environmental review process, the lead agency shall provide an opportunity for involvement by participating agencies and the public in defining the purpose and need for a project. (2) Definition - Following participation under paragraph (1), the lead agency shall define the project's purpose and need for purposes of any document which the lead agency is responsible for preparing for the project. (3) Objective - The statement of purpose and need shall include a clear statement of the objectives that the proposed action is intended to achieve, which may include - (A) achieving a transportation objective identified in an applicable statewide or metropolitan transportation plan; (B) supporting land use, economic development, or growth objectives established in applicable Federal, State, local, or tribal plans; and (C) serving national defense, national security, or other national objectives, as established in Federal laws, plans, or policies" (emphasis added).

In addition, no definition of either "cost-effective" or "early" is presented and no parameters are provided against which those terms can be evaluated. Similarly, absent from the Lead Agency's stated objective is any reference to the I-605 Freeway or to any specific freeway improvements (e.g., add new GP, HOV, or HOT lanes). Additionally, the project's P&N neither includes any reference to tolling nor to the generation of additional funding (e.g., "It is anticipated that construction of the tolled and GP lanes in each direction could be partially funded by the toll revenue anticipation bonds," p. 2-3). As such, although the construction of new GP, HOV, and/or HOT lanes may constitute a possible course of action, those improvements clearly do not constitute the only manner in which the stated objective could be obtained.

The Lead Agency states that "[n]one of the conceptual alternatives including fixed guideway or BRT in the median of the freeway were included in the final evaluation due to their <u>high costs</u> and/or their ROW impacts" (emphasis added) (p. 2-3). As indicated in Section 15126.6(b) of the State CEQA Guidelines, "the discussion of alternatives shall focus on alternatives to the project or its location which are capable of avoiding or substantially lessening any significant effect of the project, even if these alternatives would impede to some degree the attainment of the project objectives, or would be more costly." As such, cost considerations do not constitute a basis for rejection of project alternatives. In Citizens of Goleta Valley v. Board of Supervisors, the Appellate Court noted that "[t]he fact that an alternative may be more expensive or less profitable is not sufficient to show that the alternative is financially infeasible. What is required is evidence that the additional costs or lost profitability are <u>sufficiently severe as to render it impractical to proceed</u> with the project" (emphasis added). No such evidence has been presented by the Department.

Similarly, although the Lead Agency seeks to link the proposed action by referencing the alternatives analyses presented in both the MIS and PSR/PDS, the previous focus on "public transportation" (e.g., changes in local bus headways, fixed guideway and BRT services, and park-and-ride facilities) has inexplicably disappeared.

As noted in the DEIR/S: "A stand-alone TSM/TDM Alternative was identified for the corridor. It does not meet the project purpose and is described in Section 2.2.7, Alternatives Considered but Eliminated from Further Discussion. The TSM/TDM Alternative consists primarily of operational investments, policies, and actions aimed at improving traffic flow, promoting travel safety, and increasing transit usage and rideshare participation. . .TSM consists of strategies to maximize efficiency of the existing facility. . .TDM focuses on regional strategies for reducing the number of vehicle trips and vehicle miles traveled, as well as increasing vehicle occupancy" and "'[p]romoting mass transit and facilitating nonmotorized alternatives" (pp. 2-22 and 23). As further evidence of the lack of objectivity, based on the Lead Agency's own declaration: (1) "improving traffic flow, promoting travel safety, and increasing transit usage and rideshare participation" are not, either in whole or in part, apparently a part of the P&N for the proposed action; and (2) those actions would not, either direct or indirect, serve to reduce congestion, enhance operations; increase mobility, improve trip reliability, maximize throughput, optimize operations, and/or promote attainment of regional plans (p. S-1).

Because TSM/TDM activities are intended to increase "transit usage and rideshare participation" (p. 2-22) and "reduce the amount of single-occupancy vehicle trips" (p. 2-23), since it is the Lead Agency's desire to generate revenues by promoting express lane usage by "single-occupant vehicles" (p. 2-11), TSM/TDM strategies would appear to be the antithesis of the goals of the proposed action. Alternatives 1, 2, or 3 have not been formulated to reduce the number of vehicles on public roadways (e.g., "20 percent to 40 percent increase in GP lane capacity of the proposed alternatives," p. 1-22) or to reduce the number of VMT (e.g., "In 2040, daily VMT under Alternative 3 is anticipated to be greater than under the no-build condition by 1,013,000, compared to the existing condition daily VMT of approximately 4 million," p. 4-44);

rather the proposed action seeks to perpetuate the myth that spending "$1.7 billion" (p. 2-10) or more to add more lane-miles is the only means available to effectively move people and goods.

To the exclusion of all other alternatives, since the measure of "throughput" is the number of additional through lanes provided (e.g., "Does not maximize throughput because no additional through lanes are provided," pp. 2-49 and 50) or where underutilization of HOV/HOT lanes is alleged (e.g., "Does not maximize throughput because there is substantial underutilization of the HOV lanes," p. 2-42), the Lead Agency has established a set of criteria designed only to promote the construction of additional lane-miles (and not to more people or goods).

As indicated in "2010 Urban Congestion Trends – Enhancing System Reliability with Operations" (FHWA-HOP-11-024, 2010), the FHWA states that "[t]oo much traffic demand and/or not enough supply causes congestion" (p. 4). Because the DEIR/S focuses exclusively on "increased supply," the alternative's analysis ignores congestion reduction opportunities associated with "reduced demand," only one-half of the available strategies that could be formulated to reduce congestion are ever considered. In "Final Report - Traffic Congestion and Reliability: Linking Solutions to Problems" (LSP) (July 19, 2004), the FHWA notes that a "key approach to the problem of congestion involves <u>managing the demand for highway travel</u>. These strategies include providing a variety of options that result in more people traveling in fewer vehicles, trips made during less congested times, or trips not made (at least in a physical sense)" (emphasis added) (p ES-12).

As defined in the State CEQA Guidelines, the term "project" means "far more than the ordinary dictionary definition" (14 CCR 15002[d]). Similarly, "CEQA was intended to be interpreted in such a manner as to afford the fullest possible protection to the environment within the reasonable scope of the statutory language" (14 CCR 15003[f]).

In LSP, the FHWA asks: "Is Success Possible Against Congestion?" In response, it notes that "past successes tend to be localized. Multiple and systematic strategies for addressing congestion are required, given that demand is increasing on an already stressed highway and transit system" (LSP, p. ES- 13). "History has taught us that no single strategy can effectively address congestion – only through a combination of strategies can congestion be controlled" (p. 1-1). Since the DEIR/S lacks any evidence or analysis of "multiple and systematic strategies," the best that the Lead Agency can seek to accomplish is a "localized" improvement. By focusing exclusively on micro-scale improvements, neither the proposed action nor the alternatives thereto are defined in a manner promoting a broader solution to the problem that the Department purports to address in the DEIR/S nor are environmental effects of macro-scale actions ever examined therein.

As reported by the FHWA: "The effect of strategies aimed at controlling VMT growth – and controlling congestion in general – can have a dramatic impact on controlling congestion growth. <u>Strategies that reduce VMT directly can lead to a substantial slowdown in congestion growths</u>. Likewise, congestion mitigation strategies can have the same effect by increasing physical capacity, shifting demand, and improving roadway operations. In other words, congestion mitigation strategies can produce the same effect as reduced VMT growth. When used in combination, demand management and mitigation strategies can have a powerful impact on congestion growth" (emphasis added) (LSP, p. 3-8). Reducing congestion, therefore, involves at least a two-pronged strategy (i.e., demand management and mitigation strategies) that need to be pursued in combination. Only a single strategy (i.e., congestion mitigation) is, however, presented in the DEIR/S. An obvious alternative to the proposed action (to increase capacity) is to control VMT growth. As a result, both half the problem and half the solution have been totally ignored.

Besides its benefit in reducing congestion (as stated by the FHWA), VMT reductions have been identified by the Lead Agency as one of "four primary strategies for reducing GHG emissions from transportation sources" (p. 4-51). However, rather than reducing congestion, the proposed action has the potential to substantially increase congestion. As indicated in the DEIR/S:

(1) "Existing daily vehicle miles of travel in the study corridor is 4,063,000" (p. 3.1.6-21);

(2) "Under Alternative 1, on I-405, between SR-73 and I-605 in 2020, daily VMT is anticipated to have increased by 651,000, compared to the existing condition and by 1,080,000 in 2040" (p. 4-24);

(3) "On I-405, between SR-73 and I-605, in 2020, daily VMT under Alternative 1 is anticipated to be greater than under the no-build condition by 318,000, compared to the existing condition daily VMT of approximately 4 million. In 2040, daily VMT under Alternative 1 is anticipated to be greater than under the no-build condition by 525,000, compared to the existing condition daily VMT of approximately 4 million" (p. 4-35);

(4) On I-405, between SR-73 and I-605, in 2020, daily VMT under Alternative 2 is anticipated to be greater than under the no-build condition by 540,000, compared to the existing condition daily VMT of approximately 4 million. In 2040, daily VMT under Alternative 2 is anticipated to be greater than under the no-build condition by 894,000, compared to the existing condition daily VMT of approximately 4 million" (p. 4-39); and

(5) "On I-405, between SR-73 and I-605, in 2020, daily VMT under Alternative 3 is anticipated to be greater than under the no-build condition by 605,000 compared to the existing condition daily VMT of approximately 4 million. In 2040, daily VMT under Alternative 3 is anticipated to be greater than under the no-build condition by 1,013,000, compared to the existing condition daily VMT of approximately 4 million" (p. 4-44).

As further noted by the FHWA: "Adding new freeways or additional lanes to existing freeways will add large amounts of capacity to the roadway network. However there are other components of the transportation system that can be enhanced that will alleviate congestion, albeit in a more localized area. Widening arterial roads, providing street connectivity, provide grade separations at congested intersections and providing high-occupancy vehicle (HOV) lanes all will help to mitigate congestion. Also, adding capacity to the transit system, whether it is to the bus system, urban rail system or commuter rail system will assist in relieving congestion on the roadway network. Finally, adding capacity to the intercity rail system can reduce the use of highways by trucks" (LSP, p. 4-1). With the exception of HOV lanes, none of these FHWA-recognized congestion-reduction strategies have been addressed in the DEIR/S.

By directly adding to total VMT, at best, the proposed action represents a band-aid not a path to the cure. To suggest that the proposed action is wrong-headed would be to ignore the benefits that congestion mitigation can offer. However, by ignoring the root cause (i.e., traffic growth), the singular focus of the DEIR/S is, at best, myopic and promises only a short-term, localized solution. In what is, at best, at old mind-set, at least with regards to the proposed action, Caltrans appears to perceive its purpose to be "build more freeways," thus committing current and future generations to automobile and truck dependency and necessitating the need for more freeway expenditures "down the road." Since the "preferred" alternative appears to be the one that involves the largest expenditure of public funds, some people might call that "job security."

Section 15003(j) of the State CEQA Guidelines states that "CEQA requires that decisions be informed and balanced. It must not be subverted into an instrument for the oppression and delay of social, economic, or recreational development or advancement." As E.E. Schattschneider wrote: "All forms of political organizations have a bias in favor of the exploitation of some kinds of conflict and the suppression of others because organization is the mobilization of bias. Some issues are organized into politics while others are organized out" (The Semi-Sovereign People, 1961). In this context, "bias" constitutes the preoccupation with certain points of view and the simultaneous neglect of others. With regards to the DEIR/S, contrary to the requirements of CEQA, the Department's apparent bias is evident by its focus solely on "supply," absence of focus on "demand," and consideration of only new freeway lane-miles to the detriment of other accessibility-based and congestion-reducing options (e.g., "a TSM/TDM Alternative as an effective stand-alone alternative does not meet the project purpose" [p. 2-4] and "[t]he No Build Alternative is not considered a viable project alternative because it would not achieve the project's purpose" [p. 2-26]).

As indicated in a Memorandum from Mary E. Peters, Administrator, FHWA and Jennifer L. Dorn, Administrator, FTA to FHWA Division Administrators and FTA Regional Administrators (Subject: Guidance of "Purpose and Need"), dated July 23, 2003 and included in the SAFETEA-LU Guidelines, the following guidance is presented with regards to the preparation of purpose and need statements in NEPA documents: "The purpose and need statement serves as the cornerstone for the alternatives analysis, but should not discuss alternatives. The alternatives analysis is the place in the document for explaining how the considered range of alternatives meet the purpose and need. <u>Care should be taken that the purpose and need statement is not so narrowly drafted that it unreasonably points to a single solution</u>" (emphasis added) (p. 2). In addition, under NEPA, in Simmons v. U.S. Army Corps of Engineers (1997), the court cautioned agencies not to write purpose and need statements so narrowly as to "define competing 'reasonable alternatives' out of consideration (and even out of existence)."

Caltrans' website asserts that it is the mission of that State agency to "improve mobility across California" and to "maximize transportation system performance and accessibility." While freeway improvements constitute one possible manifestation of that mission, that singular strategy is not indicative of the range of physical improvements (e.g., maximize throughput) and operational actions (e.g., optimize operations) that could be undertaken in furtherance of that mission and advancement of the project's P&N.

4.3 Rejected Alternatives

The stated P&N of the proposed action is to: "[1] Reduce congestion; [2] Enhance operations; [3] Increase mobility, improve trip reliability, maximize throughput, and optimize operations; and [4] Minimize environmental impacts and right-of-way acquisition" (p. S-1). The Lead Agency subsequently uses one or more of those purpose statements as the basis for rejecting possible project alternatives.

In seeking to apply that P&N to the evaluation of possible project alternatives, the Lead Agency has misinterpreted the provisions of the State CEQA Guidelines. As specified, in part, therein, "the discussion of alternatives shall focus on alternatives to the project or its location which are capable of avoiding or substantially lessening any significant effects of the project, <u>even if these alternatives would impede to some degree the attainment of the project objectives or be more costly</u>" (emphasis added) (14 CCR 15126.6[b]). As such, the Lead Agency cannot exclude a potentially viable alternative whose implementation includes the prospects of reducing or eliminating a significant environmental effect because it does not accomplish one of the stated project purposes (objectives) to the same extent that another alternative might.

Since the Lead Agency currently lacks the funds to implement any of the build alternatives examined in the DEIR/S, it would appear disingenuous to reject another, otherwise feasible, alternative based, in whole or in part, on cost considerations (e.g., "The high cost of Alternative M3 also contributes to the determination that the alternative is not viable," p. 2-42; "The high cost of Alternative M5 also contributes to the determination that the alternative is not viable," p. 2-42; "The high cost of Alternative M6 also contributes to the determination that the alternative is not viable," p. 2-43; "The high cost of Alternative M8a also contributes to the determination that the alternative is not viable," p. 2-45; "The high cost of Alternative M9 also contributes to the determination that the alternative is not viable," p. 2-46; "The high cost of Alternative M10 also contributes to the determination that the alternative is not viable," p. 2-47; "The high cost of Alternative M11 also contributes to the determination that the alternative is not viable," p. 2-47; "The high cost of Alternative M12 also contributes to the determination that the alternative is not viable," p. 2-48; "The high cost of Alternative M13 also contributes to the determination that the alternative is not viable," p. 2-49); however, estimated "cost" is identified by the Department as a basis for the rejection of alternatives identified in the MIS.

The DEIR/S appears to present a double standard. Although "[n]one of the conceptual alternatives including fixed guideway or BRT in the median of the freeway were included in the final evaluation due to their high costs and/or their ROW impacts" (p. 2-2), none of the three build alternatives presented in the DEIR/S avoid "ROW impacts" and "[f]ull funding has not been identified for any of the proposed build alternatives and remains an unresolved issue" (p. S-39). In what appears to be an apparent inconsistency, project alternatives are rejected because they exceed the existing budget; however, each of that build alternatives examined by the Lead Agency also exceed the existing budget. Similarly, project alternatives have been rejected because of their potential ROW impacts; however, each of the build alternatives examined in the DEIR/s will also have ROW impacts.

Similarly, "costs" are only referenced in a short-term context (i.e., construction) and do not include long-term maintenance costs, administrative and management costs, financing and other debt service costs, and/or opportunity costs.

Although one of the stated purposes is to "<u>minimize environmental impacts</u> and right-of-way acquisition" (emphasis added) (p. S-1), the Lead Agency uses only a portion of that purpose statement (i.e., minimize right-of-way acquisition) as the primary basis for rejecting a number of possible alternatives. While the City generally supports the Lead Agency's desire to "minimize" ROW acquisition (particularly with regards to real property within Seal Beach), the term "minimize" appears problematic in that it may place too much emphasis on square footage calculations of affected properties over the broader objective of facilitation of movement of people and goods. There may exist situations where a small change in ROW acquisition would yield substantial congestion and mobility benefits but, pursuant to the Department's own criteria, a lesser performing alternative is deemed more desirous than another better performing option. For example, MIS Alternatives 5, 6, 7, 8, 8a, 9, 10, 11, and 12 are all rejected, in major part, because the Lead Agency asserts it "[h]as unacceptably high ROW impacts as measured by the number of single-family dwelling units and number of acres to be acquired" (pp. 2-42, 2-43, 2-44, 2-45, 2-46, 2-47, and 2-48). Since no reference to commercial uses is presented, it would appear that impacts upon ROW acquisition impacts affecting existing commercial uses is viewed by the Lead Agency differently that impacts on residential uses.

In rejecting each of those alternatives, the DEIR/S specifies the number of "single-family dwelling units" (SFDU) that will be impacted; however, with regards to Alternatives 1, 2, and 3, the Lead Agency fails to disclose the number of affected SFDU, identifying only the number of "parcels" (pp. 3.1.1-20 and 3.1.1-31) that will be impacted. For example, with regards to the rejected MIS alternatives, between 67 and 200 SFDU (34.5 to 59.6 acres) will be affected. With regards to the three build alternatives, between 90 and 108 parcels (12.65 to 13.93 acres), including existing commercial uses (e.g., "Full acquisition of commercial properties has been limited to five parcels," p. 2-4) will be affected. By offering up different forms of measurement for both the rejected and pursued alternatives, the Lead Agency appears to be seeking to enflame public sentiments against the MIS alternatives while under-valuing the corresponding effects of the three build alternatives.

With regards to "ROW acquisition and relocation," the DEIR/S presents an internally inconsistent analysis. As indicated in the DEIR/S, Alternative 1 will affect "90 public and privately owned parcels" (p. 3.1.1-20), Alternative 2 will affect "91 public and privately owned parcels" (p. 3.1.1-31), and Alternative 3 will affect "108 public and privately owned parcels" (p. 3.1.1-31). However, the CIA states that Alternative 1 will affect "[u]p to 155 public or privately owned parcels"; Alternative 2 will affect "[u]p to 173 public or privately owned parcels"; and Alternative 3 will affect "[u]p to 189 public or privately owned parcels" (Table S-1, p. S-4). As a result, although minimization of ROW impacts is purported to be a key criteria with regards to both the formulation of the proposed action and elimination of potential alternatives, it is not possible to clearly ascertain the extend of ROW impacts attributable to the three build alternatives presented in the DEIR/S.

It has to be assumed that the above referenced number of "public and privately owned parcels" relates only to those which will be directly impacted and does not include other residential and non-residential uses. Absent from the DEIR/S is any attempt to identify, quantify, or illustrate the precise or general location of those "businesses" that could be impacted during construction and/or that may suffer a detrimental change to patronage once construction has been completed, much less explain the nature and duration of potential business disruption (e.g., "Construction at major interchanges could disrupt local business operations," DEIR/S, Table S-1, p. S-15). To the extent that the Lead Agency seeks to argue the benefits or reduced traffic on local arterials (e.g., "Increase in mobility and operations of the freeway and roadway network would contribute to the increase in property tax base, sale tax revenue, and property values," CIA, p. S-6), the life of many businesses is dependent upon the volume of traffic traveling along abutting streets.

Pursuant to Section 15125(c) of the State CEQA Guidelines, "[t]he EIR must demonstrate that the significant environmental impacts of the proposed project were adequately investigated and discussed and it must permit the significant effects of the project to be considered in the full environmental context."

The DEIR/S states that "the proposed project would not normally affect tax revenue unless the use of the parcel is significantly affected" (CIA, p. 6-4); however, absent from the environmental analysis is any description of what might constitute a "significant affect." Evident of both the absence of objectivity and thoroughness of the environmental analysis can be found in the assertion that "[p]roperty values within the project area could be affected by displaced businesses, changes in the visual environment, improved access to community facilities and other residential areas, and nearby community enhancement projects" (CIA, p. 4). While "improved access" is toted as a basis for alleging an increase in property valuation (e.g., "Increase in mobility and operations of the freeway and roadway network would contribute to the increase in property tax base, sale tax revenue, and property values," CIA, p. S-5), absent from the DEIR/S is any reference to or discussion of short-term or long-term impediments to access resulting from the proposed action (e.g., street closures) and how those actions could produce negative economic ramifications.

Similarly, the Lead Agency states that "[d]ecreased congestion along the 1-405 corridor has the potential to allow regional motorists, as well as local residents, to reach businesses more efficiently, thereby allowing for increased visitation, faster customer turn-around and, consequently, increased revenues. This would be especially true for restaurants, retail stores, and shopping centers (e.g., IKEA and the South Coast Plaza) within the directly impacted area, as they are often destinations for residents and visitors" (emphasis added) (CIA, p. 6-3). When it appears beneficial to support the Lead Agency's predetermined conclusions, the DEIR/S asserts that freeway congestion adversely impact local businesses (e.g., South Coast Plaza); however, when it appears beneficial to argue that construction activities (when freeway ramps will be closed in their entirety for "up to 30 days" (RCS, Table 1, pp. 4 thru 6]) will not significantly affect those same businesses, the Lead Agency argues the loss of freeway accessibility is not significant (e.g., "There are no businesses that rely solely on freeway traffic, as they primarily serve local clientele that utilize surface streets to access the businesses," RCS, pp. 7 and 8). Although "[r]amps that provide access immediately adjacent to the South Coast Plaza (South Coast Drive NB off-ramp), Bella Terra Mall (Beach Boulevard off-ramps) or the Westminster Mall (Bolsa Avenue NB and Goldenwest SB off-ramps) will not be closed from November 1st to Jan 31" (RCS, p. 18), there are many other businesses located in proximity to closed freeway ramps and traffic detours that are also dependent upon seasonal shoppers. By acknowledging the dependence that many retailers have on revenues derived during key shopping periods, the Lead Agency must fairly and equitable consider the totality of businesses so affected and not single out only three centers to the detriment of all others.

In what appears to be a continuing application of a double standard, the Lead Agency states that "[a]ll temporary long-term closures are supported by adequate detours. . .and a robust local arterial street network. Access to all business will be maintained during construction of the I-405 improvement project and all are accessible from alternate freeway off-ramps and utilizing the local streets. Based on the short-term and temporary nature of the closures (10 to 30 days), the increased travel times and distances would not result in either a substantial economic effect on businesses or substantial delays or travels cost for residents or business patrons" (emphasis added) (RCS, p. 19). At least in one instance (i.e., Fairview Road Northbound Off-Ramp), "24,000 AADT [annual average daily traffic]" (RCS, p. 9) will be diverted onto local streets for up to 30 days. The Lead Agency, however, asserts that the proposed project is, in part, needed because "[a]s a result of the levels of traffic congestion on the freeway, traffic is being diverted to nearby arterials thereby impairing arterial mobility" (MIS, p. 55). As a result, in the perspective of the Department, "nearby arterials" are not, in fact, a "robust" system but a system that is currently operating at over capacity conditions as a result of existing congestion along the I-405 Freeway. Again, when convenient and fruitful, local arterials are "robust"; however, when a different argument is needed, those same roadways suddenly become impaired.

NEPA requires that federal agencies "consider every significant aspect of the environmental impact of a proposed action" and "inform the public that [they have] indeed considered environmental concerns in [their] decision-making process" (Earth Island Institute v. United States Forest Service [2003]). With regards to the adequacy of the alternatives analysis, the City believes that there are inherent flaws in the Lead Agency's methodology. A total of 17 topical issues were examined in the DEIR/S (i.e., land use; growth; farmlands/timberlands; community impacts; utilities/emergency services; traffic and transportation/pedestrian and bicycle facilities; visual/aesthetics; cultural resources; hydrology and floodplains; water quality and stormwater runoff; geology/soils/seismic/topography; paleontology; hazardous waste/materials; air quality; noise; energy; and biology). Based on the project's potential to produce significant environmental effects, those 17 topical issues were determined to warrant detailed project-specific analysis. With regards to the alternatives analysis, by electing to self-imposed blinders with regards to the rejected alternative's potential impacts (i.e., minimize right-of-way acquisition), absent an analysis of those same 17 topical issues, the Lead Agency is unable to objectively and fairly balance the full range of environmental and socioeconomic impacts and purported benefits and make requisite findings with regards to each alternative.

In assessing the environmental superiority of an alternative, all 17 environmental resource areas must be taken into account. The environmentally superior alternative is the alternative found to have an overall environmental advantage compared to the other alternatives based on all the impact analysis in the DEIR/S. Determining which of the alternatives is environmentally superior or even feasible involves judgment and depends on many factors, as well as requiring a weighing of one type of impact against another type (e.g., weighing short-term effects against long-term effects or weighing effects on the natural environment against effects on the human environment). Any methodology that ignores 16 of the 17 relevant or potentially relevant environmental issues and involves no balancing or weighting of those or other environmental effects only serves to minimize the range of possible alternatives brought forward for public consideration and prematurely excluding others.

4.4 Selected Alternatives

The DEIR/S consumes three pages (pp. 2-14 through 2-17) outlining how each of the three build alternatives contain "common design features" (i.e., are all the same). In comparison, it takes less than a page (pp. 2-17 through 2-18) to identify the "unique design features" (i.e., minor variations) of each alternative. As described therein: (1) "Alternative 1 generally does not have any unique features" (p. 2-17); (2) "Alternative 2 would add a second GP lane in the northbound direction from Brookhurst Street to the SR-22/7th Street interchange and a second GP lane in the southbound direction from the Seal Beach Boulevard on-ramp to Brookhurst Street' (p. 2-18); and (3) "Alternative 3 would add a tolled Express Lane in each direction of I-405 from SR-73 to SR-22 East. . .The policies governing operation of the Express Lanes in Alternative 3 are additional features unique to this alternative" (p. 2-18).

With regards to the near identical nature of the three build alternatives, the DEIR/S notes:

> In terms of pavement width, Alternative 3 has similarities to both Alternatives 1 and 2. By adding both an express lane and a general purpose lane, the overall width of the proposed paving most closely matches that proposed for Alternative 2 for most of the corridor, except for the area north of SR-22/Valley View where it resembles Alternative 1. The major difference in Alternative 3 is the addition of a direct connector bridge between SR-73 and I-405 (VIA, p. 57)

As such, based on their commonality, the three options constitute only minor variations of generally the same project. As such, the DEIR/S neither provides the project's decision makers with a range of reasonable alternatives (14 CCR 15156.6) nor fosters informed decision making (14 CCR 15002[a][1]).

Under NEPA, a federal court (Northern Plains Resource Council v. Lujan [1989]) noted that NEPA does not require a separate analysis of alternatives which are not significantly different from alternatives actually considered or which have substantially similar consequences. Under CEQA, the court noted that the State CEQA Guidelines require that EIRs describe a range of reasonable alternatives to the proposed project. That requirement is "applicable only to the project as a whole, not the various facets thereof" (Big Rock Mesas Property Owners Association v. Board of Supervisors [1977]). Although acknowledging the existence of minor differences among Alternatives 1, 2, and 3, as a result of the lack of substantive variation, the Lead Agency has failed to present a "range of reasonable alternatives" allowing for a clear choice in the manner in which the stated P&N could be attained.

To the extent that each alternative were truly unique (e.g., "The analysis of this alternative assumes the design exceptions that are unique to this alternative," DEIR/S, p. 2-5), each alternatives would be expected to generate unique transportation travel patterns within and surrounding the general project areas. The alternative improvements (e.g., I-405 Freeway mainline project sections) would, therefore, be expected to create differing levels of congestion and cause people to make differing transportation choices (i.e., varying modes choices and travel patterns), thus causing differing traffic impacts for each of the three build alternatives. The Traffic Study, however, indicates that "a single demand forecast was prepared. Forecasts for each of the alternatives utilize the same total traffic volumes on a segment" (p. 2.2-3). As a result, as further evidence of the absence of clear distinctions between alternatives, the traffic projections and associated analyses do not present unique area travel patterns associated with each of the alternative.

4.4.1 Alternative 1

As specified in the OCTA's "Renewed Measure M Transportation Investment Plan," adopted on July 24, 2006, "Project K (San Diego Freeway [I-405] Improvements between the I-605 Freeway in Los Alamitos area and Costa Mesa Freeway [SR-55])" "improvements shall adhere to recommendations of the Interstate 405 Major Investment Study (p. 13). As identified in the MIS, "[MIS] Alternative 4 is the Locally Preferred Strategy (LPS) for improvements to I-405 between I-605 and SR-73. The LPS provides for an additional general purpose lane in each direction on the freeway between I-605 and Brookhurst Street. It includes auxiliary lanes linking on-ramps to downstream off-ramps at numerous locations in the corridor. . .The preparation of the environmental documents and the associated engineering will revisit in substantially more detail many of the same topics included in the Major Investment Study. The environmental documents will be prepared in light of the OCTA identification of [MIS] Alternative 4 as the LPS" (pp. 92-93). MIS Alternative 4 is represented to be Alternative 1 in the DEIR/S (i.e., "Only one build alternative, Alternative 1, which was MIS Alternative 4, has been retained as a viable alternative and is fully evaluated in this document" (p. 2-3).

As a result, in accordance with the OCTA's "Renewed Measure M Transportation Investment Plan," Alternative 1 should be identified as the LPS or the "preferred project." This designation in the DEIR/S is critical because it serves to alert the project's stakeholders of the Lead Agency's intent, thus allowing affected parties to ascertain the objectivity and presence of inherent bias in the environmental analysis.

Despite the Lead Agency's declaration that the two scenarios are the same, it is not immediately evident that DEIR/S "Alternative 1" is the same as "MIS Alternative 4." As indicated in the MIS, "[t]he capital cost of [MIS] Alternative 4 is $490 million. It is the least expensive of the build alternatives. It is the narrowest of the build alternatives and requires the least additional right-of-way. Because it has the narrowest cross section of the build alternatives it requires the shortest bridge spans. Except for the area north of Seal Beach Boulevard, the existing freeway centerline is maintained in [MIS] Alternative 4. Much of the existing pavement and grading can be used. The roadway components, including the additional general purpose lane on the freeway in both directions north of Brookhurst Street to I-605, account for $480 million of the capital cost. The remaining $10 million is for the transit components including the capital costs associated with providing reduced headways on routes identified in Section 3.3" (pp. 70-71). With regards to congestion relief, "[MIS] Alternative 4 provides a reduction of 3.9 million hours" (p. 44). In addition, "Alternative 4 has a 12-15% reduction in general purpose lane travel time during the peak periods. It also is forecast to have a 3-10% improvement in HOV lane travel times" (p. 44).

In contrast, the DEIR/S states that "Alternative 1 would add a single GP lane in each direction on I-405 from Euclid Street to the I-605 interchange. Preliminary cost estimates for this alternative are $1.3 billion" (p. 2-5). Similarly, the "lane schematic" of MIS Alternative 4, as presented in Table 5-1 in the MIS (p. 87), differs substantially from the "lane configuration, northbound," as presented in Figure 2-1 (p. 2-6) and Figure 2-2 (p. 2-7) in the DEIR/S. Based on the Lead Agency's declaration that MIS Alternative 4 "is" DEIR/S Alternative 1, these differences and their rationale need to be fully addressed, including an explanation why the estimated cost nearly tripled.

4.4.2 Alternative 2

Since Alternative 2 appears to generally exist within a similar ROW as Alternative 1, it would appear that, if Alternative 1 were to be selected for implementation, at some later point in time, Alternative 2 or a variation thereof could be brought forward as a subsequent expansion plan. Absent from the DEIR/S is any declaration that the freeway improvements contemplated therein constitute anything other than a short-term response to an identified need or that selection of one alternative negates any other alternative and/or the possible conversion of shoulder areas to travel lanes. Unclear is whether that latter action (or any design or operational modification) would necessitate additional environmental review under CEQA and NEPA and, if so, what type of review would occur.

Once finalized, could Caltrans approve a lower intensity alternative (such as Alternative 1) and subsequent use that same documentation for a later expansion project (such as Alternatives 2 or 3)? Are there any existing limitations or authorizations allowing Caltrans to convert an existing GP or HOV lane into a HOT lane?

4.4.3 Alternative 3

As required under Section 21003.1(b) of CEQA: "Information relevant to the significant effects of a project, alternatives, and mitigation measures which substantially reduce the effects shall be made available as soon as possible by lead agencies, other public agencies, and interested persons and organizations." In addition, as specified under the State CEQA Guidelines, an adequate project description shall contain a description of: (1) the "precise location and boundaries of the proposed project"; (2) a "clear written statement of objectives sought by the proposed project," including the "underlying purpose of the project"; and (3) a "general description of the project's <u>technical, economic, and environmental characteristics</u>" (emphasis added) (14 CCR 15124).

As indicated in correspondence from Arthur T. Leahy, OCTA's former CEO to OCTA's Highway Committee (Subject: Consideration of the San Diego Freeway Improvement Project for Future High-Occupancy Toll Lane and Design-Build Authority), dated January 19, 2009, the CEO made the following request to the OCTA's Highway Committee: "Approve the consideration of the San Diego Freeway (Interstate 405) Improvement Project for the implementation of high-occupancy toll lanes utilizing the design-build and public-private partnership method of procurement and authorize staff to move forward with further evaluation of high-occupancy toll lanes and next steps in the project development process and any future project nomination process." In addition, the CEO noted that "[t]here are numerous benefits to adding HOT lanes to the Interstate 405 Improvement Project. The HOT lanes could function much like the 91 Express Lanes, with OCTA being the owner and a private operator managing the lanes. The additional costs of the HOT lanes compared to building general purpose lanes would be minimal and would be far outweighed by the revenues anticipated to be generated" (pp. 1 and 3). Although that report was submitted substantially in advance of the release of the NOP and NOI (August 26, 2009), absent from the DEIR/S is any reference to, discussion, or analysis of the formation of a "public-private partnership" (P3) or the conveyance of any portion of the I-405 Freeway or the management thereof to a "private [profit-motivated] operator."

As proposed, the "private operator" would have control and management responsibility over both the HOT and HOV lanes (e.g., "The tolled Express Lane and the existing HOV lanes would be managed jointly as a tolled Express Facility. . .From SR-22 to I-605, the existing HOV lane and the second HOV lane that is being built as part of the WCC Project would become part of the tolled Express Facility. p. 2-10). Clearly, declaration of the Lead Agency's intent to pursue a "design-build and public-private partnership method of procurement" constitutes a component of the project's "economic characteristics" (within the meaning of 14 CCR 15124).

Additionally, contemplated is the conveyance of not only the "express facility" located along that segment of the I-405 Freeway which is explicitly addressed in the DEIR/S but also other freeway segments extending for an unspecified distance beyond those limits, including, but not necessarily limited to, those associated with the WCC. As a result, by the OCTA's own admission, the proposed action is not confined to the limits identified in the DEIR/S but encompasses a larger (undisclosed) geographic area. The Lead Agency, therefore, presents a truncated project description (San Joaquin Raptor/Wildlife Rescue Center v. County of Stanislaus [1994]) which fails to address the whole of the contemplated action (14 CCR 15378).

As further indicated in correspondence from Will Kempton, OCTA's CEO to OCTA's Regional Planning and Highway Committee (Subject: Update on the Interstate 405 Improvement Project Alternatives, Business Models, and Delivery Option), dated April 16, 2012, a "P3 Concession option" (p. 2) is being considered. However, the DEIR/S contains no discussion of a possible "P3 Concessionaire" and/or the possibility that "[a]ll revenues would go to the private developer." Since toll proceeds could potentially be used to fund mitigation plans and programs and/or compensate abutting municipalities for the impacts attributable to the freeway or toll road, the OCTA's consideration of conveyance of those revenues to a non-public entity constitutes an important project feature whose potential impacts (e.g., projected revenues unavailable for alternative use; implications with regards to the setting of toll rates; consequences of the potential bankruptcy of the concessionaire) have not been addressed by the Lead Agency.

Referencing correspondence from William Kempton, OCTA's CEO to OCTA's Regional Planning and Highway Committee (Subject: Outline of the Proposed Project Delivery

Organizational Approach for the Interstate 405 Improvement Project), dated June 4, 2012, a "If Project Alternatives 1 or 2 are selected as the build alternative, OCTA would probably need to obtain its own design-build authority through the legislative process. . .If Project Alternative 3 is selected as the build alternative, a provision of Streets and Highways Code 143, passed as SB 4 X2 in February 2009, would authorize design-build for the Project and tolling for the Express Lanes" (p. 3). Because it could have ramifications beyond the proposed project, the potential impacts of all requisite enabling legislation (e.g., amendments to Section 6800 of the California Public Contract Code; authorizing design-build legislation), the prospects of legislative passage, and the ramifications of need to be addressed in the DEIR/S.

Section 6800 of the Public Contract Code allows Caltrans to enter into a maximum of 10 design-build contracts for State highway, bridge or tunnel projects, and local transportation entities may enter into a maximum of five contracts for local street or road, bridge, tunnel or public transit projects. Section 6800 does not impose a minimum cost threshold on eligible projects, but all 15 projects must be authorized (i.e., approved) by the California Transportation Commission (CTC), and must be slated to receive funding from state transportation funding programs. Section 6800 requires Caltrans to be the "responsible agency for the performance of project development services, including performance specifications, preliminary engineering, prebid services, the preparation of project reports and environmental documents, and construction inspection services." The design-build authority under Section 6800 sunsets on January 1, 2014; however, "[c]onstruction of the proposed project is planned to commence in 2015" (p. 2-26).

Because it is dependent upon OCTA's ability to secure authorizing enabling legislation, based on the speculative nature of those efforts, it must be concluded that Alternative 3 is not a reasonable alternative. Although the court's ruling was in the context of alternatives raised by stakeholders, it would appear to have equal application to alternatives presented by a project sponsor. The Supreme Court has noted: "There is reason for concluding that NEPA was not meant to require detailed discussion of the environmental effects of 'alternatives' put forward in comments when these effects cannot be readily ascertained and the alternatives are deemed only remote and speculative possibilities, in view of basic changes required in statutes and policies of other agencies – making them available, if at all, only after protracted debate and litigation not meaningfully compatible with the time-frame of the needs to which the underlying proposal is addressed" (North Buckhead Vermont Yankee Nuclear Power Corp. v. Natural Resource Defense Council [1978], quoting Natural Resource Defense Council v. Morton [1972]). It is unclear how the Lead Agency can approve a build alternative dependent upon enabling legislation absent that legislation. Similarly, if so approved, it is unclear what pressures would be put on the legislature to rubber-stamp that legislation under the premise that environmental clearance had already been achieved and that delay or denial could result in the forfeiture of discretionary federal funds to the State.

With regards to separate environmental justice considerations, under Alternative 3, SOVs may utilize the HOT lanes through the payment of a specified toll. As indicated in "The Social Impacts of Interstate Highway System, What Are the Repercussions" (Deakin, Elizabeth C., UCTC, June 2006), the author notes that "[f]or many, the social impacts of the Interstates have been positive: increased access, mobility, and options for individuals, households, and firms. For others, however - especially for those not able to own or drive a car - the Interstates have decreased access and mobility by undermining the viability of alternative modes of transport" (p. 16).

As further indicated in "The Political Calculus of Congestion Pricing" (King David, Manville, Michael, and Shoup, Donald, UCTC, January 2007), the authors concluded: "Consider the prospects for congestion pricing in Los Angeles County, which has the worst traffic congestion in the United States. . .congestion pricing will initially make many drivers worse off. The demand for driving in Los Angeles (as most other urban areas in the US) is highly inelastic, so most people confronted with congestion pricing will end up paying the tolls or driving a less convenient route instead of switching to another travel mode or time. . .A study of congestion pricing's likely impacts in the Twin Cities made a similar point: for all but two small groups - transit users and affluent drivers - the tolls would exceed the time saving" (pp. 113-114).

Absent from the DEIR/S is any discussion or analysis of potential environmental justice impacts associated with the establishment of HOT lanes extending along and beyond the declared project limits.

4.4.4 Alternative 4

On February 8, 2010, under Agenda Item 18 (Report on Traffic and Revenue Analysis for the San Diego Freeway [Interstate 405] Improvement Project and Contract Amendment), OCTA's Board of Directors "[a]uthorized staff to continue the analysis of four build alternatives for the San Diego Freeway (Interstate 405) Improvement Project through the environmental process."

As indicated in the NOP, Caltrans stated that four build alternatives will be considered, including "Alternative 4: Localized Improvements." As further indicated therein, "Alternative 4 provides an additional general purpose lane at various locations and improves various interchanges from Euclid Street to I-605" (p. 2). The NOP clearly distinguished "Build Alternative 4" from a separate "Baseline Alternative (No Build)." The "Baseline Alternative represents the 'No Build' alternative. No additional lanes or interchange improvements would be provided by this alternative" (p. 2). Similarly, the NOI identifies "Alternative 4; [sic] on I-405 from Euclid Street to I-605, providing additional general purpose lane at various locations and improving various interchanges" (p. 3) will be considered. Also, Caltrans' and the OCTA's "Public Scoping Notice" and "Newsletter" announcing the September 22, 23, and 30 and October 1, 2009 public scoping meetings included reference to "Alternative 4: Localized Improvements."

As indicated in SCAG's "Final Program Environmental Impact Report - 2012-2035 Regional Transportation Plan/Sustainable Communities Strategy, SCH No. 2011051018" (April 4, 2012) (2012 RTP/SCS PEIR): "Since mixed flow lanes carry more traffic than any other component of SCAG's transportation system, mixed-flow capacity enhancements are also necessary to address traffic bottlenecks and relieve congestion on heavily traveled corridors" (p. 2-13). In direction contradiction to that acknowledgement, the DEIR/S notes: "Alternative 4 proposed to provide localized improvements within the I-405 corridor that could be fully funded and implemented with available revenue from Orange County's Renewed Measure M transportation sales tax initiative. Alternative 4 would neither provide additional capacity along the entire corridor nor enhance interchange operations. It would not meet the project purpose and was eliminated from further consideration in this Draft EIR/EIS. All elements of Alternative 4 are included in the proposed build alternatives. A description of Alternative 4, along with the reasons for its elimination from further consideration, is provided in Section 2.2.4, Alternatives Considered but Removed from Further Discussion" (p. 2-3 and 4). Section 2.2.4 (No Build [No Action] Alternative) of the DEIR/S, however, includes no further discussion of "Alternative 4: Localized Improvements," focusing exclusively on the "No Build Alternative" (pp. 2-23 through 2-26). Although the Lead Agency had committed to include "Alternative 4: Localized

Improvements" in the DEIR/S (as a separate and distinct alternative from the "Baseline Alternative [No Build]"), the Department failed to provide that analysis and, through its false representation, limited public participation in the environmental review process.

The Department's subsequent exclusion of the "Alternative 4: Localized Improvements" from the DEIR/S has deprived the project's decision-makers and other stakeholders of both the opportunity to consider a reasonable range of alternatives and the ability to compare those options against the three build alternatives presented in the DEIR/S. Since the NOP and NOI both constituted a good-faith declaration of the Lead Agency's intent upon which the affected public must rely, the Department's subsequent exclusion of "Alternative 4" from the DEIR/S has deprived interested parties of the ability to provide meaningful pre-circulation comments to Caltrans for consideration in the preparation of the DEIR/S.

4.4.5 TSM/TDM/Mass Transit Alternative

The NOP stated that the DEIR/S will include an analysis of the "Transportation Systems Management (TSM)/Transportation Demand Management (TDM)/Mass Transit Alternative." As described therein, the "TSM/TDM/Mass Transit Alternative includes activities that will maximize the efficiency of the present highway system and expand travelers' transportation choices in terms of travel time, route, quality, and convenience. It involves low-cost operational improvements, rather than major capital projects, including but not limited to auxiliary lanes, ramp metering, ridesharing, and traffic signal timing optimization" (p. 2). Similarly, the NOI identified a "Transportation Systems Management (TSM)/Transportation Demand Management (TDM)/Mass Transit Alternative; [sic] makes only low-cost operational improvements, rather than major capital projects, to maximize the efficiency of the present highway system and expand travelers' transportation choices" (p. 3). Also, Caltrans' and the OCTA's "Public Scoping Notice" and "Newsletter" announcing the September 22, 23, and 30 and October 1, 2009 public scoping meetings included reference to a "Transportation Systems Management (TSM)/Transportation Demand Management (TDM)/Mass Transit Alternative."

No "TSM/TDM/Mass Transit Alternative" has, however, been presented in the DEIR/S. Instead, the Lead Agency notes: "Although a TSM/TDM Alternative as an effective stand-alone alternative does not meet the project purpose, as explained in Section 2.2.4, Alternatives Considered but Removed from Further Discussion, the PDT [Project Development Team] has included TSM and TDM elements as part of Alternatives 1, 2, and 3 as described in Section 2.2.1, Common Design Features of the Build Alternatives" (p. 2-4). Section 2.2.1 (Common Design Features of the Build Alternatives) of the DEIR/S states: "Although TSM and TDM measures alone do not satisfy the purpose and need of the project, the following TSM and TDM measures <u>may</u> be incorporated into each of the build alternatives for the proposed project" (emphasis added) (p. 2-17).

Under CEQA, the terms "must" and "shall" identify mandatory requirements; however, the terms "may" and "should" are permissive, with discretion left to the Lead Agency (14 CCR 15005). As a result, no commitment is made by the Department that TSM and/or TDM measures will, in fact, be included in the proposed action. Similarly, under NEPA, "[t]he use of language such as 'recommend,' 'may,' 'should,' and 'can' is intended to describe CEQ policies and recommendations. The use of mandatory terminology such as 'must' and 'required' is intended to describe controlling requirements under the terms of NEPA and the CEQ Regulations" (76 FR 3846, January 21, 2011).

The Department's subsequent exclusion of both "Alternative 4" and the "TSM/TDM/Mass Transit Alternative" from the DEIR/S has deprived the project's decision-makers and other stakeholders of both the opportunity to consider a reasonable range of alternatives and the ability to compare those options against the three build alternatives presented in the DEIR/S. Since the NOP and NOI both constituted a good-faith declaration of the Lead Agency's intent upon which the affected public must rely, the Department's subsequent exclusion of those alternatives from the DEIR/S has deprived interested parties of the ability to provide meaningful pre-circulation comments to Caltrans for consideration in the preparation of the DEIR/S.

The Department appears to have been down this same road before. Referencing Environmental Council of Sacramento v. California Department of Transportation, (2008) the court noted:

> Petitioners acknowledge that Caltrans considered and rejected many alternatives during the scoping process [Citation]. Nevertheless, Petitioners allege that the EIR fails to discuss a reasonable range of alternatives because the EIR considered only two "build" alternatives - with little variation between them - and failed to consider a transit-only alternative [Citation]. The Court agrees. The EIR did not include an in-depth discussion of the transit-only alternative because SACOG's [Sacramento Council of Governments] HOV-US 50 Corridor Study suggested that both light rail extensions and HOV lanes were necessary to alleviate congestion in the corridor [Citation]. But even if this statement is accurate, it is not a proper basis to reject the transit-only alternative as infeasible [Citation]. The test is not whether the transit-only alternative is the best strategy to achieve the Project's objectives, but whether it is a reasonable alternative that could feasibly accomplish most of the basic objectives of the Project and avoid or substantially lessen one or more of the Project's significant effects [Citation]. In this case, the objectives of the Project are to improve mobility, provide an option for reliable peak period travel time, improve traffic operations by reducing congestion and travel time, use highway facilities as efficiently as possible, provide incentives for commuters to use carpools, vanpools, or buses during peak period travel, and identify projects and strategies to improve adjacent street system and thereby enhance neighborhood livability [Citation]. The transit-only alternative is a potentially feasible alternative that could accomplish most of the basic objectives of the Project, while potentially avoiding or substantially lessening one or more potentially significant effects [Citation]. Thus, the transit-only alternative is a reasonable alternative that merits discussion and comparison to the two build options discussed in the EIR. Because the EIR included only two build alternatives, with little variation between them, Caltrans failure to include an in-depth discussion of the transit-only alternative precluded informed decision-making and informed public participation and rendered the EIR's discussion of alternatives inadequate (Minute Order, p. 14).

Under NEPA, agencies are under an obligation to follow their own regulations, procedures, and precedents, or provide a rational explanation for their departure (Big Horn Coal Company v. Temple [1986]). Although "business as usual" (BAU) has a separate meaning with regards to assessing GHG emissions, because the DEIR/S obviously suffers from the same maladies as the document prepared by Caltrans in the above referenced case, it would appears (through the presentation of the same defective analyses) that the Department believes that it is not required to accept judicial directions with regards to the preparation of adequate environmental documentation.

4.4.6 No Build Alternative

Under NEPA, Section 1502.14(d) of the CEQ Regulations requires that the alternatives analysis in an environmental impact statement (EIS) "include the alternative of no action." As described in the CEQ Questions: "There are two distinct interpretations of 'no action' that must be considered, depending on the nature of the proposal being evaluated. The first situation might involve an action such as updating a land management plan where ongoing programs initiated under existing legislation and regulations will continue, even as new plans are developed. In these cases 'no action' is 'no change' from current management direction or level of management intensity. To construct an alternative that is based on no management at all would be a useless academic exercise. Therefore, the 'no action' alternative may be thought of in terms of continuing with the present course of action until that action is changed. Consequently, projected impacts of alternative management schemes would be compared in the EIS to those impacts projected for the existing plan. In this case, alternatives would include management plans of both greater and lesser intensity, especially greater and lesser levels of resource development" (Question 3[a]).

Under CEQA, the Lead Agency misrepresents the "no build alternative" and, thereby, fails to provide the project's decision makers with an accurate and adequate environmental analysis. As indicated in the State CEQA Guidelines, where the project is a development project on identifiable property, the following applies: "[T]he no project alternative is the circumstance under which the project does not proceed. Here the discussion would compare the environmental effects of the property remaining in its existing state against environmental effects which would occur if the project is approved. If disapproval of the project under consideration would result in predictable actions by others, <u>such as the proposal of some other project</u>, this no project consequence should be discussed. In certain instances, the no project alternative means no build wherein the existing environmental setting is maintained. However, where failure to proceed with the project will not result in preservation of existing environmental conditions, the analysis should <u>identify the practical result of the project's non-approval</u> and not create and analyze a set of artificial assumptions that would be required to preserve the existing physical environment" (emphasis added) (14 CCR 15126.6[e][3][B]).

The State CEQA Guidelines further state that the "no-project" alternative is not necessarily the same as the environmental baseline (14 CCR 15126.6[e][1]).

With the exception of the "SR-22 WCC Project," the "Project EA 0J440K" (p. 2-23), and unspecified "Costa Mesa Freeway Improvements" (e.g., "The baseline conditions under the No Build Alternative would provide no additional lanes or interchange improvements to the I-405 corridor. The project area would continue to operate with no additional improvements with the exception that the two earlier committed projects [SR-22 West County Connectors (WCC) Project and the Costa Mesa Freeway (SR-55) Improvements would be implemented]," CIA, p. S-2), the Lead Agency represents the No Project Alternative as the maintenance of the status quo (e.g., "no improvements would be made to the I-405 corridor within the project limits," p. 2-23).

As indicated in the PSR/PDS: "The proposed project is currently funded with an estimated $500 million as part of the Renewed Measure M (local half-cent sales tax) freeway program. The Renewed Measure M program was reauthorized by the Orange County voters in November 2006, and it is set to begin in 2011 and sunsets in 2041. . .As part of an effort to reduce construction costs on the Renewed Measure M freeway projects, <u>OCTA will</u> be advancing the proposed project's Project Approval/Environmental Document (PA/ED) phase and fund this effort through the SAFETEA-LU demonstration funds and local Renewed Measure M matching funds" (emphasis added) (p. 38).

As indicated in correspondence from Will Kempton, OCTA's Chief Executive Officer to OCTA's Highways Committee (Subject: Update on Project Alternatives for the San Diego Freeway (Interstate 405 Improvement Project), dated August 17, 2009, the OCTA notes that "[t]o date, the focus of this evaluation has been on identifying what improvements could be built for the currently available funding (Alternative 4). . .The commitment in M2 is to add new lanes throughout the corridor, generally within existing ROW, from State Route 55 to Interstate 605, and Alternative 4 may not meet that commitment entirely" (p. 2).

Notwithstanding any declarations by the Lead Agency, it is noted that DEIR/S' Alternative 4, as referenced above, is not the same proposal as MIS Alternative 4, as identified in the MIS and purportedly carried forward by the Lead Agency as Alternative 1 in the DEIR/S (p. 2-3).

As indicated in the MIS, "[t]he Baseline Alternative (or No-Build Alternative) incorporates the funded and/or environmentally approved transportation improvements as of March 1, 2004. Highway improvements to the existing condition included in the Baseline are presented in Appendix 6.1. Within the study area, these improvements include: [1] Programmed headway and service improvements on the following OCTA transit routes: [a] 29 Beach Boulevard, [b] 43 Harbor Boulevard, [c] 47 Fairview, [d] 62 Huntington Beach-Santa Ana, [e] 64 Bolsa, and [f] 70 Edinger-Irvine Center; [2] Recently completed reconstruction of I-405 south of Euclid Street to SR-73 to provide additional travel lanes, auxiliary lanes, ramp braiding, and interchange improvements; [3] Construction of a northbound ramp from Hyland Avenue; [4] Addition of an auxiliary lane between Magnolia Avenue and Beach Boulevard; and [5] Addition of a second HOV lane in each direction north of the interchange with SR-22 (near Valley View Street) to I-605 including direct carpool lane connectors between SR-22 and I-405 and between I-405 and I-605" (p. 20-21).

As reported by the FHWA: "The effect of 'doing nothing' to the transportation system is probably intolerable. Under the two percent VMT growth rate – roughly a continuation of recent trends – peak-period congestion will worsen substantially" (LSP, p. 3-8). Doing nothing is obviously not an option available to the OCTA and Caltrans (i.e., OCTA's and Caltrans' mandates require affirmative actions). Assuming no funding augmentation, with $500 million (or $600 million) in allocated Measure M funds, based upon its own declarations, the OCTA would pursue other actions/measures to comply with the Measure M mandate. By again alleging that the proverbial "sky is falling" (e.g., "Congestion along the corridor would not be alleviated, and the situation would deteriorate with time," p. 2-23), that its "hands are tied" (e.g., "This alternative would be inconsistent with many regional and local planning goals and policies [e.g., cut-through traffic within neighborhoods located adjacent to I-405 during congested conditions, noise attenuation via the construction of soundwalls, enhanced roadway and freeway operations]," p. 3.1.1-20), and that the impacts of the "no build alternative" are greater than the impacts of the proposed action (e.g., "Direct effects of the No Build Alternative would include continued deterioration of freeway and local interchange operations. Indirect and cumulative effects of the No Build Alternative could include increased effects on the communities related to increased commute times and traffic diversion through adjacent neighborhoods," p. 2-24), the Lead Agency misrepresents both its consequential actions and those future project area conditions that would likely exist should Alternatives 1, 2, and 3 not be implemented.

To the extent that the Lead Agency seeks to define the project in a fashion that substantially deviates from its Measure M/M2 mandate and the purpose for which the funds have been allocated and fails to pursue a design option that can be reasonably implemented within the fiscal limits imposed by its available resources, it self imposes artificial constraints that promote an alternative agenda. With "$500 million" (or $600 million) in committed Measure M funding and a MIS that identifies a build alternative that can be implemented within that available budget (or close thereto), it has to be assumed that a No Build Alternative is both feasible and exists in the form of a $500 million (or $600 million) investment in localized freeway improvements. By asserting that "[t]he No Build Alternative is not considered a viable project alternative because it would not achieve the project's purpose" (p. 2-26) demonstrates that the "project's purpose" (as presented in the DEIR/S) is substantially different than the basis upon which Measure M/M2 funds were originally committed. Additionally, by indicating that Alternative 4 is not economically feasible, then the cost estimates which served as the factual basis upon which Measure M/M2 were passed were either intentionally underestimated or were so unprofessionally prepared as to bear no relationship to the stated improvements. Since the Lead Agency is now contemplating the expenditure of a purported "$1.7 billion" (p. 2-10) or more (purported to be $5.8 billion by OCTA's CEO), the accuracy of OCTA's cost estimating skills and the role that the Department has played in independently validating those costs (see Utahns for Better Transportation v. United States Department of Transportation [2002]) must be brought into question.

The fact that OCTA's eyes ($1.1 to $5.8 billion) may be bigger that its stomach ($500 to $600 million) does not alleviate either the OCTA's or Caltrans' from their obligations to produce an adequate environmental analysis.

Similar to NEPA, the State CEQA Guidelines set out the dual character of the "no-project" alternative in situations where some other future development is likely under existing designations if the present project is disapproved. As stipulated therein: "The no project analysis shall discuss the existing conditions at the time the notice of preparation is published as well as what would be reasonably expected to occur in the foreseeable future if the project were not approved, based on current plans and consistent with available infrastructure and community services" (14 CCR 15126.6[e][2]). Where the project is a development project on identifiable property, the following applies: "[T]he no project alternative is the circumstance under which the project does not proceed. Here the discussion would compare the environmental effects of the property remaining in its existing state against environmental effects which would occur if the project is approved. If disapproval of the project under consideration would result in predictable actions by others, such as the proposal of some other project, this no project consequence should be discussed. In certain instances, the no project alternative means no build wherein the existing environmental setting is maintained. However, where failure to proceed with the project will not result in preservation of existing environmental conditions, the analysis should identify the practical result of the project's non-approval and not create and analyze a set of artificial assumptions that would be required to preserve the existing physical environment" (14 CCR 15126.6[e][3][B]). Because that description is not premised on existing entitlements, the expenditure of the $500 to $600 million in committed Measure M/M2 funds constitutes what would be "reasonably expected to occur."

Although recognizing that "[t]he existing condition is the 'CEQA Baseline' condition" (p. 4-23), the Lead Agency errors in stating that "[t]he No Build Alternative represents the 'baseline' condition" (Traffic Study, p. 1-8) and "[t]he No Build Alternative provides a 'baseline' for comparing impacts associated with the build alternatives. The baseline conditions under the No

Build Alternative would provide no additional lanes or interchange improvements to the I-405 corridor. The project area would continue to operate with no additional improvements with the exception that the two earlier committed projects (SR-22 West County Connectors [WCC] Project and the Costa Mesa Freeway [SR-55] Improvements would be implemented)" (CIA, p. S-2). The City asserts that the No Build Alternative, or a variation thereof, must include those improvements that could be reasonably accomplished through the expenditure of $500 to $600 million in committed Measure M/M2 funds.

No other reference to the "Costa Mesa Freeway improvements" is presented in the DEIR/S. Further explanation of the nature and relevancy of those improvements is required, including an explanation why those improvements were not universally considered throughout the DEIR/S.

The DEIR/S' No Build Alternative does not meet applicable NEPA and CEQA requirements.

4.5 Operational Performance

The role of the EIR is to make manifest a fundamental goal of CEQA, namely to "inform the public and responsible officials of the environmental consequences of their decisions before they are made" (Laurel Heights Improvement Association v. Regents of University of California [1988]). In citing CEQA, the court stated that "'[t]he EIR must contain facts and analysis, not just the bare conclusions of the agency' [Citation]. 'An EIR must include detail sufficient to enable those who did not participate in its preparation to understand and to consider meaningfully the issues raised by the proposed project' [Citations]. 'CEQA requires an EIR to reflect a good faith effort at full disclosure; it does not mandate perfection, nor does it require an analysis to be exhaustive' [Citation]" (Bakersfield Citizens for Local Control v. City of Bakersfield [2004] [Bakersfield]). "Failure to comply with the information disclosure requirements constitutes a prejudicial abuse of discretion when the omission of relevant information has precluded informed decisionmaking and informed public participation, regardless whether a different outcome would have resulted if the public agency had complied with the disclosure requirements [Citations]" (Bakersfield, quoting from Dry Creek Citizens Coalition v. County of Tulare [1999]). Similarly, in Dry Creek Citizens Coalition v. County of Tulare (1999), the court stated that "[a]n adequate EIR must be 'prepared with a sufficient degree of analysis to provide decision makers with information which enables them to make a decision which intelligently takes account of environmental consequences' [Citation]."

As indicated in the DEIR/S: (1) "Alternative 1 is considered a viable project alternative because it would achieve the project's purpose and need by accomplishing the following: [a] Reduce congestion; [b] Enhance operations; [c] Increase mobility, improve trip reliability, maximize throughput, and optimize operations; and [d] Minimize environmental impacts and ROW acquisition" (p. 2-8); (2) "Alternative 2 is considered a viable project alternative because it would achieve the project's purpose and need by accomplishing the following: [a] Reduce congestion; [b] Enhance operations; [c] Increase mobility, improve trip reliability, maximize throughput, and optimize operations; and [d] Minimize environmental impacts and ROW acquisition" (p. 2-10); and (3) "Alternative 3 is considered a viable project alternative because it would achieve the project's purpose and need by accomplishing the following: [a] Reduce congestion; [b] Enhance operations; [c] Increase mobility, improve trip reliability, maximize throughput, and optimize operations; and [d] Minimize environmental impacts and ROW acquisition" (p. 2-14).

As indicated in Caltrans' "Performance Measures for the Quarter Ending December 31, 2011" (Office of Strategic Planning and Performance Management, undated), it is the Department's broader objective to, "[b]y 2012, ensure that 100% of projects meet their approved purposes and need at project completion" (Objective 3.3, p. 22). The corresponding performance measure is the "[p]ercent of projects that meet their approved purpose and need at project completion" (Ibid.). In the case of the proposed project, absent specified quantitative or qualitative standards, that performance measure is all but meaningless since there is no verifiable standard against which performance can be effectively judged. Merely stating that a specific project meets its "approved" P&N does not make it so absence of a qualitative or qualitative assessment of projected performance.

What constitutes an "approved" purpose and need statement, what agency is responsible for that approval, and what is the process through which "approval" is vetted? How does Caltrans calculate full or partial attainment and evaluate performance? Was the proposed action's P&N and single objective (see p. S-1) "approved" and, if so, by who?

As reported in "Suggested Procedures for Evaluating the Effectiveness of Freeway HOV Facilities" (Turnbull, Katherine F. Henk, Russell H., and Christiansen, Dennis L, February 1991):

> Many HOV facilities have been implemented without clearly defining the goals and objectives of the project. This lack of a clear understanding of the purpose and goal of the project makes evaluating the effectiveness difficult, since there is no way of knowing if the goal has been reached when the goal has not been defined. Compounding this problem in some cases is the use of objectives that either cannot be measured or are inappropriate.
>
> Many evaluations have been conducted using very general evaluation criteria. These measures may be as simple as a statement that the HOV lane should reduce travel times for bus and automobile commuters, without identifying the level of time savings that should occur. Thus, no benchmark or specific threshold is identified against which the project can be measured. If the HOV facility leads to any improvement in the general evaluation measure, the project is considered successful (p. 13).

The DEIR/S uses nebulous terms like "reduce," "enhance," "increase," "improve," "maximize," "optimize," and "minimize" (p. S-1); however, no effort has been made to: (1) define or quantify those terms so as to allow comparative evaluation; and (2) establish a yardstick above which conditions are deemed to be acceptable and below which they are deemed not. Freeway users might universally agree that "free flow conditions," "unrestrained speeds," and "extra-wide lanes" might be desirous; however, drivers accept some level of reduced flow and design constraints (e.g., speed limits) as trade-offs for living in southern California. Prior to stating that "we need this or that" (e.g., comparing "apples to apples" rather than "apples to oranges"), there needs to exist a more fundamental discussion concerning "what constitutes acceptable operational conditions" and "what types of trade-offs are reasonable, appropriate, and acceptable to fulfill broader societal goals."

By defining the project "corridor" as a short segment of the I-405 Freeway and ignoring the benefits in a more programmatic approach to corridor planning, the only question now being asked is how many and what type of new lanes should be constructed along a defined segment (defined not by the boundaries of the condition that the proposed action seeks to resolve but by relatively arbitrary points of ingress and egress). As a profession, traffic engineers are now debating choices such as building or not building parking structures, asking whether the incentivization or decentivization of downtown parking produces the greatest potential to reduce inner-city traffic snarls (i.e., getting vehicles out of downtown areas).

The USEPA's OBNE notes that "[d]evelopment patterns have contributed to increased vehicle use. Investment in highway capacity encourages more vehicle travel by temporarily reducing travel time and costs. Dispersed, low-density development with significant distances between housing, jobs, schools, and shopping make walking, bicycling, or use of transit difficult for most trips. Urban design that emphasizes the automobile, such as large surface parking lots, wide streets, and a lack of sidewalks, make vehicle use more comfortable and safer than walking or bicycling, even for short trips" (p. 2).

The traffic modeling presented in the DEIR/S only serves to allow the Lead Agency and the affected public to answer the comparative question of which alternative is "better" with regards to the variables presented (i.e., vehicle throughput and relative speed). It does not, however, allow decision makers and stakeholders to ascertain whether different investment options (e.g., dedicated truck lanes, public transit, and bicycle lanes) may produce greater or lesser gains.

The primary basis of the traffic study is vehicular throughput, defined as "the number of vehicles able to pass a fixed point along the corridor during the greatest hour of demand." This analytical approach focuses on vehicles passing particular points on the freeway but ignores a more critical measure of a transportation improvement, namely the movement of people and goods, particularly given our overburdened transportation system. Vehicle throughput does not provide complete disclosure of transportation impacts and mitigations (e.g., accommodation of added SOVs can adversely impact [a] the overall transportation system by reducing overall mobility and [b] the environment by increasing VMT) and results in a failure to consider other related transportation and environmental impacts beyond Caltrans' ROW.

Although the DEIR/S uses a number of indices focusing exclusively on vehicle counts, such as "vehicles per lane per hour" (vphpl) and "vehicles per hour" (vph) (e.g., p. 3.1.6-75), the fundamental focus of transportation planning should more rightfully be directed toward the movement of people and goods (not only on the movement of automobiles and trucks). One of the criteria that should be appropriately utilized to evaluation performance relates to the number of people moved. Since HOVs would typically include more occupants that SOVs, an emphasis on vehicle throughput would not serve as a valid yardstick; however, person throughput is never considered. With regards to "vehicle throughput," as indicated in Table 11 (I-405 Improvement Project Alternatives Comparison - Vehicle Throughput), the Lead Agency makes specific representation as to performance (measured in percent improvement). Vehicle throughput is, however, measures against the Lead Agency's No Project Alternative which incorrectly assumes no improvements to the designated corridor, including those fully funding improvements identified in Alternative 4.

Table 11
I-405 Improvement Project Alternatives Comparison - Vehicle Throughput

Performance	Alternative 1	Alternative 2	Alternative 3	No Build Alternative
SR-73 to Brookhurst Street	0%	0%	24%	Not specified
Brookhurst Street to SR-22 East	20%	40%	50%	Not specified
SR-22 East to I-605	13%	25%	23%	Not specified

Source: California Department of Transportation, Draft Environmental Impact Report/Environmental Impact Statement – San Diego Freeway Improvement Project, Orange and Los Angeles Counties, California, SCH #2009091001, Table 2-1 (I-405 Improvement Project Alternatives Comparison), p. 2-30

In "What We've Learned about Highway Congestion," included in "Access – Transportation Research at the University of California" (Fall 2005), the author (Pravin Varaiya) notes: "A high-occupancy-vehicle (HOV) restriction reduces congestion by encouraging carpooling. But it also increases congestion in two ways. First, the restriction imposes a non-HOV congestion penalty by increasing congestion on the non-HOV lanes. Second, it imposes an HOV capacity penalty by decreasing the capacity of the HOV lane itself. Analysis of Bay Area data suggests that the effect of the combined penalties is larger than the positive carpooling effect. Thus, the likely net result of HOV restrictions in the Bay Area is worsening congestion. Bay Area data facilitate such assessments because the area's HOV lanes are time limited (5:00 to 9:00 a.m. and 3:00 to 7:00 p.m.), allowing us to compare traffic on the same freeway segments during and outside of HOV restriction periods" (p. 7).

"Bay Area data" would appear to have substantial relevancy in assessing the proposed project because much of the methodology cited in the DEIR/S was "developed by Bay Area Metropolitan Transportation Commission" (e.g., Traffic Study, pp. 2.5-25, 2.6-25, and 2.7-27). Why were "time limited" HOV lanes not included in the environmental analysis?

As further indicated in "Caltrans Strategic Plan 2007-2012" (December 17, 2007) and Caltrans' "Performance Measures for the Quarter Ending December 31, 2011" (undated), one of the Department's mobility goals states: "By 2012, reduce single occupancy vehicle (SOV) commute trips by 5%" (Objective 2.4). Pursuant to its strategic plan, strategies to accomplish that objective include: (1) "Work closely with local jurisdictions on land use issues to promote mode shift" (Strategy 2.4.1); (2) "Partner with stakeholders and region on implementing Transportation Demand Strategies" (Strategy 2.4.2); (3) "Establish baseline performance data for vehicle occupancy" (Strategy 2.4.3); (4) "Improve interconnectivity between modes (Strategy 2.4.4); (5) Complete California's HOV system" (Strategy 2.4.5); (6) "Partner with transit and rail authorities making transit options more useful, inviting, and less difficult to use" (Strategy 2.4.6); (7) "Increase support for non-motorized and promotion/incentives for use of other alternative means of transportation" (Strategy 2.4.7); and (8) "Assess the need for a Park and Ride Lot Program" (Strategy 2.4.8). The corresponding "performance measure" is the "percent of single-occupant vehicles compared to the total commute trips" (PM2.4A). As outlined in "Performance Measures for the Quarter Ending December 31, 2011," categories of "commute trips" include drove alone (single-occupant vehicles), carpooled, public transportation, walked, bicycle, motorcycle, other means, and worked at home. The performance report states that a reduction in SOV commute trips is the "desired trend."

Notwithstanding that Statewide policy declaration, under Alternative 3, Caltrans is proposing to allow SOVs to utilize the HOT lanes, thus creating an incentive for single-occupant travel and, in so doing, a disincentive for carpool formation. Although the Traffic Study alleges that "[t]he Express Lanes would encourage carpooling" (p. 1-12), the introduction of HOT lanes would appear to promote rather than curtain single-occupant automobile usage. As such, because the Department's Statewide goals appear divergent from project-specific objectives, the DEIR/S should explain this apparent dichotomy and describe how the introduction of HOT lanes will promote the attainment of Statewide "Objective 2.4."

As specified in the FHWA's "Federal-Aid Highway Program Guidance on High Occupancy Vehicle (HOV) Lanes" (August 2008), "[e]ffective management of an HOV lane involves developing and using an HOV operation and enforcement plan, along with a performance-monitoring program (p. II-2). States implementing low-emission and energy-efficient and/or HOT vehicle exceptions must operate in accordance with the restrictions and requirements of

Section 166(d) in Title 23 of the U.S.C. which established a minimum average operating speed that HOV facilities with exempted vehicles must maintain. In accordance therewith, the minimum average operating speed is defined at Section 166(d)(2)(A) as 45 miles per hour (mph) for an HOV facility with a speed limit of 50 mph or greater and not more than 10 mph below the speed limit for a facility with a speed limit of less than 50 mph.

The Federal Clean Air Act Amendments (CAAA) created the inherently low-emission vehicle (ILEV) program and TEA-21 allowed States to authorize ILEVs to use HOV lanes without meeting the occupancy requirements. Absent from the Lead Agency's air quality conformity analysis is any reference to or compliance with this authorization.

Recently approved regulations of the California Air Resources Board (CARB) require automobile manufacturers to offer more zero- or very low-emission cars (e.g., battery electric, hydrogen fuel cell and plug-in hybrid vehicles) in California starting with model year 2018. By 2025, one in seven new automobiles sold in California (roughly 1.4 million) must be ultra-clean.

As indicated in Table 2.5.10 (Speed Index and Demand-to-Capacity Ratio Summary – Alternative 1 [2040]), as presented in the Traffic Study, no segments of the designated corridor achieve that standard. As further indicated in Table 2.6.10 (Speed Index and Demand-to-Capacity Ratio Summary – Alternative 2 [2040]), with the sole exceptions of northbound Brookhurst to SR-22 East during the AM peak hour and southbound Brookhurst to SR-22 East in the PM peak hour, under Alternative 2, the HOV lane does not appear to meet the specified standard. Although the Lead Agency deems Alternative 2 to be a success (i.e., "Alternative 2 is considered a viable project alternative because it would achieve the project's purpose and need," p. 2-10), low-emission, energy-efficient, and HOT vehicles would be prohibited from using the HOV lane. Building in prohibitions on use by low-emission and energy-efficient vehicles would appear contrary to any P&N statement promoting the minimization of environmental impacts. No such disclosure is, however, presented in the DEIR/S.

Referencing Table 2.7.10 (Speed Index and Demand-to-Capacity Ratio Summary – Alternative 3 [2040]), the City acknowledges that all segments of the corridor exceed the federal standard; however, because it was neither established as an objective nor examined by the Lead Agency, the Department never considers potential modifications to Alternative 2 (e.g., increased vehicle occupancy requirements) allowing utilization by low-emission and energy-efficient vehicles.

Conversely, Section 166(d)(2)(B) provides that an HOV facility is considered degraded if average operating speed in the HOV lanes drops below 45 mph for 90 percent of the time over a consecutive 180-day period during morning or evening weekday peak hour periods (or both for a reversible facility). If HOT or low-emission and energy-efficient vehicles are allowed to use an HOV lane and the lane becomes degraded, Section 166(d)(1)(C) requires the State to limit or discontinue the use of the lane by the number of HOT vehicles and/or low-emission and energy-efficient vehicles necessary to bring the facility back to compliance or to take other actions that will quickly bring the operational performance up to the Federal standard.

When exempted vehicles are allowed to operate on HOV facilities, the State must annually certify to the FHWA that it continues to meet all requirements of 23 U.S.C. 166, including those related to vehicle eligibility; operational performance monitoring, evaluation, and reporting; and enforcement. The State is required to include in its certification a clear demonstration that the presence of low-emission and energy-efficient or HOT vehicles has not caused the facility to become degraded (as defined by 23 U.S.C. 166[d][2][A]).

For HOT lanes (pursuant to 23 U.S.C. 166[d]), the following additional elements are required in the annual certification: (1) the State must indicate the presence of a program that addresses how motorists can enroll and participate in the toll program; (2) the State must indicate that it has implemented a system that will automatically collect the tolls or indicate that such a system will be implemented in a reasonable period of time following establishment of the HOT lane; and (3) the State must demonstrate policies and procedures to manage demand for the facility by varying the toll amount, if necessary to ensure acceptable performance. Absent from the DEIR/S is any discussion of: (1) the existing facility's compliance with those standards; (2) the ability of Alternative 3 to conform therewith; and (3) operational and monitoring considerations proposed to ensure on-going attainment of operational performance requirements. In addition, based on those projects and other actions identified therein, the OCTA's 2010 LRTP identifies "level of improvement of the Year 2035 Unconstrained Plan over the Year 2035 Baseline" (p. 89). Those performance measures, as listed in Table 12 (Unconstrained Plan Performance Analysis), constitute potential performance standards against which individual project's can and should be judged. Absent from the DEIR/S, however, is any reference to those performance measures or any evaluation of the proposed action's furtherance or compliance thereof.

Table 12
Unconstrained Plan Performance Analysis

Performance Measure	2035 Baseline	2035 Unconstrained Plan
Daily vehicle hours traveled	3.4 million	Reduce by 24%
Daily hours of delay due to congestion	1.5 million	Reduce by 58%
Average peak period freeway speed (AM)	29 miles per hour	Increase by 31%
Average peak period HOV speed (AM)	35 miles per hour	Increase by 32%
Average peak period roadway speed (AM)	13 miles per hour	Increase by 86%
Daily transit trips	144,000	Increase by 55%

Source: Orange County Transportation Authority, Destination 2035 – Moving Toward a Green Tomorrow, Table 5-12 (Unconstrained Plan Performance Analysis [Compared to 2035 Baseline), p. 89.

4.6 Toll Revenues

If a State chooses to implement variable or dynamic pricing on an HOV facility, a Section 166 (23 U.S.C. 166) toll agreement must be executed pertaining to the use of toll revenue collected from the operation of the facility. Specifically, tolls may be collected subject to the requirements of Title 23 U.S.C. Section 129, which mandates that all toll revenues will be used first for debt service, for reasonable return on investment of any private person financing the project, and for the costs necessary for the proper operation and maintenance of the facility (including reconstruction, resurfacing, restoration, and rehabilitation). Section 129 further provides that if there are any excess revenues, then the State may use these revenues for any purpose that is eligible under Title 23 as long as the State annually certifies that the facility is being adequately maintained. Section 166 further requires that the State, in using any excess toll revenue, give priority consideration to projects for developing alternatives to SOV travel and projects for improving highway safety.

To the extent that a public project produces revenues, those revenues constitute a component of the proposed action and are, therefore, a subject of the resulting environmental analysis. Absent from the DEIR/S, however, is any discussion of toll revenues, such as the amount anticipated, authorizations concerning and limitations regarding the use of those funds, and

OCTA's tentative plans concerning those public monies (e.g., "All toll revenues would go to the P3 Concessionaire"). Also, the Lead Agency does not specify whether a P3 agreement (including the allocation of public funds to private for-profit entities), as a component of the proposed action or a consequential result thereof, is subject to CEQA and/or NEPA compliance.

How would the conveyance of "all toll revenues" to a private concessionaire affect the ability of the OCTA and the Department to utilize those same revenue to pursue TSM/TDM programs or provide environmental mitigation in response to the proposed action? What are the projected gross and net revenues from Alternative 3 and how was that projection derived? What economic information is presented to or will likely be presented to the project's decision makers that has not been included in the DEIR/S? Why has the Lead Agency elected not to include any economic information in the DEIR/S?

Since the DEIR/S does not address the generation or dispersion of toll revenues, design-build construction strategies, or P3 agreements, insufficient information is provided by the Lead Agency to submit meaningful comments thereupon. The City's inability to raise substantive comments should neither be construed by the Lead Agency as any endorsement of agency plans or proposals nor affirmation that construction and operational (e.g., "The operation of the tolled lanes would be funded by toll revenue, p. 2-3) issues regarding those items would not result in the generation of potentially significant environmental effects.

4.7 Consistency with Regional and Local Transportation Plans

4.7.1 Consistency with Regional Transportation Plans

As indicated in the DEIR/S, the "proposed project is included in the 2008 Regional Transportation Plan (RTP) and 2011 Federal Transportation Improvement Program (FTIP) and includes the following project description for the project [ORA030605]: "FROM SR-73 TO I-605 ADD 1 MF [mixed flow or GP lane] LANE EACH DIR AND PROVIDE ADDITIONAL CAPITAL IMPROVEMENTS, INCLUDING PROJECTS ORA045, ORA151, ORA120310" (pp. 1-1 and 4).

As indicated in the OCTA's "Project Study Report/Project Development Support" (July 2008): "The proposed project is included in the Southern California Association of Governments 2004 Regional Transportation Plan (RTP) as project ORA030605. The project was added to the RTP in Amendment #3, which was adopted June 7, 2007. <u>The project is included in the RTP for study only</u>. The project description would "<u>construct on</u> [sic] <u>additional general purpose lane</u> in each direction on I-405 and provide additional improvements from SR-73 to LA County line" (emphasis added) (p. 18). From these excerpts, with regards to conformity with the RTP, regional plan consistency only exists to the extent that a single mixed-flow (general purpose) lane where to be implemented (Alternative 1) (e.g., "Alternative 2 is not consistent with the RTP or FTIP," p. 3.1.1-31; "Alternative 3 is not consistent with the current RTP or FTIP, p. 3.1.1-32). Similarly, since ORA030605 was included "for study only," from that declaration, it cannot be assumed that the merely listing of that project equated to regional plan consistency.

As indicated in the CIA, Alternatives 2 and 3 are "[c]urrently, inconsistent with the Regional Transportation Plan (RTIP) 2008" (p. S-4). The DEIR/S notes that "the design concept and scope for Alternatives 2 and 3 are substantially different from what was analyzed in the <u>2008</u> RTP" (emphasis added) (p. 4-5) and "Alternatives 2 and 3 will have to go through the SCAG RTP and FTIP amendment process prior to being able to determine consistency with the plans" (p. 4-5). As such, neither Alternatives 2 nor 3 can be deemed consistent with the RTIP.

On December 12, 2011, the OCTA Board approved the OCTA's "Express Lane Planning and Implementation Principles." As indicated, in part, therein: (1) "Design and management of the interface of express lane facilities with existing freeway, high-occupancy vehicle, and express facilities shall seek to achieve a consistent, seamless user experience"; (2) "Express lane projects shall not be implemented to replace committed projects to be funded with local transportation sales tax revenues"; (3) "Although Caltrans and Federal Highway Administration control highway operations, OCTA does not intend to replace existing mixed-flow freeway lanes with express lanes"; and (4) "Existing high-occupancy vehicle lanes may be functionally encompassed within an express lane, provided: (a) The total number of lanes is increased by the project; and (b) Both vehicle throughput and average vehicle occupancy levels can be maintained and/or improved" (emphasis added).

Absent from the DEIR/S is any reference to or analysis of the proposed actions consistency and compliance with OCTA's adopted "Express Lane Planning and Implementation Principles." However, since "[e]xpress lane projects shall not be implemented to replace committed projects," it would appear that Alternative 4 constitutes the only build alternative consistent with that policy document. What is the Lead Agency's definition of "committed projects"?

In addition, absent from the DEIR/S is any analysis of the proposed action's consistency with the 2012 RTP/SCS. Since "[l]and use impacts would occur if the proposed project effects would conflict either with General Plan land use designations or zoning, or with applicable environmental plans and policies" (p. 3.1.1-20), the DEIR/S' failure to address (or even acknowledge the existence of) the 2012 RTP/SCS prevents the Lead Agency from determining the presence of potential conflicts with applicable plans and policies.

The 2012 RTP/SCS notes that the congestion management process (CMP) "requires and ensures that highway capacity projects that significantly increase the capacity of single occupancy vehicles (SOV) be developed in a comprehensive context that considers all possible alternatives, including transit, TDM and TSM strategies" (emphasis added) (p. 40). As a result of the inclusion of Alternative 3 and its allocation of finite capacity to SOVs to the deference of HOV+2, any assertion of regional plan consistency would necessitate that the proposed action's CEQA and NEPA documentation examine the project in a "comprehensive context" (e.g., program-scale corridor planning) and include an expanded analysis of both transit and TDM/TSM alternatives.

As further evidence of project fragmentation, ORA030605 has been included on the list of "FTIP Project" in the 2012 RTP/SCS. That project is described as "I-405 FROM SR-73 TO I-605 ADD 1 MF LANE EACH DIR AND PROVIDE ADDITIONAL CAPITAL IMPROVEMENTS. #317. COMBINED WITH ORA045, ORA151 AND ORA120310" (emphasis added) (p. 66). Although those "combined" projects are not separately identified in the 2012 RTP/SCS, referencing the "Orange County RTIP Project" list which was included in the 2008 RTP, the following additional projects have been identified: (1) ORA045 – "BOLSA AVE (CHESTNUT TO GOLDENWEST) WIDEN BOLSA AVE BRIDGE FROM 4 TO 6 LANES" (p. 47); (2) ORA120310 – "WESTMINSTER – GOLDENWEST BRIDGE WIDENING OVER I-405, ADD 1 SB LN (5 TO 6 LNS)" (p. 50); and (3) ORA151 – "BOLSA CHICA RD (DUNCANNON TO RTE 405 WIDEN FROM 4 TO 6 LANES" (p. 51). Although SCAG now defines ORA030605, ORA045, ORA151, and ORA120310 as a single project, improvements to "combined" local arterials and bridge overcrossings have been separately processed and have neither been identified as a part of the proposed action nor have the cumulative impacts of those improvements been incorporated into the Lead Agency's analysis of cumulative environmental effects.

4.7.2 Consistency with Local Transportation Plans

The determination of consistency of lack of consistency with local plans is a critical determination under NEPA. In Maryland-National Capital Park and Planning Commission v. U.S. Postal Service (1973), the Court stated: "When local zoning regulations and procedures are followed in site location decisions by the Federal Government, there is an assurance that such 'environmental' effects as flow from the special uses of land - the safety of the structures, cohesiveness of neighborhoods, population density, crime control, and esthetics - will be no greater than demanded by the residents acting through their elected representatives." Although a limited number of compatible policies may be identified, in whole, the City has determined that the proposed action is not sufficiently consistent with the Seal Beach General Plan.

Based on their unique perspective and special expertise, the Lead Agency should defer to local government decisions concerning the interpretation and project-specific application of local plans and policies adopted by those agencies for the purpose of environmental protection.

5.0 ENVIRONMENTAL COMPLIANCE

CEQA contains a "substantive mandate" requiring public agencies to refrain from approving projects with significant environmental effects if "there are feasible alternatives or mitigation measures" that can substantially lessen or avoid those effects (Mountain Lion Foundation v. Fish and Game Commission [1997]). As specified in Citizens of Goleta Valley v. Board of Supervisors (1988): "CEQA defines 'feasible' as 'capable of being accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, social, and technological factors' [Citation]. The fact that an alternative may be more expensive or less profitable is not sufficient to show that the alternative is financially infeasible. What is required is evidence that the additional costs or lost profitability are sufficiently severe as to render it impractical to proceed with the project." Compliance with that "substantive mandate" requires that the Lead Agency both "describe a range of reasonable alternatives to the project, or to the location of the project, which would feasibly attain most of the basic objectives of the project but would avoid or substantially lessen any of the significant effects of the project" (14 CCR 15126.6[a]) and "identify and focus on the possible significant impacts of the proposed project" (14 CCR 15126.2[a]). Absent from the DEIR/S is both a range of reasonable alternatives and objective analysis of the potential environmental effects of the proposed action.

5.1 Tiering or Environmental Documents

CEQ Regulations (40 C.F.R. Parts 1500-1508) and FHWA regulations (23 C.F.R. 771.111[g]) recognize the use of tiering as one option for complying with NEPA. The intent if tiering is to encourage agencies to eliminate repetitive discussions and focus on the actual issues which are ripe for decision at each level of environmental review.

The genesis of the proposed action stems from the passage of Measure M in November 1990 and Measure M2 in November 2006. Each of the capital improvements projects identified therein constitute a "program" collectively addressing identifiable and interrelated traffic and transportation problems within Orange County. Additionally, projects that are consistent with applicable regional transportation plans can avail themselves of certain environmental standards and practices designed to promote both permit streamlining and environmental disclosure. Although both CEQA and NEPA encourage and promote the "tiering" of environmental documents, the Lead Agency has not elected to tier the DEIR/S upon the 2012

RTP/SCS PEIR. It is assumed that the decision not to pursue tiering is the result of: (1) the 2012 RTP/SCS' broader focus on sustainability and the implications of that focus on alternative solutions and general aversion to SOVs; (2) the lack of consistency between the proposed action and the 2012 RTP/SCS; (3) an attempt to support the asserting that the proposed action has "independent utility and logical termini" and can be viewed as independent of other segments of the regional network; and/or (4) an attempt to avoid the disclosure of cumulative environmental effects, including the linkage between transportation and growth.

As indicated in the SAFETEA-LU Guidelines: "The FHWA/FTA guidance on linking planning and NEPA describes considerations for using planning information in the NEPA process. In accordance with that guidance: [1] The purpose and need for a project can be shaped by goals and objectives established in a corridor or subarea study carried out by a state DOT, MPO [metropolitan planning organization], or transit agency as part of the statewide or metropolitan planning process; [2] A general travel corridor or general mode or modes (i.e., highway, transit, or a highway/transit combination) resulting from transportation planning analyses may be part of the project's purpose and need statement; and [3] If the financial plan for an MPO's long-range transportation plan indicates that funding for a specific project will require special funding sources (e.g., tolls or public-private financing), such information may be included in the purpose and need statement" (Question 33).

As further indicated in the FHWA's "Guidance on Using Corridor and Subarea Planning to Inform NEPA" (April 5, 2011): "In February 2007, the Federal Highway Administration (FHWA) and Federal Transit Administration (FTA) issued statewide and metropolitan transportation planning regulations that implemented changes to Federal law as a result of Public Law 105-178, the Transportation Equity Act for the 21st Century (TEA-21) and Public Law 109-59, the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). The transportation planning regulations supplement authority under the Council on Environmental Quality (CEQ) NEPA regulations and allow the FHWA and FTA, as NEPA lead agencies, to use the results or decisions of in State department of transportation (DOT), metropolitan planning organization (MPO), or public transportation operator corridor and subarea planning studies as part of the environmental review process under NEPA so long as legal requirements are met. . .The statewide and metropolitan transportation planning regulations and Appendix A to 23 C.F.R. Part 450 allow for analysis from corridor and subarea studies to be fully utilized during project environmental review, when conditions in that regulation are satisfied" (pp. 1-2). "Corridor and subarea studies can be used to produce a wide range of analyses or decisions for FHWA review, consideration and possible adoption in the NEPA process for an individual transportation project, including: [1] The foundation for purpose and need statements; [2] Definition of general travel corridor and/or general mode(s); [3] Preliminary screening of alternatives and elimination of unreasonable alternatives; [4] Planning-level evaluation of indirect and cumulative effects; [5] Regional or eco-system-level mitigation options and priorities; and [6] Linkage with housing, development, economic, and environmental goals and analysis" (p. 5). Despite those benefits, no efforts have been made to either define the proposed action in the context of a broader planning-related corridor or utilize foundational work contained in SCAG's subarea plans.

5.2 Fragmentation/Segregation

As indicated in the NSR: "I-405 is considered a bypass route to the Interstate 5 (I-5) Santa Ana/Golden State Freeway through Orange County and an important component of the county's transportation system" (emphasis added) (p. 1). As further indicated in the DEIR/S, the "I-405 represents a major link to other freeway systems within the Orange County area and is a strategic component of the county's transportation system" (emphasis added) (p. 1-19). Webster defines a "system" as "[a] regularly interacting or interdependent group of items forming a unified whole." Although the Lead Agency recognizes that the I-405 Freeway is part of a larger functioning and interconnected "system," only a small part of that system has been considered in the DEIR/S. Absent from the DEIR/S is any discussion of the operation of the system as a whole or the relationship between its component parts. For example, to the extent that the I-405 is a "bypass route to the Interstate 5," then the converse is likely true (i.e., Interstate 5 is a bypass to the I-405). During the project's 4.5-year construction period, some number of drivers may, therefore, elect to divert their trips to the I-5 Freeway in order to avoid the construction zone. Similarly, once a toll is imposed, non-toll paying SOVs and HOV+2 (who might otherwise be charged a toll) may change their trip patterns to use the I-5 in lieu of the I-405 Freeway. Although the relationship between those two highways is acknowledged (i.e., "bypass"), no analysis of trip diversion between those two highways is presented.

Pursuant to Section 1501.2(b) of the CEQ Regulations, agencies shall "identify environmental effects and values in adequate detail so they can be compared to economic and technical analyses." The federal court (Fritiofson v. Alexander) has stated that CEQ's regulations require connected, cumulative, and similar actions to be considered together in the same EIS. Where proposals are functionally or economically related, those proposals must be considered in a single EIS.

In "Update on Project Alternatives for the San Diego Freeway (Interstate 405 Improvement Project)," as presented at the OCTA Board of Director's August 24, 2009 meeting, the OCTA noted that if the I-405 Freeway were to be "built for demand – up to 20 lanes [would be] needed" (p. 3). The PSR/PDS identifies a 2030 horizon year (e.g., "The design year used for the PSR/PDS is 2030 as approved by the PDT [Project Development Team]. Year 2030 is the current forecast year for OCTAM [Orange County Transportation Analysis Model] and the horizon year for the SCAG Regional Transportation Plan," p. 16).

In actuality, the forecast year for the 2012 RTP/SCS is not 2030 as indicated in the DEIR/S but 2035. As indicated in the DEIR/S' traffic analysis, a 2040 design year has been assumed (p. 3.1.6-39). If "up to 20 lanes" were determined to be "needed" by 2030, an even greater number of lanes would logically be needed in either 2035 or 2040. The Lead Agency states that the "No Build Alternative configuration would not accommodate future traffic demand" (p. 2-23). However, since OCTA itself states that "20 lanes [are] needed" by 2030, it is evident that none of the three build alternatives will "accommodate" projected future traffic demand. From those excerpts, it become evident that the proposed action constitutes only a short-term solution to identified "congestion" problems and that the proposed improvements include an eye toward subsequent expansion (e.g., "Alternative 3 would provide a full standard highway cross section, with 12-ft-wide mainline travel lanes and shoulders on the left and right sides in both directions," p. 2-11). As such, while building in flexibility for later expansion through retention of lane-sized shoulders, the Lead Agency recognizes but never discloses the anticipated need for subsequent improvements to the I-405 Freeway corridor beyond its stated horizon. Just as geographic boundaries cannot be arbitrarily set to avoid the analysis of "what's just around the corner," self-imposed blinders cannot be installed to avoid, at least a perception, of "what's up ahead."

In certain circumstances, California authorizes the use of shoulders and/or narrow lanes on freeways as travel lanes. As indicated in the FWHA's "Efficient Use of Highway Capacity Summary – Report to Congress" (November 2010): "In dedicated shoulder-lane operations, either general purpose or HOV-specific capacity has been added through the permanent conversion of shoulders. Most HOV applications use the interior lane for HOV operations, while the exterior shoulder is used for general purpose traffic so as to maintain the same number of general purpose lanes that existed prior to implementation. A typical HOV application would convert a three-lane freeway with 12-ft lanes, 10-ft exterior shoulder, and 8-ft interior shoulder to 11-ft general purpose lanes, 14-ft (including buffer striping) HOV lane, 5-ft exterior shoulder, and 2-ft interior shoulder" (pp. 25-26). While "[i]t is always desired to have a minimum 12-ft lane width for all freeway travel lanes. . .with regard to temporary shoulder use, narrower lane widths can be acceptable due to the limited use and operating conditions during their use" (p. 35). Designed with a 14-foot wide interior shoulder and 10-foot wide exterior shoulder, the proposed I-405 Freeway improvements could be subsequently converted to readily accommodate both an additional HOV/HOT lane and an additional GP or transit-only lane. Within the general project area, such conversions have occurred along the I-5 Freeway.

By maintaining shoulder widths conforming to the above standards, the Lead Agency appears acknowledge that additional capacity-enhancing efforts will be required in the future. The conversion of interior and exterior shoulders to temporary of permanent HOV and GP lanes would appear a logical "next step."

In accordance with CEQ Regulations, the purpose of cumulative effects analysis is to document agency consideration of the context and intensity of the effects of a proposal for agency action, particularly whether the action is related to other actions with individually insignificant but cumulatively significant impacts (40 CFR 1508.27[b][7]). Under NEPA, the federal court noted that "[p]lanning and building highways in a piecemeal fashion threatens to frustrate [the analysis of alternatives required by NEPA] by allowing a gradual, day-to-day growth without providing an adequate opportunity to assess the overall, long-term environmental effects of that growth" (Patterson v. Exon [1976]). Under CEQA, segmentation occurs when a single project is split into smaller components with the effect of avoiding analysis of the environmental impacts of the total project (Burbank-Glendale-Pasadena Airport Authority v. Hensler [1991]). The harm created by segmentation is that "a narrow view of a project could result in the fallacy of division, this is, overlooking its cumulative impacts by separately focusing on isolated parts of the whole." Accordingly, under CEQA, the term "project" is "given a broad interpretation in order to maximize protection of the environment" (McQueen v. Board of Directors of the Mid-Peninsula Regional Open Space District [1988]). An "impermissably truncated" project description severely distorted not only the actual project but the alternatives to the project. Even were the EIR is deemed to be adequate in all other respects, the selection and use of a "truncated project concept" constitutes a violation of CEQA (County of Inyo v. City of Los Angeles [1981]).

As indicated in Caltrans' "California HOV/Express Lane Business Plan 2009," excluding toll roads in Orange County (e.g., SR-73, SR-133, SR-241, and SR-261), "[a]s of July 2008, the existing HOV lane system had 1,424 existing lane-miles and 124 lane-miles under construction. Future expansion of the network includes 269 programmed lane-miles and 974 proposed lane-miles planned by state and local agencies" (p. 5). In that publication, no "express lanes" are "planned or programmed" along the I-405 Freeway between the I-605 and SR-73 Freeways. Although the proposed action constitutes a modification of and addition to the "California HOV/Express Lane Business Plan," by asserting that the proposed action has independent utility and logical termini" (DEIR/S, p. 1-24), the Lead Agency seeks to ignore the existence of and contributory environmental impacts of those functionally or economically-related facilities.

In Kings County Farm Bureau v. City of Hanford (1990), the court ruled that an EIR is deficient if it "avoids analyzing the severity of the problem and allows the approval of projects which, when taken in isolation, appear insignificant, but when viewed together, appear startling."

For example, the Department states that anticipated toll rates for travel through the designated 14-mile to 16-mile corridor may be $9.75 during peak period (p. 2-20). It is not inconceivable that tolls along the abutting limited-length "corridor" to the north (under the jurisdiction of the Los Angeles County Metropolitan Transportation Authority) and tolls along the abutting limited-length "corridor" length to the south (under the jurisdiction of the OCTA but potentially operated by a different P3 concessionaire) might also be "similar" (expressed in 2012 dollars). A driver's 42-mile to 48-mile morning commute to work might, therefore, cost $29.25 or, assuming those rates are reversed during the PM peak hour, $58.50 a day ($292.50/ week or $14,625/year).

As indicated in the Seal Beach General Plan (Housing Element), "[t]he area median income for Orange County in 2011 was reported as $84,200. For extremely-low-income households in Orange County, this results in an income of $27,700 or less for a four-person household, when adjusted for high housing costs" (p. II-7). Based on that median annual income, an Orange County resident using the proposed HOT lanes as a part of a daily commute to work would spend over 50 percent of their household income merely on toll fees. Toll fees would likely consume too large of a percentage of living costs even for occasional use.

Similarly, as indicated in the LACMTA's "HOV Performance Program Evaluation Report," "[l]ow speeds encountered as vehicles in the carpool lanes approach the carpool lane terminus and experience delays reentering the general-purpose traffic stream. These delays can nullify travel time savings accrued upstream while traveling in the carpool lane" (p. 96). To the extent that the Lead Agency seeks to define the project "corridor" as only a segment of an interconnected network, the environmental analysis needs to acknowledge that substantial bottlenecks will be created at each end and that any alleged travel time savings may, in fact, be "nullified." By focusing exclusively on the identified corridor, insufficient information is presented to fully consider the traffic-related ramifications both to the north and to the south.

As indicated in "San Diego Freeway (I-405) Frequently Asked Questions" (USDOT, Caltrans, and OCTA, undated) (http://www.octa.net/pdf/405/faq.pdf):

> The maximum number of lanes northbound on I-405 under any of the current alternatives would be ten, including two carpool lanes. Conceptual engineering showed that two lanes would be terminated into SR-22/7th Street, three lanes (one carpool lane and two general purpose) would terminate into I-605 northbound, and five lanes (one carpool lane and four general purpose) would continue northbound on I-405 matching the existing condition in LA County. During the upcoming environmental and preliminary engineering phase, a detailed traffic study will be conducted to determine what potential traffic impacts might occur near the LA County line and how such impacts might be avoided, minimized, or mitigated (Question 20).

Despite the Lead Agency's declaration that potential bottlenecks attributable to lane merging near the County line will be examined in the DEIR/S, no such analysis is presented therein.

As outlined in 23 C.F.R. 771.111(f), in order to ensure meaningful evaluation of alternatives and to avoid commitments to transportation improvements before they are fully evaluated, the action evaluated in each EIS shall: (1) connect logical termini and be of sufficient length to address environmental matters on a broad scope; (2) have independent utility or independent significance (i.e., be usable and be a reasonable expenditure even if no additional transportation improvements in the area are made); and (3) not restrict consideration of alternatives for other reasonably foreseeable transportation improvements. The FHWA's assessment of independent utility and logical termini occurs during the NEPA review and is intended to include consideration of whether the proposed action will result in a usable facility and will be a reasonable expenditure, even if no additional improvements in the area are made.

Referencing the "HOV/Express Lane Business Plan 2009": "According to a report by Caltrans, nearly 50% of the HOV lanes in the state experience periods of degradation in the peak hour according to the federal definition – meaning that average speeds of 45 mph speed or lower have been measured more than 10% of the time" (p. 9). As such, "50% of the HOV lanes" in California share a similar malady. Rather than seeking a cure, Caltrans seeks to apply temporary solutions one freeway leg at a time.

Absent from the DEIR/S is any reference to the following current HOT/HOV lane projects: (1) "Draft Environmental Impact Report/Environmental Impact Statement and Section 4(f) Evaluation - I-710 Corridor Project, Los Angeles County, California, District 07-LA-710-PM 4.9/24.9, EA 249900" (Caltrans and LACMTA, June 2012) (I-710 Corridor DEIR/S); (2) "Final Environmental Impact Report/Environmental Assessment with Finding of No Significant Impact – The Interstate 10 (San Bernardino Freeway/El Monte Busway) High Occupancy Toll Lanes Project, SCH No. 2009061060" (Caltrans, April 2010); (3) "Final Environmental Impact Report/ Environmental Assessment with Finding of No Significant Impact – The Interstate 110 (Harbor Freeway/Transitway) High Occupancy Toll Lanes Project, SCH No. 2009061059" (Caltrans, April 2010); (4) "Draft Environmental Impact Report – Add One High Occupancy Vehicle Lane in Each Direction on the San Bernardino Freeway (Interstate 10) from Puente Avenue to State Route 57/71 in Los Angeles County" (Caltrans and LACMTA, November 2011); and (5) "Final Environmental Impact Report/Environmental Impact Statement – Interstate 5 (Santa Ana Freeway) from State Route 91 in Orange County to Interstate 605 in Los Angeles County, California" (Caltrans and FHWA, June 19, 2007) (I-5 FEIR/S). Similarly, absent there from is any discussion of planned or proposed transit expansion projects including, but not limited to, the California High-Speed Rail Authority's "California High-Speed Train."

The Lead Agency states that "'[s]egmentation' may occur when a transportation need extends throughout an entire corridor, but environmental issues and transportation needs are inappropriately discussed for a segment of the corridor" (p. 1-24). The DEIR/S then goes on to conclude that "[t]he proposed project satisfies the requirements for independent utility and logical termini" (p. 1-22) and "[b]y meeting FHWA requirements for independent utility and logical termini, and offering several transportation improvements within these boundaries, the project avoids 'segmentation'" (p. 1-24). The City disagrees with that rationalization. Rather than presenting reasoned analysis of the Lead Agency's rationale for the establishment of "independent utility and logical termini," only a conclusionary statement is presented absent supporting documentation. Since improvements to other segments of the I-405 and I-605 Freeways (and other freeways in southern California) can be reasonably anticipated, by defining the project's "corridor" and "termini" in the manner presented, the Lead Agency presents an incomplete and flawed environmental analysis.

As indicated in a Memorandum from FHWA's Director, Office of Environmental and Planning to Regional Federal Highway Administrators and Federal Lands Highway Program Administrators (Subject: Guidance on the Development of Logical Project Termini), dated November 5, 1993:

"Logical termini for project development are defined as (1) rational end points for a transportation improvement, and (2) rational end points for a review of the environmental impacts. The environmental impact review frequently covers a broader geographic area than the strict limits of the transportation improvements. . .Choosing a corridor of sufficient length to look at all impacts need not preclude staged construction. Therefore, related improvements within a transportation facility should be evaluated as one project, rather than selecting termini based on what is programmed as short range improvements. Construction may then be 'staged,' or programmed for shorter sections or discrete construction elements as funding permits" (emphasis added) (p. 2). The FHWA further notes that "the termini chosen must be such that: [1] environmental issues can be treated on a sufficiently broad scope to ensure that the project will function properly without requiring additional improvements elsewhere, and [2] the project will not restrict consideration of alternatives for other reasonably foreseeable transportation improvements" (p. 9).

As stipulated in the State CEQA Guidelines, "CEQA was intended to be interpreted in such a manner as to afford the fullest possible protection to the environment within the reasonable scope of the statutory language" (14 CCR 15003[f]). By seeking to treat congestion as a localized condition (evident only along a narrowly described segment of a major north-south freeway linking Orange and Los Angeles Counties) which can be cured by focusing only on a 14-mile or 16-mile long length of a single freeway (ignoring the adjoining segments of that same freeway feeding that congested link), the Lead Agency unreasonably confines the resulting environmental analysis to only that segment of the freeway system where short-term (insufficient) funding commitments have been made (ignoring the existence of other funding commitments by that same agency and assignable to other freeway segments).

The Lead Agency has already sought to fragment the larger transportation improvement project once by isolating the WCC from the proposed action (e.g., "construction of the SR-22 WCC Phase II Project is underway on the 2-mile segment of the I-405 that overlaps SR-22. The project will add two HOV lanes in the median of I-405 between SR-22 and I-605, along with HOV direct connectors at the I-405/SR-22 and I-405/I-605 interchanges," p. 2-1). By continuing to piecemeal highway construction projects along definable links, CEQA and NEPA compliance, as well as the environment those statutes were designed to protect, "die a 1,000 cuts."

5.3 Undisclosed Project Facilities

NEPA stipulates that "connected actions" be considered as part of an EIS and CEQA stipulates that the project examined in an EIR must include the "whole of the action." That, however, is not the case with the proposed action. As indicated the AQR: "the following TSM and TDM measures may be incorporated into each of the build alternatives for the proposed project. . .[1] Pedestrians improvements would be added wherever possible; [2] Additional Park & Ride/Intermodal facilities would be added at various locations to integrate with Bus Rapid Transit (BRT), express bus, Go Local Metrolink Connectors, community circulators, and local bus. . .[3] Auxiliary lanes would be provided in various locations" (AQR, PM Conformity Hot Spot Analysis, August 1, 2007, unpaginated).

Although specific to the I-5 Freeway, the following excerpt from the I-5 FEIR/S would also appear to have relevancy to the proposed action: "Because the I-5 Corridor travels through Los Angeles and Orange Counties, compliance with the Los Angeles County CMP and Orange County CMP is required. Each of the cities within the study area is responsible for implementing the requirements of the CMP. The CMP must include a Transportation Demand Management

(TDM) component that includes a trip reduction and travel demand element that promotes alternative transportation methods, such as carpools, vanpools, transit, bicycles, and park-and-ride lots. The adoption of a TDM ordinance was required of every local jurisdiction within Los Angeles and Orange Counties" (emphasis added) (pp. 43-44). Referencing OCTA's "2011 Orange County Congestion Management Program" (CMP):

> Park-and-ride lots serve as transfer points for commuters to change from one mode of travel (usually single-occupancy automobile) to another, higher capacity mode (bus, train, carpool, or vanpool). Providing a convenient system of park-and-ride transfer points throughout Orange County encourages ridesharing and the use of higher capacity transit systems, which improves the efficiency of the transportation system. Park-and-ride lots are also a natural companion to Orange County's network of High Occupancy Vehicle (HOV) lanes and transitways on the freeways (p. 27).

Although "park-and-ride lots" are identified by Caltrans as required components of a CMP, identified the OCTA as "natural companions" to HOVs lanes, and listed as "TSM and TDM measures [that] may be incorporated into each of the build alternatives," no discussion of those lots is presented in the DEIR/S. While no definition of "natural companions" is presented, Webster defines "natural" as "having an essential relation with" or "occurring in conformity with the ordinary course of" or "existing in and produced by" or "having a physical or real existence." In the context of the DEIR/S, "natural companion" must, therefore, be interpreted as being integrally connected with the proposed action.

The Lead Agency states that the proposed project will include "bicycle and pedestrian facilities to further offset increased fuel consumption associated with the projected increase in VMT" (DEIR/S, p. 3.2.8-6). Those "bicycle and pedestrian facilities" are, however, neither specifically identified nor is their location discussed (even in the broadest fashion). To the extent that the Lead Agency seeks to place pedestrians and bicyclists in close proximity to freeway traffic, there may exist unknown and unaddressed health and safety issues which have yet to be evaluated in the DEIR/S. In Seal Beach, Almond Avenue is designated as a Class III bicycle route. How do project-related impacts to Almond Avenue affect the functionality of that roadway as a "bicycle and pedestrian facility"? To the extent that the proposed action impedes bicycle use, how would that action serve to "offset increased fuel consumption"?

Absent from the DEIR/S is any discussion or analysis of those "pedestrian improvements," "park & ride/intermodal facilities," "auxiliary lanes," and "added" public transit services and facilities represented to be associated with the proposed action. As such, based on their exclusion, the project would be expected to produce additional physical changes which have not been disclosed by the Lead Agency. Alternatively, as a result of there noticeable absence, OCTA can subsequently assert that, absent there inclusion in the DEIR/S, the agency has no authorization or obligation for their construction, construction, operation, and/or maintenance.

5.4 Other Related, Connected, Cumulative, and Similar Projects

As indicated in the DEIR/S: "There are no additional projects anticipated within or around the project area Therefore, no additional cumulative impacts are anticipated" (VIA, p. 59). In contrast, the CIA states that "[c]umulative impacts are addressed within the individual chapters of this CIA. Table 1-1 [Reasonably Foreseeable Projects] contains a list of [19] reasonably foreseeable projects which could be implemented during construction of the proposed project" (p. 1-20).

Additionally, Caltrans recently prepared separate CEQA and NEPA documents for at least two other HOV lane project, including: (1) "Final Environmental Impact Report/Environmental Assessment with Finding of No Significant Impact – The Interstate 10 (San Bernardino Freeway/El Monte Busway) High Occupancy Toll Lanes Project, SCH No. 2009061060" (April 2010); and (2) "Final Environmental Impact Report/Environmental Assessment with Finding of No Significant Impact – The Interstate 110 (Harbor Freeway/Transitway) High Occupancy Toll Lanes Project, SCH No. 2009061059" (April 2010). Neither of those environmental documents nor does the DEIR/S identify one another as connected, cumulative, and similar actions nor do any of those documents consider the combined impacts of toll road development. Similarly, after a multi-year construction process that the City and its residents have had to endure, Caltrans is now completing the WCC. With regards to that project, the DEIR/S notes:

> On the portion of SR-22 that overlaps with I-405 within the project limits (I-405 PM 20.8/24.0), two projects – the I-405/SR-22 HOV Connector (EA 071621) and the I-405/I-605 HOV Connector (EA 072631) – are currently in the construction phase and are collectively referred to as the SR-22 West County Connectors (WCC) Project. The SR-22 WCC Project area includes the portion of I-405 between I-605 and SR-22 East and the portion of I-605 between I-405 and Katella Avenue. The SR-22 WCC Project will add a second HOV lane on I-405 in each direction from SR-22 East to I-605, and it will also provide structures to directly connect the HOV lanes between the I-405, SR-22 East, and I-605. During the design phase of the SR-22 WCC Project, the SR-22 WCC Project area was evaluated by the Department for system connectivity and compatibility with the proposed future I-405 Improvement Project (p. 1-20).

The Lead Agency represents the WCC, not as a related, connected, cumulative, or similar project, but as part of the existing "baseline" and, therefore, not incrementally contributing to the generation of cumulative environmental effects. That categorization only serves to circumvent the Lead Agency's obligation to analyze the cumulative effects of "other closely related past, present, and reasonably foreseeable probable future projects" (14 CCR 15355[b]).

Under NEPA, in Webb v. Gorsuch (1983), the federal court noted that, "[g]enerally, an administrative agency need consider the impact of other proposed projects when developing an EIS for a pending project only if the projects are so interdependent that it would be unwise or irrational to complete one without the others." Under CEQA, in San Franciscans for Reasonable Growth v. City and County of San Francisco (1987), the court "found the cumulative impact analyses of the EIRs to be insufficient because those impacts were evaluated using a list of projects which included only those projects already approved but not yet under construction and projects actually under construction [Citation]. We concluded that it would have been both practical and reasonable for the City to include in the cumulative analyses projects under environmental review, even if the projects had not yet surmounted all the 'regulatory hurdles' [Citation]." In compliance therewith, other related, connected, cumulative, and similar projects not considered in the DEIR/S are identified below.

- **2012 RTP/SCS**. SCAG notes that "the 2012 RTP includes a <u>regional Express Lane network</u> that would build upon the success of the 91 Express Lanes in Orange County and two demonstration projects in Los Angeles County planned for operation in late 2012. Additional efforts underway include the extension of the 91 Express Lanes to I-15 in Riverside County along with planned Express Lanes on the I-15. Also, traffic and revenue studies are proceeding for I-10 and I-15 in San Bernardino County" (emphasis added) (p. 15). As identified by SCAG, the "express/HOT lane network" includes those freeway segments presented in Table 13 (Express/HOT Lane Network).

Table 13
Express/HOT Lane Network

County	Route	From	To
Los Angeles	1-405	I-5 (North SF Valley)	LA/OC County Line
	I-11-	Adams Blvd (s/o I-10	I-405
	I and SR-110	Adams Blvd	US-101
	US-101	SR-110	I-10
	I-10	US-101	I-710
	I-10	I-710	I-605
LA, Orange	SR-91	I-110	SR-55
LA, SB	I-10	I-605	I-15
Orange	I-405	LA/OC Line	SR-55
	I-5	SR-73	OC/SD County Line
	SR-73	I-405	MacArthur
Riverside	SR-91	OC/RV County Line	I-15
	I-15	Riv/SB County Line	SR-74
	I-15	SR-74	Riv/SD County Line
San Bernardino	I-10	I-15	SR-210
	I-10	SR-210	Ford St
	I-15	SR-395	Sierra Ave
	I-15	Sierra Ave	6th Street
	I-15	6th Street	Riverside/SB County Line

Source: Southern California Association of Governments, 2012-2035 Regional Transportation Plan/Sustainable Communities Strategy, April 4, 2012, Table 2.6 (Express/HOT Lane Network), p. 56

Referencing the 2012 RTP/SCS PEIR: "The 2012-2035 RTP/SCS also includes an expansion of the existing Express/HOT lanes and toll road system in Orange County to address the congested commuter corridor between housing-rich Riverside County and jobs-rich Orange County. Additionally, improvements to several major corridors in other parts of the region are proposed to be financed by tolls, including the SR-710 Tunnel Gap Closure and the High Desert Corridor" (p. 2-13). As described and illustrated in the 2012 RTP/SCS, a large segment of the freeway system within southern California will include either new HOT or converted HOV lanes. Since presently only a segment of the I-91 Freeway contains a toll road, the regional implications of that "network" needs to be examined as a collective whole and the cumulative impacts addressed in the DEIR/S.

In correspondence from the OCTA to SCAG, dated February 14, 2012 (Re: Comments on the Draft 2012 Regional Transportation Plan and Program Environmental Impact Report), as included in the 2012 RTP/SCS PEIR, the OCTA made no formal request to modify the description of ORA030605 in order to include or accommodate HOV/HOT lanes. The OCTA did, however, note that "[t]he draft RTP includes the implementation of a regional high-occupancy toll lane network. This network appears to utilize existing and planned high-occupancy vehicle lanes to generate new revenues by selling excess capacity to single-occupancy drivers. The proposed regional HOT lane network assumes that Orange County would include HOT lanes on Interstate 5 (I-5) between the San Diego County border and the southern end of State Route 73 (SR-73); along I-405 between the northern end of SR-73 and the Los Angeles County border; and along State Route 91 (SR-91) extending the Express Lanes west to the Los Angeles County border. On December 12, 2011, the OCTA Board approved the Express Lane Planning and Implementation Principles. OCTA requests that these principles be incorporated into the assumptions for segments of the regional HOT lane network that are within Orange County. Furthermore, the proposed HOT lane improvements to I-5, and SR-91 should be subject to further study to evaluate right-of-way impacts, community issues, and overall feasibility, prior to inclusion in the constrained plan" (emphasis added) (Response to 2012-2034 RTP/SCS Comments, Part III). Because the OCTA acknowledged the existence of a "regional HOT lane network" and promotes the development of "a consistent, seamless user experience," the cumulative impacts of other planned or proposed components of that network should be addressed either as a component of the proposed action or as contributors to the cumulative impacts examined in the DEIR/S.

As further indicated in correspondence from the Transportation Corridors Agency (TCA) to SCAG, dated February 13, 2012 (Re: Comments on the Draft 2012 Regional Transportation Plan/Sustainable Communities Strategy and Program Environmental Impact Report), as included in the 2012 RTP/SCS PEIR: (1) "Tolled centerline miles in the region will increase from 61 in 2008 to 408 in 2035, including toll roads, express lanes, HOT lanes, and tolled truck lanes"; (2) "Toll roads and express lanes charge users a fee for travel"; (3) "The toll road system is designed to interrelate with transit service"; and (4) "SCAG has launched a two-year study of congestion pricing strategies that can provide needed transportation facilities" (emphasis added) (Response to 2012-2034 RTP/SCS Comments, Part III). This projected increase in toll-lane miles constitutes a fundamental change in freeway operations throughout southern California, extending substantially beyond the geographic confines of the proposed action.

The potential for congestion pricing to induce change in driving habits and travel patterns is acknowledged by SCAG. SCAG has noted that: (1) "The primary purpose of congestion pricing is to make important changes in the ways we use the scarce resources of roads and parking capacity" and '[c]ongestion pricing changes the way we drive by more accurately pricing the cost of a finite resource – roads and parking spaces" (Express Travel Choices Study, Frequently Asked Questions, January 13, 2011, pp. 4-5); and (2) "Tolling can have a significant impact on travel behavior" and "[t]hese effects can collectively become quite significant as prices increase" (emphasis added) (SCAG, Discrete Choice Models and Behavior Response to Congestion Pricing Strategies, May 11, 2011, Slide 20). Nowhere in the DEIR/S or in any other planning-related and.or environmental documentation (e.g., SCAG's "two-year study of congestion pricing strategies") are the larger impacts of that change examined.

- **Express Travel Choices Study**. SCAG notes that "[t]he Riverside County Transportation Commission (RCTC) is in the process of working with the Orange County Transportation Authority (OCTA) to extend the SR 91 Express Lanes into Riverside County and is studying the potential for Express Lanes in the I-15 corridor. The San Bernardino Associated Governments (SANBAG) is studying possible Express Lane implementation in the I-10, I-15 and SR 210 corridors. Also, OCTA is including an Express Lane option in its proposed I-405 widening project between I-605 and SR 55" (Express Travel Choices Study, Frequently Asked Questions, January 13, 2011, p. 7).

Absent from the DEIR/S is any discussion or analysis of the proposed "express lanes" on the I-10, I-15, SR-91, and SR-210 Freeways.

- **Destination 2035 – Moving Toward a Green Tomorrow**. As noted in San Franciscans for Reasonable Growth v City and County of San Francisco (1984), "probable future projects" can be interpreted as reasonably probable future projects. The court found that projects that are undergoing environmental review are reasonably probable future projects. In Gray v. County of Madera (2008), the court stated that "any future project where the applicant has devoted significant time and financial resources to prepare for any regulatory review should be considered as probable future projects for the purposes of cumulative impact." Each of the project's listed in OCTA's 2010 LRTP, therefore, constitute "probable future projects" for the purpose of cumulative impact assessment.

  Presented in the OCTA's 2010 LRTP is a "full list of freeway projects included in the Year 2035 Preferred Plan," including "[l]ane additions for specific freeway and toll road segments between the 2008 Base Year and 2035 Preferred scenario" (p. 74). As indicated therein: "These projects draw from approved funding programs, including Measure M2, as well as recent and ongoing OCTA planning efforts that have analyzed transportation needs and opportunities throughout Orange County. The Preferred Plan of projects also considers available funding and financial resources over the course of the next 25 years. <u>Particular emphasis is placed on the identification of a program of projects that can be implemented using the funding sources that are reasonably anticipated to be available</u>" (emphasis added) (p. 71).

  Because each of the following projects are proposed by the same "sponsor," they demonstrate OCTA's currently planned activities scheduled to occur within the proposed project's build-out period. The listing presented in <u>Table 14</u> (Orange County Transportation Authority - Year 2035 Preferred Plan) is inclusive of only those projects located with Orange County, identified by the OCTA as components of the "Year 2035 Preferred Plan," and does not include any transportation system improvements located in Los Angeles County. Additional related, connected, cumulative, and similar projects is presented in the LACMTA's "2009 Long Range Transportation Plan" (October 2009).

  The proposed action is listed among the above described projects. It is, however, noted that, with the singe exception of "throughput," the long-range plan's stated "goals and objectives" differ from the P&N described for the proposed action. As presented in the OCTA's 2010 LRTP, the OCTA's goals/objectives include: "(1) Expand Transportation System Choices; Expand access to travel options across all travel modes, improve connectivity to major destinations, and improve integration between transportation options. (2) Improve Transportation System Performance: Improvements to travel speeds, travel times, person throughput, and roadway and transit service levels. (3) Ensure Sustainability: Timely maintenance of transportation infrastructure, implementation of environmental protection strategies, and use of innovative project delivery methods to reduce taxpayer costs" (p. 1).

  Since the proposed action is a component of the OCTA's broader implementation program, it is unclear why project-level objectives would differ so substantially from the program-level objectives presented in OCTA's 2010 LRTP. The rationale for this dichotomy should be addressed and an explanation presented how the project's P&N serves to promote the attainment of the goals and objectives presented therein.

Table 14
Orange County Transportation Authority - Year 2035 Preferred Plan

Category	Project	Description
Transportation System Management Projects	Interstate 5 HOV expansion from Pacific Coast Highway to Avenida Pico	Add one HOV lane in each direction from Pacific Coast Highway to Avenida Pico
	Interstate 5 HOV Lane Expansion	Add one HOV lane each direction from State Route 55 to State Route 57
	Interstate 5 HOV Lane Expansion	HOV ramp improvements at Barranca Parkway
	Interstate 405 HOT Project	Convert existing HOV lane to HOT, add one additional HOT lane each direction from State Route 73 to Interstate 605
	State Route 57 Improvements	Provide HOV interchange at Cerritos Avenue
	State Route 57 Improvements	Add one truck climbing auxiliary lane in the northbound direction from Lambert Road to Los Angeles County line
	State Route 57 Improvements	Add one HOV lane each direction from MacArthur Boulevard to Interstate 405
	State Route 73 HOV Connector	Add HOV lane connector to Interstate 405
	State Route 81/State Route 241 Interchange	Add HOV/HOT connector at State Route 241/State Route 91 interchange (eastbound on-ramp/westbound off-ramp)
	Freeway Service Patrol & Call Box Program	Continuation of motorist aid services
	Toll Roads Video Detection Demonstration Project	Image-based toll collection system demonstration project
General Purpose Improvements	Interstate 5 Improvements between State Route 55 and El Toro "Y"	Add one mixed-flow lane in each direction from State Route 55 to Interstate 405
	Interstate 5 Improvements from State Route 57 to State Route 91	Add one mixed-flow lane in each direction from State Route 57 to State Route 91
	Interstate 5 Improvements South of the El Toro "Y"	Add one mixed-flow lane in each direction from Avery Parkway to Alicia Parkway
	Interstate 5 Improvements South of the El Toro "Y"	Reconfigure interchange of Interstate 5 with Avery Parkway
	Interstate 5 Improvements South of the El Toro "Y"	Reconfigure interchange of Interstate 5 with La Paz Road
	Interstate Improvements Projects from State Route 55 to Interstate 5	Add one ancillary lane in the northbound direction from Jefferey [sic] Road to Culver Drive
	Interstate 405 Improvements Project from State Route 55 to Interstate 5	Add one mixed-flow lane in each direction from Interstate 5 to State Route 55
	Interstate 405 Improvement Projects from State Route 73 to Interstate 605	Add one mixed-flow lane in each direction from State Route 73 to Interstate 605
	State Route 55 Improvements	Add one mixed-flow lane in each direction from Interstate 405 to Interstate 5
	State Route 55 Improvements	Add one mixed-flow lane in each direction from Interstate 5 to State Route 22
	State Route 55 Improvements	Add one auxiliary lane in each direction between select on/off ramps through project limits from Interstate 405 to Interstate 5

Table 14 (Continued)
Orange County Transportation Authority - Year 2035 Preferred Plan

Category	Project	Description
Purpose Improvements	State Route 57 Improvements	Add one mixed-flow lane in the northbound direction from Lincoln Avenue to Orangethorpe Avenue
	State Route 57 Improvements	Add one mixed-flow lane in the northbound direction from Orangewood Avenue to Katella Avenue
	State Route 91 Improvements from State Route 55 to Orange County/Riverside County Line	Add one westbound lane from State Route 241 to Gypsum Canyon Road
	State Route 91 Improvements from State Route 55 to Orange County/Riverside County Line	Add one auxiliary lane in each direction from State Route 241 to Green River Road
	State Route 91 Improvements from State Route 57 to State Route 55	Add one mixed-flow lane in the eastbound direction from State Route 57 to State Route 55
Interchange Projects	Interstate 5/Stonehill Drive Interchange	Add southbound off-ramp at interchange with Stonehill Drive
	Interstate 5 Local Interchange Upgrade	Improve interchange of Interstate 5 with Avenida Pico
Interchange Projects	Interstate 5 Interchange Upgrade	Reconstruct interchange of Interstate 5 with 1st Street/4th Street to increase weaving length to standard on southbound Interstate 5
	Interstate 5/Marguerite Parkway Interchange	Add interchange at Marguerite Parkway
	Interstate 5/Alicia Parkway Interchange Improvement	Improve interchange of Interstate 5 with Alicia Parkway
	Interstate 5/Los Alisos Boulevard Interchange	Add Interchange at Los Alisos Boulevard
	Interstate 5/North Irvine Traffic Mitigation Ramp Improvements	Improve access ramps to/from Interstate 5
	Interstate 405/South Bristol Braid Interchange Reconstruction	Reconfigure interchange of Interstate 405 with State Route 55 and Bristol Street
	Interstate 405/Irvine Center Drive/ North Irvine Traffic Mitigation Improvements	Improve various access ramps to/from Interstate 405
	Interstate 605 Freeway Access Improvements	Ramp improvements at interchange with Katella Avenue
	State Route 55/Meats Avenue Interchange	Construct on-ramp/off-ramps at the interchange to State Route 55
	State Route 57 Improvements	Ramp improvements at Lambert Road
	State Route73/Glenwood Drive/Pacific Park Drive Interchange	Construct southbound ramp interchange with Glenwood Drive/Pacific Park Drive
	State Route 91 Improvements from State Route 57 to State Route 55	Improve interchange with State Route 55
	State Route 91 Improvements from State Route 57 to State Route 55	Improve interchange with Lakeview Drive
	State Route 91/Gypsum Canyon	Improve access ramp at Gypsum Canyon Road

Table 14 (Continued)
Orange County Transportation Authority - Year 2035 Preferred Plan

Category	Project	Description
Interchange Projects	State Route 91/Fairmont Boulevard Interchange	Add interchange and overcrossing at Fainmont [sic] Boulevard
	State Route 241/Jeffrey Road Interchange	New interchange at Jeffrey Road
Other Projects	Soundwall Program	Construct soutndwalls along freeways to minimize traffic noise from freeways into residential neighborhoods
	State Highway Operation and Protection Program (SHOPP)	Various freeway safety improvements, as needed
Environmental Mitigation	Environmental Cleanup and Freeway Mitigation Programs	Transportation-related water quality program and acquisition/restoration habitat, respectively

Source: Orange County Transportation Authority, Destination 2035 – Moving Toward a Green Tomorrow, Table 5-2 (Preferred Plan Freeway Projects), pp. 75-76

As reported in the FHWA's "Final Report - Traffic Congestion and Reliability: Trends and Advanced Strategies for Congestion Mitigation" (September 1, 2005), "vehicle merging maneuvers" have "the most severe effect on traffic flow" (p. 2-4) and "[a]s the traffic grows on a roadway with fixed capacity, bottleneck-related congestion becomes increasingly dominant" (p. 2-9). "Physical bottlenecks are locations where the physical capacity is restricted, with flows from upstream sections (with higher capacities) being funneled into them. . .On much of the urban highway system, there are specific points that are notorious for causing congestion on a daily basis. These locations – which can be a single interchange, a series of closely spaced interchanges, or lane-drops – are focal points for congestion in corridors; major bottlenecks tend to dominate congestion in corridors where they exist" (LSP, pp. 2-1 and 2).

The DEIR/S notes that "[d]uring the 54-month construction period, construction-related delays along the I-405, I-605, SR-22, and SR-73 freeways and interchanges, as well as on the surrounding local arterials, are anticipated" and "[l]ane reductions and restrictions are also anticipated on mainline, connector, ramp and arterial roadway facilities to accommodate construction activities. These restrictions may include: [1] Narrower lane and shoulder widths; [2] Reduction in number of lanes; [3] Elimination of separate turn lanes at intersections; [4] Speed reduction due to sharper lane transition/taper" (TDM, p.10, see also DEIR/S, p. S-13).

Although it does nothing to alleviate the above described problems, accepting virtually no responsibility, the OCTA's "2011 Orange County Congestion Management Plan" asserts that "public outreach" (e.g., "OCTA and Caltrans developed a comprehensive public outreach program for commuters impacted by construction projects and improvements on Orange County freeways. The outreach program alleviates traffic congestion during freeway construction by providing up-to-date ramp, lane, and bridge closure information; as well as suggestions for alternate routes and travel modes," p. 26), in combination with the actions of other agencies (e.g., "most jurisdictions implement traffic management plans to alleviate roadway congestion during construction," p. 26), constitutes appropriate mitigation for freeway construction impacts.

It is not unreasonable to assume that for a period of 4.5 years, major construction-related bottlenecks and travel delays will be created along segments of the I-405 Freeway where construction activities are evident and where additional enforcement activities are occurring (e.g., "A highly visible CHP presence would alert motorists that road work is being performed and that motorist behavior is under surveillance," RCS, p. 23; Draft TDM, p. 13). Since the Lead

Agency purports that one of the stated purposes of the proposed action is to “reduce congestion,” the creation of both short-term and long-term conditions leading or contributing to bottlenecks cannot be ignored. Similarly, although the three build alternatives are “expected to reduce the level of cut-through traffic within adjacent jurisdictions for motorists seeking alternative travel routes” (p. 3.1.1-21), absent from the DEIR/S’ analysis is the potential for and consequences of “cut-through traffic” during the facility’s lengthy construction period.

The analysis of only a single freeway segment without the inclusion of other adjoining segments and the continuity resulting therefrom will produce unaccounted for bottlenecks during both peak periods. To the extent that Caltrans has plans to eliminate those bottlenecks with subsequent or concurrent widening plans (e.g., “Opportunities to improve the operation of ‘intentional’ bottlenecks can have the effect of boosting physical capacity,” LSP, p. 2-1), those plans and the elimination of those bottlenecks thus become cumulative, connected, related, or similar projects that must be addressed in the DEIR/S. As now presented, the proposed project will create new bottlenecks which are never disclosed, the elimination of which are dependent upon connecting freeway improvements which themselves are ignored by the Lead Agency.

5.5 Improper Delegation of Authority

Under CEQA, as stipulated in Friends of La Vina v. County of Los Angeles (1991), the court stated that “CEQA [shall] ‘be interpreted in such manner as to afford the fullest possible protection to the environment within the reasonable scope of the statutory language’ [Citation]. Implicit in the requirement that the agency exercise independent review, analysis, and judgment when using EIR materials submitted by an applicant's consultant is a heavy demand for independence, objectivity, and thoroughness. Moreover, this standard pursues the prescription that an EIR be ‘a document of accountability’ [Citation]." "The lead agency must independently participate, review, analyze and discuss the alternatives in good faith" (Kings County Farm Bureau v. City of Hanford [1990]). "So significant is the role of lead agency that CEQA proscribes delegation" (Planning and Conservation League v. Department of Water Resources [2000]).

In addition, NEPA requires that the federal agency verify the accuracy of information supplied by an applicant (40 C.F.R. 1506.5[a]) and respond to substantive issues raised in comments (40 C.F.R. 1503.4[a]). Although the record is clear as to the role played by the OCTA (e.g., project sponsor), absent from the DEIR/S is any evidence of the Department’s role in the formulation of project alternatives or the independent validation of information and assumptions presented in the DEIR/S. The record suggests that OCTA independently formulated the identified alternatives, independently rejected other potential build and no build options, performed the environmental analysis, drafted the proposed “measures,” and that Caltrans merely rubber-stamped OCTA’s documentation and cost estimates (as prepared by or on behalf of the OCTA).

As reported in “Suggested Procedures for Evaluating the Effectiveness of Freeway HOV Facilities”: “It is important to ensure that the results of the evaluation are not biased intentionally or unintentionally. Thus, it is suggested that evaluations be conducted by neutral, unbiased, third parties. While it is critical that the sponsoring agencies, both transit and highway, are actively involved in conducting the study, there is much to be gained by maintaining an outside perspective during the evaluation” (p. 8).

As specified under Section 21100 of CEQA: “All lead agencies shall prepare, or cause to be prepared <u>by contract</u>, and certify the completion of, an environmental impact report on any project which they proposed to carry out or approve that may have a significant effect on the environment" (emphasis added).

As indicated on the OCTA's "List of Existing Awarded Federally Funded Contracts" (May 31, 2012), "Parsons Transportation Group" (Parsons) (previously Parsons Brinckerhoff Quade and Douglas, Inc.) and its subcontractors (i.e., Albert Grover & Associates; Group Delta Consultants; McLean & Schultz; Nossaman, Guther, Knox and Elliott; Paragon Partners; Psomas; Stantec; TEC Management; URS Corporation; and Value Management Strategies) are working directly under contract to the OCTA (Contract No. C80693) rather than under contract to the Lead Agency. As described by the OCTA, the contract includes "[p]roject report and environmental document preparation consultant services for I-405 widening" in the amount of "$13,584,174."

It is not disclosed whether any of those same entities also have contracts or other business relationships with the USDOT, FHWA, and/or Caltrans and what provisions might exist in those federal contracts with regards to dual relationships with both a project sponsor (if different from the NEPA lead agency) and permitting agencies.

As indicated in Title 23, "[a]ny of the lead agencies may select a consultant to assist in the preparation of an EIS in accordance with applicable contracting procedures and with 40 CFR 1506.5(c)" (23 C.F.R. 771.123[d]). However, if Caltrans were to select Parsons, an established vendor of the "project sponsor" and "applicant" to prepare environmental documents for the proposed action, an inherent conflict of interest would be created potentially affecting the objectivity of the resulting analysis.

Under NEPA, "[t]he lead agencies are responsible for managing the environmental review process and the preparation of the appropriate environmental review documents" (23 C.F.R. 771.109[c][1]); "[t]he draft EIS shall be prepared by the lead agencies, in cooperation with the applicant (if not a lead agency)" (23 C.F.R. 771.123[c]). In accordance therewith, as indicated in the NOI, "Caltrans. . .will prepare an environmental impact statement (EIS)" (p. 2). As further indicated in the NOP, "the California Department of Transportation. . .will prepare an environmental impact report [EIR] for the project" (p. 1).

In what is substantially more than mere semantics, in this case, the DEIR/S appears to have been prepared directly by the "sponsor" or, more specifically, by a contractor working directly for the OCTA. In what appears to be evidence of "the fox guarding the hen house," with regards to the proposed action, the project "sponsor" rather than the State and federal agencies responsible for environmental oversight appears to have prepared and is presently processing the documentation which: (1) establishes the yardstick against which "feasibility" is measured; (2) determines the "feasibility" of the alternatives to be considered and the "infeasibility" of the alternatives to be rejected; (3) selects from those alternatives the sponsor's "preferred alternative"; (4) identifies the impacts of the sponsor's actions on the human and natural environment; (5) determines the "significance" of those impacts; (6) self-imposes "feasible" conditions in response to those sponsor-identified impacts; and (7) determine to what extent those conditions need to be monitored or enforced.

Since the sponsor has already declared the insufficiency of funds to construct the proposed capital improvements, it would appear unlikely that same sponsor would: (A) acknowledge the existence of "significant" environmental effects; and/or (B) divert finite funds to mitigate those impacts it elects to disclose. If monitoring or compliance activities were to be established, it is likely that the firm preparing the EIR/EIS (with the $13.6 million contract) would be the same firm tasked with the monitoring or compliance of its own work efforts, including those construction and operational obligations it elected to self-impose.

5.6 Unsupported Conclusory Statements

In support of the three build alternatives, the Lead Agency alleges that the "[i]ncrease in mobility and operations of the freeway and roadway network would contribute to the increase in property tax base, sale tax revenue, and property values" (CIA, Table S-1, p. S-6). No information or analysis is, however, presented in support of that statement.

As indicated in the USEPA's OBNE: "Communities are also realizing that adding new road capacity no longer generates the same economic benefits it may have at one time. Studies have indicated that new highway development, which was often viewed as necessary to economic development in the past, offers increasingly fewer economic benefits at the state and national levels. As the national road network nears completion, the benefits of additional network construction decrease drastically. New roads may offer fewer benefits on the local level, too; although they may appear to spur growth, they often simply shift economic activity away from other areas" (p. 33).

If a linkage between "mobility" and enhancements to the "property tax base, sale tax revenues, and property values" can be demonstrated, it might be further concluded that further improvements to mobility would lead to further localized economic benefits. Those alternatives presented in the MIS that offered the greatest promise for improving freeway/arterial mobility (e.g., "Alternative 8 is forecast to have the largest increase in transit ridership [9.9%], MIS, p. 83) where, however, eliminated by the Lead Agency analysis notwithstanding any off-setting "property tax base, sale tax revenues, and property value" benefits.

As reported in the USDOT's "NHTS 2001 Highlights Report, BTS03-05" (2003), while job-accessibility weighs heavily in residential location choice and strongly influences regional traffic conditions, more trips are made for retail shopping and personal services than for getting to and from work. In 2001, 44.6 percent of trips nationwide were for "family/personal business" (which includes shopping and other activities) versus 14.8 percent for commuting to work. Most trips can, therefore, be assumed to be shorter distance and duration and not dependent upon freeway conditions.

Without any supportive evidence or documentation, the Lead Agency asserts that "[d]ecreased congestion along the 1-405 corridor has the potential to allow regional motorists, as well as local residents, to reach businesses more efficiently, thereby allowing for increased visitation, faster customer turn-around and, consequently, increased revenues" (CIA, p. 6-3). As evidenced by the projected LOS "F" conditions along the designated segment, other than in the context of vehicle throughput and relative speed, the Lead Agency has not presented evidence supporting the assertion that the proposed action "decreased congestion."

In reality, it is more likely that other factors dictate shopping decisions. Since most shopping is discretionary, motorists have the ability to alter trip times to correspond to off-peak periods, select alternative routes, or combine multiple-leg trip destinations (e.g., stopping for groceries on the way home from work). Similarly, an individual's selection of travel destination is based on factors (e.g., attraction and perceived desirability) which may not be dependent upon time or distance. If the Lead Agency seeks to premise its assertion on the project's facilitation of motorists driving to more remote shopping destinations, then: (1) the project is "travel inducing" and (2) additional project-induced increases in VMT (and corresponding GHG emissions) must be assumed.

To the extent that increased mobility induces destinations to move further apart from one another, that outward migration ultimately leading to higher travel times and increased incurred costs. As evidence by the historic flight from the central city to suburbia, at least in the near term, transportation infrastructure served to allow for faster speeds and larger geographic catchment (e.g., shoppers purchased homes farther from their workplace). Over the long-term, however, those perceived benefits produced sprawl (suburbanization) and laid the foundation for the congestion that the proposed action now seeks to address (e.g., "Improvement in mobility and trip reliability along the I-405 freeway and roadway network would encourage the residents to continue living in Orange County," CIA, p. 6-8).

The proposed action primarily serves to promote the perpetuation of vehicle-dependent land-use patterns rather than promoting New Urbanism-based changes to those patterns, sustainable life-style choices, transportation and land-use linkages, and expansion of non-vehicle-dependent transportation alternatives, as evidenced, in part, by the increased attraction of "transit-oriented development" (TOD).

Various transportation management studies have demonstrated that "accessibility" is the valid indices and that a focus on "mobility" results in a misguided emphasis on road building to the detriment of social interaction. As indicated in "Congestion and Accessibility: What's the Relationship?", the authors wrote:

> Congestion in U.S. metropolitan areas has increased steadily in recent years [Citation]. While nobody likes to sit in traffic, congestion levels are at best an indirect and imperfect measure of people's and firms' access to opportunities. As such, widely cited measures of the economic costs of congestion that simply tally people's time spent in traffic are conceptually problematic and perhaps misleading. Congestion measures reflect potential mobility, but do not reveal individuals' relative access to jobs and activities, or firms' relative access to suppliers and customers. A growing chorus of transportation planning researchers. . .argue that transportation planning should focus on increasing access to destinations rather than increasing mobility on transportation networks. While conceptually distinct, congestion and accessibility are related. But what is the nature of this relationship? The perception that congestion makes it harder for individuals to access opportunities is rational on its face, yet congestion also arises because an area offers attractive opportunities to large numbers of people and firms. A central tenet of urban economics is that cities form and grow because they foster such agglomeration economies, which increase productivity but also introduce negative externalities such as congestion [Citation]. Furthermore, a traveler's perceived burden of congestion is highly variable, depending on the purpose, timing, and other aspects of the trip [Citation]. As a result, the relationship between congestion and accessibility is complex and far from a simple inverse relationship (p. 1).
>
> The concept and measurement of accessibility contrasts importantly from the concept and measurement of traffic congestion in at least two ways. First, the units of analysis in accessibility measurement are typically individuals, households, firms, or places, while those for congestion are usually transportation networks, links, or vehicles. Second, by emphasizing opportunities and potential, the concept of

> accessibility is necessarily abstract, ephemeral, and, as a result, difficult to measure. Traffic congestion metrics, on the other hand, typically measure the volume and velocity of vehicles on links in networks [Citation]. While conceptually straightforward, such measures make traffic patterns the end themselves, rather than the means to economic transactions and social interactions. The result of this dichotomy may be competing and contradictory definitions of transportation functionality (pp. 2-3).

As noted in "Determining the Effectiveness of HOV Lanes": "There is not enough evidence to state whether HOV lanes increase or decrease accidents when installed on mainline freeways" (p. iii). Without collaborating evidence, the DEIR/S, however, states that "[b]uild alternatives would increase freeway capacity and freeway speeds. They are anticipated to reduce rear-end and sideswipe accidents due to stop-and-go traffic and weaving, respectively" (Table 3.1.1-1, p. 3.1.1-29). To the extent that traffic accidents relate to unforeseen or unexpected roadway conditions (e.g., bottlenecks), as may be attributable to construction activities, road closures, and diversions, the proposed action could contribute to the occurrence of roadway incidents. Similarly, if accidents can be estimated based on total miles driven, the substantial increase in VMT associated with the proposed project, a quantifiable number of accidents could be estimated.

Based on the projected project-induced increase in VMT, it is evident that the proposed project will alter regional traffic patterns, including (as asserted by the Lead Agency) removing those vehicles from local arterials which had previously sought alternative routes to avoid the congested freeway. As noted in the AQR, "diesel engine emissions are responsible for a majority of California's estimated cancer risk attributable to air pollution" (p. 80). Without any supporting analysis, the DEIR/S concludes that: (1) "Alternative 2 would not increase the percentage of DPM [diesel particulate matter] in the fleet mix and would improve vehicle speeds in the project area. As a result, Alternative 2 diesel particulate matter emissions would likely be less than Baseline emissions" (p. 80); and (2) "Alternative 3 would not increase the percentage of trucks in the fleet mix and would improve vehicle speeds in the project area. As a result, Alternative 3 diesel particulate matter emissions would likely be less than Baseline emissions" (p. 81).

To the extent that the Lead Agency seeks to assert a benefit from reducing congestion of local streets, it bears an obligation to examine the fleet mix of any such traffic so diverted. Even to the extent that it can be demonstrated that the "percentage of trucks" would remain unchanged, with the projected increase in freeway traffic and total VMT between 2009, 2020, and 2040, a substantially greater number of trucks will travel the I-405 Freeway corridor and a substantially greater number of truck miles will be driven.

The AQR states that only between 3 and 3.5 percent of vehicles within the corridor are trucks under 2009, 2020, and 2040 conditions (Tables 1-1, 1-2, 1-3, and 1-4, pp. 7-8). Caltrans' own RCR, however, states: "According to the publication '1997 Annual Average Daily Truck Traffic on the California State Highway System,' truck volumes on I-405 in Orange County range from approximately 7,550 to 19,680, 4.9% and 7.1% of the ADT respectively. The low occurs in the vicinity of I-5 (Segment 1) and the high in the vicinity of SR-22 (Segment 5)" (pp. 14-15; see also MIS, p. 15). As further indicated in the MIS: "The current truck and total volumes on I-405 are shown in Table 4.5-2 and 4.5-3 in the 'Corridor Mobility Problem and Purpose and Need Statement.' The truck percentages shown in those tables apply only to the general purpose lanes so the truck percentages were adjusted to reflect all traffic. They range from 4.9% to 5.7% depending upon the time of day and direction of travel" (p. 69).

Absent from the DEIR/S is any reference to the I-710 Corridor DEIR/S. As described therein: "The California Department of Transportation (Caltrans), in cooperation with the Los Angeles County Metropolitan Transportation Authority (Metro), the Gateway Cities Council of Governments (GCCOG), the Southern California Association of Governments (SCAG), the Ports of Los Angeles (POLA) and Long Beach (POLB) (collectively known as the Ports), and the Interstate 5 Joint Powers Authority (I-5 JPA) (collectively referred to as the I-710 Funding Partners), proposes to improve Interstate 710 (I-710, also known as the Long Beach Freeway) in Los Angeles County between Ocean Blvd. and State Route 60 (SR-60). The proposed project is referred to as the I-710 Corridor Project. I-710 is a major north-south interstate freeway connecting the city of Long Beach to central Los Angeles. Within the I-710 Corridor Project Study Area (Study Area), the I-710 serves as the principal transportation connection for goods movement between POLA and POLB, located at the southern terminus of I-710 and the Burlington Northern Santa Fe (BNSF)/Union Pacific (UP) Railroad rail yards in the cities of Commerce and Vernon" (p. ES-1).

The I-710 (Long Beach) Freeway interconnects with the I-405 north of the Los Angeles/Orange County line. Because the I-710 Corridor Project constitutes a concurrent activity being undertaken by Caltrans, it is both a related project producing cumulative impacts and its accompanying CEQA/NEPA analysis provides a source of relevant information germane to the assessment of the proposed action. One of the alternatives examined therein included a "tolled freight corridor" (e.g., "Although tolling trucks in the freight corridor could be done under either Alternative 6A or 6B, for analytical purposes, tolling has only been evaluated for Alternative 6B, as this alternative provides for higher freight corridor capacity than Alternative 6A due to the automated guidance feature of Alternative 6B", p. ES-11; "Tolls would be collected to help fund the construction and operation of the project. Trucks using the freight corridor would pay a toll in exchange for the travel time savings and trip time reliability offered by the freight corridor as compared to the adjacent general purpose lanes or alternative routes," p. 2-25).

Because various technical studies upon which the information presented in the I-710 Corridor DEIR/S is derived is not readily accessible (e.g., not available on the Caltrans' website), specific information on truck volumes could not be discerned from that document. As indicated in the "I-710 Corridor Project Traffic Operations Analysis Report, Final Report" (URS, January 2012) (TOAR): (1) "heavy duty trucks make up over thirty percent of the traffic stream during the day, as opposed to an average daily truck percentage of 6 to 13 percent on comparable freeways within Los Angeles County" (p. 2-1); (2) "High volumes of both trucks and cars have led to existing traffic congestion throughout most of the day (6:00 a.m. to 7:00 p.m.) on I-710 <u>as well as on the connecting freeways</u>. This is projected to worsen over the next 25 years" (emphasis added) (p. 3-1); and (3) for southbound I-405 Freeway, under the "no build" alternative, "[a]ll basic freeway segments (4 out of 4) are expected to operate at a poor LOS E or F during the evening peak hour" (p. 8-3). Although the amount of truck traffic likely to divert from the I-710 Freeway onto the I-405 Freeway is never disclosed, as indicated in <u>Table 15</u> (I-710 Freeway Corridor Average Daily Traffic Volumes), an inordinately high volume of truck traffic is anticipated along the I-710 Freeway. At a very minimum, by 2035, the projected increase in truck volumes along the I-405 Freeway would be comparable to the increase anticipated along the I-710 Freeway under the "No Build" scenario (i.e., 32.7 percent).

Because the "I-405 is considered a bypass route to the Interstate 5 (I-5) Santa Ana/Golden State Freeway through Orange County (NSR, p. 1), information from the I-5 FEIR/S has potential relevancy to the proposed action. As indicated therein: "The I-5 Corridor is a major local and regional truck route. The percent of trucks currently served by I-5 ranges from 8.1 to

20 percent, with the highest truck traffic levels occurring within the segment between SR 91 and Beach Boulevard. Midday peak hour truck percentages are typically higher than AM and PM peak hours, and can reach as high as 20 percent or more of the ADT" (p. 15).

Table 15
I-710 Freeway Corridor Average Daily Traffic Volumes

I-710 Segment		Existing (2008)		2035 No Build									
				No Build		Alternative 5A		Alternative 6A		Alternative 6B		Alternative 6C	
From	To	Total	Trucks	Total	Trucks	Total	Trucks	Total	Trucks	Total	Trucks	Total	Trucks
Del Amo	I-405	179,800	42,000	227,600	74,300	286,000	80,600	317,400	93,400	317,400	93,400	317,400	93,400
I-405	Wardlow Road	179,600	41,600	227,500	74,400	291,000	80,900	314,100	89,500	314,100	89,500	314,100	89,500
Percent Trucks		-	23.2	-	32.7	-	27.8	-	28.5	-	28.5		28.5

Source: California Department of Transportation and Los Angeles County Metropolitan Transportation Authority, Draft Environmental Impact Report/Environmental Impact Statement and Section 4(f) Evaluation - I-710 Corridor Project, Los Angeles County, California, District 07-LA-710-PM 4.9/24.9, EA 249900" (California Department of Transportation and Los Angeles County Metropolitan Transportation Authority, June 2012, Tables 3.13-7 and 3-13-8, p. 3.13-21 and 22.

Caltrans' "2010 Annual Average Daily Truck Traffic on the California State Highway System" (undated), which is potentially the source for the Lead Agency's assumptions, notes that, in Orange County, the "trucks percentage of total vehicles" is 4.45 percent at Mile Post (MP) 24.044 (Seal Beach, Jct. Rte. 605)" (p. 367). As indicated in Caltrans' "2009 Annual Average Daily Truck Traffic on the California State Highway System" (December 2010), comparing 2009 and 2010 truck volumes, the percentage of truck traffic at that same MP is 4.29 percent (p. 358), indicating a significant upward trend (3.6 percent/year) in truck traffic which is unaddressed in the DEIR/S. In fact, there does not seem any viable realistic scenario in which truck volumes would remain unchanged over a 31-year period (i.e., 2009-2040).

As a result, it would appear that the assumptions presented in the DEIR/S are not supportable by substantial evidence and have been selected to support a predetermined outcome rather than to foster informed decisionmaking. In addition, that material misrepresentation not only serves to substantially underestimate potential environmental impacts but reduces the range of alternatives available for considerations (e.g., dedicated truck lane).

As indicated in the FHWA's "Integrating Freight into NEPA Analysis" (September 2010), the USDOT states that the "FHWA has adopted the policy of managing the NEPA project development and decision-making process as an "umbrella," under which all applicable environmental laws, executive orders, and regulations are considered and addressed prior to the final project decision and document approval. Freight considerations are a vital component in this process. Conclusion of the NEPA process results in a decision that addresses multiple concerns and requirements, including freight. The FHWA NEPA process enables transportation officials to make project decisions that balance engineering, freight, and transportation needs with social, economic, and natural environmental factors" (p. 26). Despite that policy, freight movement does not appear to have been addressed by the Lead Agency.

If freight-hauling vehicles can increase vehicle speeds and reduce travel time by paying a toll, particularly if carrying perishable cargo and/or time-critical items, why would freight-haulers not elect to utilize HOT lanes over GP lanes (e.g., "Alternative 3 would not increase the percentage of trucks in the fleet mix and would improve vehicle speeds in the project area," DEIR/S, p. 3.2.6-51)? If the adage "time is money" bears some applicability to commercial vehicles and, as acknowledged, the I-405 Freeway is a "bypass" to the I-5 Freeway, why would some truck traffic now utilizing (or projected to utilize) the I-5 Freeway not divert to the I-405 Freeway HOT lanes? How could increased truck traffic on the "express lanes" impact travel speeds?

As indicated in the TOAR: "Auto vehicle types are classified by occupancy: drive alone (DA), shared ride with one person (SR2), and shared ride with 2 or more passengers (SR3). Heavy duty trucks are classified as light-heavy, medium-heavy, and heavy-heavy trucks. Light-heavy trucks are 8,500 to 14,000 gross vehicle weight in pounds (GVW), medium-heavy trucks are 14,000 to 33,000 GVW, and heavy-heavy trucks are 33,000 GVW or more. . . these vehicles are reported as trucks with 5 or more axles, trucks with 4 axles, trucks with 3 axles and truck with 2 axles" (p. 4-7). Since trucks are larger than automobiles, a "passenger car equivalent" (PCE) factors is typically applied to trucks. In calculating HOT/HOV/GP-lane capacity, what PCE has been applied for light-heavy, medium-heavy, and heavy-heavy trucks? What percentage of each truck type now exists within the project area and what percentage is anticipated in the future? Is that mix consistent with the mix anticipated along the I-710 Corridor and, if not, why not? Are truck emissions the same as those associated with automobiles? How would increased truck volumes effect emission projections? What is diesel particulate matter (diesel PM) and what are the potential health risks associated with long-term exposure?

The Traffic Study alleges that "[t]he Express Lanes would encourage carpooling by providing discounted tolls for HOVs with 3 or more occupants" (p. 1-12). No evidence is, however, presented to support that claim. Similarly, no information or analysis is presented addressing HOV+2 and HOV+3 and the impacts of congestion pricing on carpool formation.

5.7 Secondary Impacts

The EIS must identify all the indirect effects that are known and make a good faith effort to explain the effects that are not known but are "reasonably foreseeable" (23 C.F.R. 1508.8[b]). As defined in Section 1508.8 of the CEQ Regulations, "'effects' include: (a) Direct effects, which are caused by the action and occur at the same time and place. (b) Indirect effects, which are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems."

Similarly, as defined in Section 15358 of the State CEQA Guidelines: "Effects include: (1) Direct or primary effects which are caused by the project and occur at the same time and place. (2) Indirect or secondary effects which are caused by the project and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect or secondary effects may include growth-inducing effects and other effects related to induced changes in the pattern of land use, population density, or growth rate, and related effects on air and water and other natural systems, including ecosystems." As specified in Section 21061 of CEQA, an EIR intended to serve as an "informational document."

As indicated in SCAG's 2012 RTP/SCS: "Transportation projects including new and expanded infrastructure are necessary to improve travel time and can enhance quality of life for those traveling throughout the region. However, these projects also have the potential to induce population growth in certain areas of the region" (p. 80). "SCAG's analysis also indicates that every 10 percent decrease in congestion is associated with an employment increase of approximately 132,000 jobs. Congestion relief will be a major contributing factor to our future employment growth" (p. 16).

Although no methodology is presented, the Lead Agency asserts that implementation of Alternative 1 will "result in approximately 32,000 direct/indirect/induced jobs," Alternative 2 will result in "approximately 34,000 direct/indirect/induced jobs," and Alternative 3 will result in "approximately 42,000 direct/indirect/induced jobs" (CIA, p. .6-2). Rather than demonstrating how those estimates were derived, the Lead Agency presents a link to a FHWA website were, it must be assumed, a methodology can be found (requiring stakeholders to independently calculate the number of jobs attributable to each alternative without guidance concerning how those estimates were derived). Since no publication is cited, readers lacking computer access would be prevented from reviewing the Lead Agency's analytical assumptions and challenging or validating the document's conclusions.

As evidenced by these excerpts, the Lead Agency acknowledges that the three build alternatives will produce measureable "direct/indirect/induced" impacts. As further evidence of the DEIR/S' internal inconsistency, the Department concludes that "the proposed project <u>does not have</u> the potential to change land uses or induce growth but instead would provide increased lane capacity along I-405" (emphasis added) (p. 3.1.2-10) and "[t]he build alternatives are <u>not anticipated</u> to induce any other changes in land use and zoning in the project study area" (emphasis added) (p. 3.3.1-33); thus, seeking to avoid any analysis of the indirect and secondary consequences of the 32,000 to 42,000 "direct/indirect/induced jobs" that the Lead Agency purports that the proposed action will generate.

As indicated on FHWA's website (Employment Impacts of Highway Infrastructure Investment), the current economic environment "will exert downward pressure on the highway construction employment relative to the 2007 estimate of 27,800 jobs per $1 billion of Federal-Aid highway capital expenditure. . .The employment impacts of highway infrastructure investment do not remain constant over time. Increases in construction materials prices and wages over time will tend to reduce the number of jobs supported by each $1 billion invested."

Since the Lead Agency asserts that the proposed action is consistent with the 2008 RTP, as reported in SCAG's "The New Economy and Jobs/Housing Balance in Southern California" (April 2001): "The current (1997) regional average ratio of jobs to households is 1.25 jobs per household" (p. 15). Based on that ratio, the proposed action would result in 25,600 to 33,600 "direct/indirect/induced" housing units. The induced impact of not even a single housing unit is, however, examined in the DEIR/S. The Lead Agency's failure to examine the secondary or growth-inducing aspects of the proposed action is further highlighted by the declaration that "[t]he proposed improvements would add additional capacity to the freeway system and reduce commute times. Reduced commute times may facilitate land use planning, especially as it relates to new residential and commercial land uses because residents and shoppers may be attracted to these locations due to increased mobility. <u>This may have a secondary effect of generating economic activity</u>" (emphasis added) (DEIR/S, Table 3.1.1-1, p. 3.1.1-29). Although the DEIR/S acknowledges the project's potential to produce a "secondary effect," that impact is never addressed.

With regards to planned street and overcrossing closures and traffic diversions and detours, the Lead Agency notes that "[a]lternative routes and detours will be used to give motorists the opportunity to avoid the work zone by <u>diverting to other highway[s] or adjacent surface streets</u>"

(emphasis added) (RCS, p. 24). With regards to ramp closure, at the Fairview Road Northbound Off-Ramp, "24,000 AADT [annual average daily trips]" (RCS, p. 9) will be diverted onto other local streets for up to 30 days. The potential impacts of dumping 24,000 AADT onto other local streets and the potential level of service (LOS) and volume/capacity (V/C) impacts that would likely result from that added daily and peak-hour traffic are not, however, addressed (e.g., "Supplemental traffic analysis along alternate and detour routes may need to be performed during the final design phase to evaluate roadway and intersection performance and mitigation measures in response to added traffic," RCS, p. 24). For example, based on the proposed diversion of traffic to the Fairview Road/South Coast Drive intersection (see "Alternative Route Map – Sheet 2" and "Sheet 4" in the RCS), unaddressed is how that intersection will be impacted (e.g., southbound traffic redirected to require left turns onto Fairview Road rather than right turns).

Similarly, because some motorists will inevitably seek to avoid the construction delays along the I-405 Freeway (lasting up to 4.5 years), some drivers will voluntarily divert to "other highway or adjacent surface streets." Since the "I-405 is considered a bypass route to the Interstate 5 (I-5) Santa Ana/Golden State Freeway through Orange County" (NSR, p. 1), it can be concluded that during the construction period, some of the vehicles that would otherwise travel along the I-405 Freeway will select the I-5 Freeway as an alternative travel route. Absent from the DEIR/S is any effort to identify those alternative routes, quantify the number of vehicle, or analyze the potential short-term and long-term impacts of that added traffic to those "other highways and adjacent surface streets."

As indicated in the State CEQA Guidelines: "Effects analyzed under CEQA must be related to a physical change" (14 CCR 15358[b]). The Lead Agency recognizes that, as a result of the increased traffic resulting from traffic diversion and detours, physical modifications and/or other affirmative actions may be required in response thereto. The Department notes that "[p]otential mitigations that could be made on alternate and detour routes include: [1] Street/intersection improvements (widening, pavement rehabilitation, removal of median, restriping, etc.) to provide added capacity to handle detour traffic; [2] Signal improvements, adjustment of signal timing and/or signal coordination to increase vehicle throughput, improve traffic flow and optimize intersection capacity; [3] Turn restrictions at intersections and roadways necessary to reduce congestion and improve safety; [4] Parking restrictions on alternate and detour routes during work hours to increase capacity, reduce traffic conflicts and improve access" (RCS, p. 24). Nowhere in the DEIR/S are the environmental effects of those anticipated physical changes examined.

5.8 Lack of Measurable Analytical Criteria

With regards to construction-term impacts, as indicated in the DEIR/S: (1) "Based on the <u>short-term</u> and temporary nature of the closures (10 to 30 days), the increased travel times and distances would not result in either a <u>substantial economic effect</u> on businesses or substantial delays or travels cost for residents or business patrons" (emphasis added) (CIA, p. 6-7); (2) "Detour routes represent a <u>short term</u> inconvenience to both the traveling public but do not represent a <u>substantial burden</u> to either businesses (limited access) or the traveling public (substantially longer or indirect travel)" (RCS, p. 18); and (3) "No <u>temporary long-term</u> closures have been identified that would result in any <u>substantial effect</u> on emergency access or response times" (RCS, p. 20). A "temporary long-term closure" would appear to be an oxymoron.

In contrast, the Lead Agency also states that construction activities "would necessitate the closures of various facilities, such as the I-405 mainline, branch connectors, interchange ramps, and local arterials. Closures of these facilities may be overnight, short-term, during an extended weekend, or long-term. . .Long-term closure of arterial overcrossings may be employed during construction to expedite construction and shorten the duration that the overcrossing is out of service" (emphasis added) (DEIR/S, p. 2-26). Additionally, the RCS identifies a number of freeway ramps which will be closed for "up to 30 days" (Table 1, pp. 4 thru 6) (e.g., "These ramps will require complete closure for a period up to 30 days during ramp reconstruction because the new ramp alignments will occupy the current ramp locations, and construction access and right-of-way requirements preclude use while under construction," p. 6).

In reality, for each of the three build alternatives, it is the Lead Agency intent that "[l]ong-term closure of arterial overcrossing[s] lasting up to 12 months may be employed during construction to expedite construction and shorten the duration that the overcrossing is out of service. The potential locations for temporary long-term closures include the following: [1] Ward Street OC - 8 to 12 months; [2] Talbert Avenue OC - 8 to 12 months; [3] Slater Avenue OC - 8 to 12 months; [4] Bushard Street OC - 8 to 12 months; [5] Newland Street OC - 8 to 12 months; [6] Edinger Avenue OC - 8 to 12 months; [7] McFadden Avenue OC - 8 to 12 months; [8] Edwards Street OC - 8 to 12 month" (DEIR/S, Table 2-1, p. 2-35). Since no prohibitions have been identified, it is conceivable that other overcrossings may also be closed for extended periods. No plans are presented in the RCS or elsewhere in the DEIR/S addressing planned detours or anticipated impacts attributable to those long-term closures and no analysis is presented concerning how such closures could affect residents and businesses, rather the Lead Agency merely states that "[c]onstruction of the proposed project would result in some temporary and intermittent inconvenience for some current land use operations due to temporary traffic lane and ramp closures and temporary construction easements" (p. 3.1.1-32).

There are sufficient inferences in the DEIR/S to suggest that the potential for additional street closures is substantially greater than now indicated by the Department. For example, the Lead Agency anticipates "[c]losure of secondary streets during construction to allow quick construction and reopening" (RCS, p. 23). Those "secondary streets," however, are never identified. With specific focus on the College Park East neighborhood in Seal Beach, how would residents and motorists traveling along Almond Avenue be "inconvenienced" and what is the "temporary and intermittent" nature and extent of that "inconvenience"?

Absent both some definition of "substantial economic effect" and the identification of affected uses, the Department lacks any objective basis to ascertain the nature of potential effects on affected properties. For example, a large chain-store may be able to weather a restriction on access or a reduction in drive-past customers to a greater degree than either a single mom-and-pop or drive-through establishment dependent upon daily proceeds and drive-by customers (e.g., "Alternate routes and detours will be used to give motorists the opportunity to avoid the work zone by diverting to other highway or adjacent surface streets," RCS, p. 24). To the extent that the Lead Agency asserts that certain businesses may benefit from traffic diversions (e.g., "it should be noted that during the temporary long-term closures for the Magnolia Street SB off-ramp and the Westminster Ave SB on-ramp, the Bella Terra and Westminster Malls could experience increased economic activity due to the detour related drive-by traffic," RCS, p. 20), then the converse must also be true (i.e., some businesses could experience temporary or permanent loss of customers and decreased economic activities due to traffic diversions). Other than unsupported conclusions, no analysis of adverse economic impacts has been presented.

From "Alternative Route Map – Sheet 1" through "Sheet 9" in the TDM, it can be surmised that the long-term closure of identified arterials will, at least for the term of the closures, substantially reduce traffic volumes on those arterial segments between the nearest paralleling arterial and the point of closure. In addition, assuming that the intervening segments of those arterials remain open for access to those properties abutting those roadways (and located between the paralleling arterial and point of closure), there may be conditions where raised medians prevent motorists from exiting residents and/or commercial establishments, making U-turns, and returning in the opposition travel direction to those paralleling arterials. No discussion of those potential conditions has been presented in the DEIR/S, rather the Department merely states that "[a]ccess during construction would be maintained but may require reconfiguration during construction" (p. 3.1.1-32).

With regards to anticipated long-term arterial closures, as indicated in the TDM: "Although impacts to local commuters, residents and local businesses would be more severe during the closure, the impacts would end sooner because the improvements would be completed quicker allowing the roadway to re-open to public faster" (emphasis added) (p. 10). No definition of "severity" is, however, provided. The terms "sooner," "quicker," and "faster" neither allow for any assessment of the "severity" of the resulting impact nor allow for a determination of the potential significance of that effect.

From the above excerpt, the Lead Agency appears to equate the severity of potential impacts to the length of time the impact exists. There exists nothing in either CEQA or NEPA that includes time variability with regards to the assessment of the level of significance of an identified impact. Under the Lead Agency's rationale, there exists some unspecified universality with regards to the date/time/duration below which an impact is less-than-significant and above which that same impact becomes significant. To the extent that the Lead Agency seeks to establish duration as a component to impact assessment, with regards to each such determination, additional documentation supporting that position needs to be presented.

Although "Caltrans is the Lead Agency for the proposed project and has full discretion to establish the criteria for determining significance under CEQA" (AQR, p. 54), that criteria needs to be explicitly identified so that stakeholders can judge where the bar is being set.

For example, with regards to air quality, the DEIR/S' analysis (Section 3.2.6) fails to include a discussion of the South Coast Air Quality Management District's (SCAQMD) CEQA daily threshold values for the construction or operation of a proposed project. In addition, the analysis fails to use these threshold values in determining potentially significant air quality impacts. As an example, the SCAQMD daily threshold for oxides of nitrogen (NOx) during construction is 100 pounds per day. The analysis shows that construction activities would result in as much as 106 pounds per day (Table 3.2.6-8, p. 3.2.6-29); however, those emissions are never compares to the SCAQMD threshold. Since no threshold standard is present, the DEIR/S does not consider the resulting construction-term impact to be significant and no mitigation is proposed. In Orange County, SCAQMD's threshold standards are routinely used by those local agencies traversed by the I-405 Freeway in fulfillment of their CEQA compliance obligations.

5.9 Deferred Analysis and Mitigation

Under NEPA, the EIS must ensure that environmental information is available to the project's decision makers and to the public "before decisions are made and before actions are taken" (40 C.F.R. 1500.1[b]). It is critical that "[i]mportant environmental consequences will not be 'overlooked or underestimated only to be discovered after resources have been committed or the die otherwise cast.' In short, NEPA requires that the evaluation of a project's environmental consequences take place early in the project's planning process" (North Buckhead Civic Association v. Skinner [1990]).

Under CEQA, the Lead Agency is precluded from deferring the preparation of a reasonable analysis of project-related and cumulative environmental effects to later stages in the development process. This deferral of environmental assessment until after project approval violates CEQA's policy that impacts be identified before project momentum reduces or eliminates the agency's flexibility to subsequently change its course of action. More importantly, a deferred analysis and a deferred assessment of mitigation measures fails to provide evidence that the direct, indirect, and cumulative impacts of the proposed action can and have been effectively mitigated either to below a level of significance or to the maximum extent feasible.

With regards to mitigation, in Communities for a Better Environment v. City of Richmond (2010), the court ruled that "[f]ormulation of mitigation measures should not be deferred until some future time" ([Citation]). An EIR is inadequate if '[t]he success or failure of mitigation efforts may largely depend upon management plans that have not yet been formulated, and have not been subject to analysis and review within the EIR' ([Citation]). 'A study conducted after approval of a project will inevitably have a diminished influence on decisionmaking. . .Numerous cases illustrate that reliance on tentative plans for future mitigation after completion of the CEQA process significantly undermines CEQA's goals of full disclosure and informed decision making; and consequently, these mitigation plans have been overturned on judicial review as constituting improper deferral of environmental assessment ([Citation]). . .Fundamentally, the development of mitigation measures, as envisioned by CEQA, is not meant to be a bilateral negotiation between a project proponent and the lead agency after project approval; but rather, an open process that also involves other interested agencies and the public."

Cited below are a number of examples of deferred analysis.

- **Emergency response time impacts**. As indicated in the TDM: "Full freeway lane, ramp and arterial street closures would also be required during night times and on weekends (55-hour closure) during various roadway and structure construction activities. Complete ramp closure up to 30 days is also necessary for some of the interchange ramps and prolonged closure ranging from 3 to 12 months is anticipated to facilitate construction of certain arterials and overcrossing structures" (p. 8).

  As indicated in the FHWA's "Advanced Metropolitan Planning and Operations – An Objective-Driven Performance-Based Approach, A Guidebook" (February 2010): ""With homeland security concerns as well as natural disasters, efficient emergency response and evacuations are critical, and rely upon effective coordination and communication between transportation agencies and law enforcement" (p. 1-1). Rather than initiating that coordination early in the planning and environmental review process, the Lead Agency seeks to relegate "homeland security concerns" to an unspecified later date (e.g., "coordination with local jurisdictions and emergency service providers will be required during the final design," RCS, p. 20).

  The Department alleges that "[n]o temporary long-term closures have been identified that would result in any substantial effect on emergency access or response times" (RCS, p. 20); however, as a goal toward which it strives, Caltrans hopes to "[l]imit delay to less than 30 minutes above normal recurring traffic delay on existing facilities" (TDM, p. 8). It is unclear whether emergency service providers were made aware of either the planned "long-term closure of arterial overcrossings lasting up to 12 months" (DEIR/S, Table 2-1, p. 2-35) or the potential for 30-minute traffic delays. Since no response time analysis has been presented in the DEIR/S, it is not possible to determine how and to what extent those closures will impact emergency response. Contrary to CEQA, it appears that the Lead Agency has sought to defer that analysis until a later date, following the completion of the environmental compliance process.

Planned "[l]ong-term closure of arterial overcrossing[s] lasting up to 12 months" include "Talbert Avenue" (DEIR/S, Table 2-1, p. 2-35). The Department notes that "Orange Coast Memorial Medical Center: 9920 Talbert Avenue, Fountain Valley, CA 92708" (RCS, p. 20) is one of four hospitals located within the study area. Although the Talbert Avenue overcrossing may be closed for one year, absent either any supporting analysis or coordination with emergency service providers, the DEIR/S concludes that "[n]o temporary long-term closures have been identified that would result in any substantial effect on access to or response times to/from these hospitals" (Ibid.).

- **Unspecified arterial street improvements**. During freeway, individual ramps, select overcrossings, specified arterials, and unspecified secondary street closure activities, at least in certain instances, the Department has identified alternative routes and detours designed to route motorists around construction zones. With the exception of freeway ramps, the number of vehicles (as measured in annual average daily trips [AADTs]) has not been specified. However, in at least one case (i.e., Fairview Road Northbound Off-Ramp), during such closures, "24,000 AADT" (RCS, p. 9) will need to be ushered along existing roadways already operating at undesirable LOS conditions (e.g., LOS "D" or worse). Rather than analyzing the impacts of those planned diversions on both arterials and secondary streets, the Department seeks to defer that analysis to after the environmental process has been completed. As indicated in the DEIR/S: "Supplemental traffic analysis along alternate and detour routes may need to be performed during the final design phase to evaluate roadway and intersection performance and mitigation measures in response to added traffic. Potential mitigations that <u>could</u> be made on alternate and detour routes include: [1] <u>Street/intersection improvements</u> (widening, pavement rehabilitation, removal of median, restriping, etc.) to provide added capacity to handle detour traffic; [2] <u>Signal improvements</u>, adjustment of signal timing and/or signal coordination to increase vehicle throughput, improve traffic flow and optimize intersection capacity; [3] <u>Turn restrictions</u> at intersections and roadways necessary to reduce congestion and improve safety; [4] <u>Parking restrictions</u> on alternate and detour routes during work hours to increase capacity, reduce traffic conflicts and improve access" (emphasis added) (RCS, p. 24).

  Under CEQA, words like "should" indicate guidance and words like "could" or "may" indicate a permissive element which is left to the agency's discretion (14 CCR 15005[b]-[c]) and do not constitute enforceable requirements. As such, there exist no assurances that any of the statements whose action words include "could," "should" or "may" will actually be performed and, if implemented, will produce their intended results.

  As defined, in part, in the State CEQA Guidelines, "'[p]roject' means the whole of the action, which has a potential for resulting in either a direct physical change in the environment, or a reasonably foreseeable indirect physical change in the environment"

(14 CCR 15378[a]). The State CEQA Guidelines further specify that "[i]f a mitigation measure would cause one or more significant effects in addition to those that would be caused by the project as proposed, the effects of the mitigation measures shall be discussed but in less detail than the significant effects of the project as proposed" (14 CCR 15126.4[a][1][D]). The above excerpt states that "potential mitigation" may include unspecified street/intersection improvements, signal improvements, turn restrictions, and/or parking restrictions. Those improvements (whether identified as project facilities or mitigation measures) constitute "physical changes" attributable to the proposed action and are subject to CEQA. Instead of including an analysis of those physical changes in the DEIR/S, the Lead Agency has sought to defer both their identification and investigation to an unspecified later date.

It is assumed that the "final design stage" occurs immediately prior to the commencement of construction, at a time when stakeholders lack the ability to comment and when both further change and additional mitigation becomes impractical.

5.10 Reliance upon Outdated Plans and Policies

It is apparent the DEIR/S has either been sitting on the shelf too long (and passed its expiration date) or the document's authors have relied upon trite and generic analyses extracted from other documents (as if one-size fits all). In either case, on too many occasions, the Lead Agency seeks to utilized out-dated and superseded documents as the basis for its conclusions. What results is an incomplete and potentially erroneous assessment of the proposed action's consistency with relevant agency plans and policies.

For example, the DEIR/S misrepresents the applicable regional transportation plan (e.g., "The 2008 RTP presents the transportation vision for the SCAG region through the year 2035 and provides a long-term investment framework for addressing the region's transportation and related challenges," emphasis added, p. 3.1.1-19). Reliance upon a now defunct 2008 document prevents the Lead Agency from presenting a defensible analysis the proposed action's consistency or inconsistency with the current regional plan. Absent from the DEIR/S is any reference to SCAG's 2012 RTP/SCS (adopted on April 4, 2012) or its corresponding 2012 RTP/SCS PEIR (certified on April 4, 2012). The 2012 RTP/SCS was adopted and the 2012 RTP/SCS PEIR was certified prior to the release of the DEIR/S; however, no discussion of those documents is presented therein. Similarly, the DEIR/S cites the OCTA's "2006 Long-Range Transportation Plan (LRTP)" (emphasis added) (pp. 3.1.1-17 and 18) (i.e., "'New Directions' is an LRTP developed by OCTA and is designed to address the County's transportation services," p. 3.1.1-17), as the basis for determining consistency with regional transportation plans; however, in 2010, the OCTA adopted "Destination 2035 – Moving Toward a Green Tomorrow," thus relegating "New Directions" to its archives.

The project's air quality analysis is based on the EMFAC2007 emissions model (e.g., "EMFAC2007 was used to calculate operational emissions, DEIR/S, p. 3.2.6-22). The EMFAC2007 model has now been updated and replaced with EMFAC2011. As a result, the air quality analysis does not reflect the current analytical methodology, thus potentially leading to inaccurate emission calculations.

Absent from the DEIR/S is any "bibliography" or "list of references" allowing stakeholders to independently review the information contained in cited studies and referenced documents. If included, the Lead Agency's over-reliance upon antiquated information (e.g, "2006 Long-Ranch Transportation Plan" and "2008 Regional Transportation Plan") would become readily apparent.

5.11 Lack of Clearly Defined Threshold of Significance Criteria

The primary roles of CEQA are to inform lead, responsible, and trustee agencies about the effects of their actions, to create a formal mechanism to receive public input, to explore ways to mitigate adverse effects, and to determine whether there are alternatives to the proposed action that could reduce or avoid identified effects. Under CEQA, agencies are asked to drawing a "line in the sand" beyond which any impact would be deemed to be "significant." Section 15382 of the State CEQA Guidelines defines "significant effect on the environment" as "a substantial, or potentially substantial, adverse change in any of the physical conditions within the area affected by the project including land, air, water, minerals, flora, fauna, ambient noise, and objects of historic or aesthetic significance. An economic or social change related to a physical change may be considered in determining whether the physical change is significant."

Referencing Section 21000(d) of CEQA, the Legislature declared that "[t]he capacity of the environment is limited, and it is the intent of the Legislature that the government of the State take immediate steps to identify any critical thresholds for the health and safety of the people of the State and take all coordinated actions necessary to prevent such thresholds being reached." As required under Section 21001(f) therein, it is the policy of the State to "[r]equire governmental agencies at all levels to develop standards and procedures to protect environmental quality." At a minimum, a lead agency's standards cannot impose lower thresholds than established under applicable State and federal statutes and regulations. As long as they are factually based, fairly applied, and clearly articulated, lead agencies have the authority to impose there own threshold of significance criteria. No information is presented in the DEIR/S to suggest that the Lead Agency has formulated any independent threshold of significance criteria.

Absent from the DEIR/S is any clear description of the Lead Agency's threshold of significance criteria. Because a "CEQA checklist" is presented in Appendix A (CEQA Checklist) of the DEIR/S, by inference, it is assumed that the threshold of significance standards presented herein constitute the criteria that the Lead Agency seeks to apply to the proposed action. Beyond mere reliance upon the checklist, a number of sections of the State CEQA Guidelines are directly relevant to the assessment of an impact's significance (14 CCR 15064, 15064.4, 15064.5, 15064.7, 15065, and 15382). As stipulated therein, "[a] threshold of significance is an identifiable quantitative, qualitative or performance level of a particular environmental effect, non-compliance with which means the effect will normally be determined to be significant by the agency and compliance with which means the effect normally will be determined to be less than significant" (14 CCR 15064.7[a]). "The determination of whether a project may have a significant effect on the environment calls for careful judgment on the part of the public agency involved, based to the extent possible on scientific and factual data" (14 CCR 15064[b]). Where in the DEIR are the quantitative, qualitative, and/or performance-based thresholds of significance presented?

Although the CEQA checklist provides broad guidance, its purpose is to be used early in the environmental review process to facilitate scoping activities, not after the completion of the DEIR/S as a summation of the preliminary findings presented therein. Referencing Section 15063(d)(3) of the State CEQA Guidelines: "An Initial Study shall contain in brief form. . .An identification of environmental effects by use of a checklist, matrix, or other method, provided that entries on a checklist or other form are briefly explained to indicate that there is some evidence to support the entries."

As noted in Appendix A of the DEIR/S, the "CEQA checklist" was prepared on March 18, 2010. Both the NOP and NOI were released on August 26, 2009. As such, it is evident that the referenced checklist was not a part of any public outreach effort and, up to the release of the DEIR/S, was strictly an internal document.

The insufficiency of the checklist can be demonstrated by the precise working of that document. For example, with regards to the assessment of air quality impacts, the checklist queries whether the project would "[v]iolate any air quality standard or contribute substantially to an existing or projected air quality violation" (emphasis added) (Appendix A, p. 2). In order to support any conclusion, the Lead Agency, therefore, needs to disclose the existence of "all" air quality standards. Since the standards of the local air quality management district (i.e., South Coast Air Quality Management District) have neither been presented nor cited, the Lead Agency draws (erroneous) conclusions without presenting the substantial evidence (e.g., quantitative thresholds) upon which that conclusion is based.

5.12 Lack of Efficacy of Mitigation Measures

For a reader unfamiliar with the DEIR/S, Table S-1 (Project Impact Summary Table), containing the proposed "avoidance and minimization measures" and "mitigation measures," is surprisingly absent from the document's table of contents (p. vi). Similarly, with regards to each of the three building alternatives, no distinction is made therein relative to which of those "effects" and/or "measures" are applicable to which alternatives. As such, to the extent that specific actions are unique to individual alternatives, readers are required to conduct a detail review of the text of the DEIR/S in order to determine the relevancy of each "effort" and "measure."

Although represented as separate items (e.g., "Table S-1 summarizes project impacts by alternative and identifies avoidance and minimization measures. Where applicable, these measures are sometimes also mitigation measures, as discussed in Chapter 4 of this Draft EIR/EIS," p. S-12), as indicated above, it is not possible to clearly distinguish between "avoidance and minimization efforts" and "mitigation measures" and how those distinct "efforts" and/or "measures" differ in terms of their application and enforceability. Because that distinction is made intentionally obtuse, no differentiation between "avoidance and minimization measures" and "mitigation measures" can be made herein.

Pursuant to Section 21081.6(b) of CEQA and Section 15126.4(a)(2) of the State CEQA Guidelines, "[m]itigation measures must be fully enforceable through permit conditions, agreements, or other legally-binding instruments." The purpose of this requirement is to "ensure that feasible mitigation measures will actually be implemented as a condition of development, and not merely adopted and then neglected or disregarded" (Federation of Hillside & Canyon Associations v. City of Los Angeles [2000]). As indicated by the Governor's Office of Planning and Research's (OPR) "Tracking CEQA Mitigation Measures under AB 3180" (March 1996): "A measure that did not mitigate the impact could not be the basis for a finding that impacts were mitigated."

Although the following analysis cites specific "efforts" and/or "measures" presented in the DEIR/S without differentiation between "avoidance and minimization measures" and "mitigation measures" (as those terms are used by the Lead Agency), the issues raised should not be considered unique to only those "efforts" and/or "measures" so cited but should be interpreted as having relevancy or potential relevancy beyond the specific actions cited.

5.12.1 Measures which are not Mitigation

- **LU-1**. If a build alternative is selected for implementation, OCTA shall request the County of Orange and the cities along the project corridor to amend their respective General Plans to reflect the selected build alternative and the modification of land use designations for properties that would be acquired for the project that are not currently designated for transportation uses (pp. S-13 and 3.1.1-33).

  As stipulated in the State CEQA Guidelines: "'Mitigation' includes: (a) Avoiding the impact altogether by not taking a certain action or parts of an action. (b) Minimizing impacts by limiting the degree or magnitude of the action and its implementation. (c) Rectifying the impact by repairing, rehabilitating, or restoring the impacted environment. (d) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action. (e) Compensating for the impact by replacing or providing substitute resources or environments" (14 CCR 15370). Under NEPA, mitigation includes avoiding an impact by not taking a certain action, or parts of an action; minimizing an impact by limiting the degree or magnitude of the action and its implementation; rectifying an impact by repairing, rehabilitating, or restoring the affected environment; reducing or eliminating an impact over time, through preservation and maintenance operations during the life of the action; and compensating for an impact by replacing or providing substitute resources or environments (40 C.F.R. 1508.20).

  Mitigation measures must satisfy the constitutional test of "substantially advancing legitimate governmental interests." The California Supreme Court has ruled that this requirement consists of two elements. First, the courts (Nollan v. California Coastal Commission [1987]) have delineated the "essential nexus" that must exist between the legitimate public interest being protected and the mitigation which is imposed. A basis link between the imposed mitigation measures and the identified environmental effect is needed in order to satisfy this test. Second, the courts (Dolan v. City of Tigard [1994]) have stated that the imposed mitigation measure must substantially advance legitimate governmental interests and be "roughly proportional" to the project's individualized environmental effects.

  With regards to the above referenced action, the Lead Agency's strategy only includes a commitment by the OCTA to submit a "request" to each affected agency. The submittal of a "request" (whether written or oral) bears no "nexus" or "rough proportionality" (14 CCR 15041[a]) with the identified impact (e.g., loss of property and forfeiture of any right of use), offset or compensate for the environmental effect, or offer reasonable assurance that any further actions will result from the Lead Agency's actions.

  No factual basis is provided supporting any asserting by the Lead Agency that this and other similar measures (e.g., COM-5, COM-7, COM-8, COM-9, COM-11, UT-1, UT-2) will serve to reduce, avoid, eliminate, rectify, or compensate for any of the environmental effect identified in the DEIR/S.

5.12.2 Measures which are not Measureable

- **LU-2**. Caltrans shall implement a TMP throughout the duration of the construction activities and make this document available to the public. The TMP shall seek to minimize project-related construction disruptions and would include traffic strategies designed in coordination with local jurisdictions (pp. S-13 and 3.1.1-33).

  Words like "minimize" or "maximize" and their derivatives are meaningless because no actual performance is promised or specified and no yardsticks are presented against which each measures efficacy can be judged. For example, with regards to impacts on residents and businesses attributable to street closures and access restrictions, "LU-2" states that "Caltrans shall implement a TMP [traffic management plan] throughout the duration of the construction activities and make this document available to the public. The TMP shall seek to minimize project-related construction disruptions and would include traffic strategies designed in coordination with local jurisdictions" (emphasis added) (p. 3.1.1.33). The term "seek to minimize" is never defined, no performance standards are established against which attainment can be measures, and no remedial actions are proposed should the proposed measure fall short of its intended (but unmeasureable) results.

  Similar language is presented in the CIA. As indicated therein: (1) "Implementation of the TMP as outlined in Section 4.6 would minimize impact to the use of community services and facilities" (emphasis added) (p. 5-20); (2) "The Draft TMP (Appendix C), describes the action plan for minimizing impacts to community facilities during construction" (emphasis added) (p. 5-21); (3) "Implementation of the TMP would minimize impacts related to circulation and access during the construction period" (emphasis added) (p. 5-27); and (4) "The Transportation Management Plan (TMP) is a specialized program designed to minimize the impacts of a construction project by applying a variety of techniques including Public Information, Motorist Information, Incident Management, Construction Strategies, Demand Management and Alternate Route Strategies" (emphasis added) (RCS, p. 21). As a result, neither the DEIR/S nor its accompanying technical studies offer further clues as to how "minimize" will be quantified, evaluated, and/or monitored.

  In addition, although there is no indication that construction would conceivably take less than the time period specified (e.g., 54 months), the Department is "considering" the establishment of economic motivations to push the contractor into greater performance (e.g., "A supplemental construction strategy under consideration for this project is the use of an incentive/disincentive program to motivate the contractor to achieve the overall construction schedule and minimize impacts to traveling public and local communities," RCS, p. 24). As a result, the contractor may have agency-sanctioned disincentives to take any actions that could potential delay performance (e.g., facilitate private property accessibility to the detriment of movement of construction equipment). If the contractor has to choice between his paycheck and what the Department categorizes merely as a "short-term inconvenience" (RCS, p. 18) or "intermittent inconvenience" (DEIR/S, p. 3.1.1-32), the affected property owners will be the parties that suffer.

  As indicated in Appendix D (Draft Traffic Management Plan) of the CIA, the following "TMP goals" are presented "[1] Maintain travel lanes on I-405 mainline except as allowed per approved lane closure charts; [2] Limit delay to less than 30 minutes above normal recurring traffic delay on existing facilities; [3] Maintain traffic flow throughout the corridor and surrounding areas; [4] Provide a safe environment to the work force and traveling public" (CIA, Appendix D, p. 7). With the single possible exception of the 30-minute delay limitation, the purported goals neither impose/stipulate any meaningful actions nor respond to the TMP's stated purpose (e.g., minimize project-related construction disruptions," p. 3.1.1.33). In light of the planned closure of the mainline freeway (e.g., "During construction, there will be numerous different closures of the freeway mainline, branch connectors, interchange ramps and local arterials required to accommodate various construction activities," TMP, p. 10), the goal to "maintain travel lanes on I-405 except as allowed [by Caltrans]" serves no apparent purpose. With the plethora of freeway mainline, ramp, overcrossing, arterial, and secondary street closures, Caltrans' proposal merely directs motorists to use other streets over which it has not jurisdiction and whose capacity (to accommodate those added vehicles) is undemonstrated. The provision of a "safe environment" is both a legal requirement and a liability risk if such an environment were not to be maintained.

Given the opportunity to avoid a 30-minute delay by selecting an alternative destination, if comparable services are available elsewhere, most motorists would seek to avoid the delay. As a result, the Lead Agency cannot demonstrate that the TMP will effectively mitigation "project-related construction disruptions" (Measure LU-2). No factual basis is provided supporting any asserting by the Lead Agency that this and other similar measures (e.g., COM-6, COM-8, COM-9, T-1, VIS-1, VIS-6, VIS-16) will serve to reduce, avoid, eliminate, rectify, or compensate for any potential environmental effect.

5.12.3 Measures that Constitute only Restatements of Existing Requirements

- **COM-13**: Where acquisition and relocation are unavoidable, the provisions of the Uniform Act and the 1987 Amendments, as implemented by the Uniform Relocation Assistance and Real Property Acquisition Regulations for Federal and Federally Assisted Programs adopted by the United States Department of Transportation (March 2, 1989) and, where applicable, the California Public Park Preservation Act of 1971 will be followed. An appraisal of the affected property will be obtained, and an offer for the full appraisal will be made (pp. S-13 and 3.1.4-40).

With regards to "COM-13," there is no corresponding text reference in the DEIR/S allowing stakeholders to understand the environmental impact that this measure seeks to address. The DEIR/S does, however, note that "the property owners would be entitled to compensation to the extent provided by law in accordance with the Uniform Relocation Assistance and Real Property Acquisition Policies Act, as amended" (p. 3.1.4-33). Similarly, the AQR states that "[a]ll construction vehicles and equipment would be required to be equipped with the <u>State-mandated emission control devices</u> pursuant to State emission regulations and standard construction practices" (emphasis added) (p. 1). If "State-mandated," since it is prohibited from non-compliance, the stated measure imposes no additional obligation upon the Lead Agency other than to build the project in the manner in which it is already required by law.

Compliance with existing laws and regulations does not constitute mitigation under either CEQA or NEPA because it imposes no additional obligations upon the Lead Agency beyond those the agency is already bound. As such, this and other actions merely specifying compliance (e.g., COM-2, COM-10, WQ-1, WQ-3, WQ-4, WQ-6, GEO-1,

GEO-2, GEO-6, HAZ-4, HAZ-5, HAZ-10, HAZ-11, AQ-1, AQ-2, AQ-11, AQ-12, NOI-2, NOI-3, BIO-2, BIO-4, BIO-5, BIO-9) cannot be cited as the factual basis for reducing the impact for these this and those related measures have been formulated.

5.12.4 Measures that do not Specify any Actual Action

- **COM-4**. Provision of motorist information (i.e., existing changeable message signs, portable changeable message signs, stationary groundmounted signs, traffic radio announcements, and the Caltrans Highway Information Network [CHIN]) (pp. S-14 and 3.1.4-30).

  Measures intended to reduce, avoid, or eliminate an identified environmental effect must actually include some specified action that the Lead Agency or another entity will perform. This and similar measures (e.g., COM-5, COM-6, COM-8, COM-9, T-1, VIS-1, VIS-6) are drafted in a fashion that do not obligate any party to any actual action. If there exists no action-causing behavior or other corrective actions, no factual basis exists for asserting that imposition and/or compliance will reduce any corresponding environmental impact.

5.12.5 Delegation to Non-Governmental Entities Responsibility for Mitigation

- **UT-2**. During construction, emergency service providers will be alerted in advance of any temporary road closures and delays so that they have adequate time to make appropriate accommodations to ensure prompt emergency response times that fulfill their responsibilities and defined service objectives (pp. S-18 and 3.1.5-18).

  As specified under CEQA: “Each public agency is responsible for complying with CEQA and these Guidelines. A public agency must meet its own responsibilities under CEQA and shall not rely on comments from other pubic agencies or private citizens as a substitute for work CEQA requires the lead agency to accomplish” (14 CCR 15020). Here, the Lead Agency’s obligation is only to “alert” emergency service providers of pending construction activities and street closures. The Department is self-imposing no obligations to ensure that timely emergency response can and will be provided. It is up to private providers (not the agency creating the impediments) to “make appropriate accommodations,” including any incurrence of associated added costs. Because there is no assurance that similar levels of emergency response can be provided (e.g., “Limit delay to less than 30 minutes above normal recurring traffic delay on existing facilities,” TDM, p. 8) and because the term “appropriate” is left undefined, it is potentially the victim or patient that predicated the emergency response action that bears the ultimate risk and compensatory obligation.

5.12.6 Deferred Mitigation

- **VIS-14**. Design all visible concrete structures and surfaces to adhere to the Aesthetic and Landscape Master Plan when developed (pp. S-23 and 3.1.7-86; VIA, p. 1).

  Although the above “measure” is included in Chapter 3.1.7 (Visual/Aesthetics) in the DEIR/S, no reference to or discussion of the “Aesthetic and Landscape Master Plan” is presented in Chapter 2 (Project Alternatives) or in Chapter 3.1.7 (Visual/Aesthetics). Only an indirect reference is provided in the VIA (i.e., “In addition, the aesthetics and appearance of the measures will need to use the corridor master plan as a guiding document," emphasis added, p. 115). As a result, unless intentionally withheld, it appears that the "Aesthetic and Landscape Master Plan" and "corridor master plan" constitute project-related documents which do not yet exist but will be developed at an unspecified later date.

In addition, measures that stipulate performance "prior to completion of the final EIR/S" (e.g., HAZ-1, HAZ-3, HAZ-4, HAZ-5, HAZ-7, HAZ-8) only serve to: (1) impede informed decisionmaking by denying decision makers the opportunity to consider those plans and/or analyses in the context of additional information only obtainable through peer review; and (2) limit the affected public's opportunity to review, consider, and submit comments relating to the merits of those plans and the adequacy of those analyses.

Since they have yet to be developed, "measures" specifying compliance with non-existent documents and absence any measureable performance standards cannot be cited as demonstrating any potential off-setting environmental benefits. As such, this and other actions merely specifying compliance (e.g., VIS-5, VIS-11, HYD-4, HYD-6, WQ-2, WQ-6, PAL-1, AQ-7, BIO-2) cannot be cited as the factual basis for reducing the impact for these this and those related measures have been formulated.

5.12.7 Non-Enforceable Mitigation

- **GEO-2**. Selection of earth-retaining system types should be based on consideration of foundation bearing capacity, anticipated settlement and ability of the system to tolerate settlements, overall slope stability, constructability, and cost (pp. S-27 and 3.2.3-9).

  Section 21081.6(b) of CEQA requires that mitigation measures be "fully enforceable through permit conditions, agreements, or other measures." Measures that stipulate that the Lead Agency or another party "should" or "may" do something does not actually obligate the Lead Agency or that party to do anything. If no inherent requirements are established, compliance cannot be enforced.

  This and other similar measures (e.g., GEO-3, GEO-4, GEO-6) containing only recommendations cannot be cited as the factual basis for reducing, avoiding, eliminating, rectifying, or compensating for the impact that the measure was formulated to address.

When each of the above avoidance, minimization, and mitigation measures are eliminated, some topical issues addressed in the DEIR/S have few if any measures left. Since the Lead Agency states that each of the identified measures have been integrated into the proposed action and, therefore, constitutes a part of the project description then, with the exception of the narrow consideration among the three build alternatives, nothing (in terms of actual mitigation) is actually being provided for the purpose of mitigating the potential direct, indirect, and cumulative environmental effects of the proposed action.

5.13 Non-Disclosure of Critical Information

Although the administrative record is replete with references to OCTA's intent to authorize use (for a toll payment) of the "express lanes" established under Alternative 3 by SOVs, with the exception of reference to rejected alternatives presented in the MIS, only a single reference to “single-occupant vehicles,” “single-occupancy vehicles,” and/or “SOVs” can be found therein (i.e., The Express Lane Facility would be continuously monitored. During peak periods of congestion, monitoring would be used to adjust toll amounts to ensure that all user groups [i.e., HOVs, buses, and single-occupancy vehicles] of the Express Lanes experience free-flow conditions with less congestion and more throughput per lane than the GP lanes. The Express Lanes provide an option to users to obtain increased reliability in travel time,” p. 2-11). The term “SOV” is not even defined in Appendix G (Acronyms) in the DEIR/S. Because of its potentially broad reaching ramifications to not only the environmental analysis but to public perception, this lack of reference appears more than an oversight but disingenuous (e.g., an intentional withholding of critical information) and obfuscate the precise nature of the proposed action and OCTA’s intent.

Numerous documents critical to an understanding of the proposed action and upon which the Lead Agency’s analysis and preliminary conclusion (in the DEIR/S) appears to have been derived have not been included therein and, in some instances, their existence not acknowledged or, if acknowledged, referenced in such a way as to derive the affected public of the ability to review and consider those documents. For example, the DEIR/S table of contents identifies 18 “appendices” (p. iii); however, the following key documents are not included therein: (1) “Traffic Study – San Diego Freeway (I-405) Improvement Project SR-73 to I-605, Orange and Los Angeles Counties” (Caltrans, May 2011); (2) (2) “Community Impact Assessment – San Diego Freeway (I-405) Improvement Project SR-73 to I-605, Orange and Los Angeles Counties” (Caltrans, August 2011) (CIA); (3) “Noise Study Report – San Diego Freeway (I-405) Improvement Project SR-73 to I-605, Orange and Los Angeles Counties” (Caltrans, June 2011) (NSR); (4) “Noise Abatement Decision Report – San Diego Freeway (I-405) Improvement Project SR-73 to I-605, Orange and Los Angeles Counties” (Caltrans, September 2011) (NADR); (5) “Initial Site Assessment I-605, Orange and Los Angeles Counties” (Caltrans, March 2011) (ISA); (6) “Relocation Impact Memorandum – San Diego Freeway (I-405) Improvement Project SR-73 to I-605, Orange and Los Angeles Counties” (Caltrans, February 2011) (RIM); (7) “Air Quality Report – San Diego Freeway (I-405) Improvement Project SR-73 to I-605, Orange and Los Angeles Counties” (Caltrans, May 2011) (AQR); and (8) “Visual Impact Assessment – San Diego Freeway (I-405) Improvement Project SR-73 to I-605, Orange and Los Angeles Counties” (Caltrans, May 2011) (VIA). Much of the information presented in the DEIR/S, including its listed “appendices,” appears to be based on the more thorough analyses presented in these “missing” documents. It is the City’s belief that the above referenced documents were not widely disseminated and where not included in the information packets that were provided to local libraries.

One of the City’s expressed concerns relates to the anticipated relocation of the existing soundwall in the vicinity of Almond Avenue in Seal Beach. The DEIR/S is so vague in detail, although its relocation can be deciphered through a close examination of utility drawings (differentiating between “Existing R/W” and “Proposed R/W,” Appendix K, Utility U-24 and 2-25), with regards to each alternative, there is no explicit declaration of the Department’s intent. Leaving its details to speculation, the Lead Agency states: “Numerous soundwalls within the corridor would be replaced to accommodate the widened paving. In some instances, retaining walls would be placed below these walls, although these retaining walls are anticipated to be less than 5 ft in height. A new wall would then be constructed on top of the retaining wall section. [1] Alternative 1: 17 new soundwalls, 6 existing soundwalls would be replaced at a greater height, 14 existing soundwalls would be replaced in-kind, and 6 soundwalls would be provided for gap closure (i.e., to account for removal of embankment). [2] Alternative 2: 15 new soundwalls, 5 existing soundwalls would be replaced at a greater height, 20 existing soundwalls would be replaced in-kind, and 7 soundwalls would be provided for gap closure (i.e., to account for removal of embankment). [3] Alternative 3: 16 new soundwalls, 6 existing soundwalls would be replaced at a greater height, 23 existing soundwalls would be replaced in-kind, and 7 soundwalls would be provided for gap closure (i.e., to account for removal of embankment)" (DEIR/S, p. 3.1.7-31). As a result of this lack of reasonable disclosure, City residents and businesses are unable to clearly ascertain the precise nature of the proposed improvements and formulate meaningful comments on the DEIR/S.

The DEIR/S notes that "[v]isual impacts related to utility relocations would be minor, and in some areas would improve because some utilities would be relocated within bridge structures or underground; however, relocation of utility lines would have <u>little impact</u> on visual quality because existing views would, <u>for the most part</u>, remain unchanged" (emphasis added) (p. 3.1.7-32). The terms "little impact" (in the context of a defined quantitative or qualitative threshold) and "for the most part" (in the context of those locations where visual quality is anticipated to change) are left undefined but suggest that impacts will, in fact, occur and, in some instances, the resulting changes would be considered adverse.

Unless underground at the full and complete expense of the Department, it is further the City's believe that relocation of the existing soundwall near Almond Avenue will predicate the need to relocate the existing overhead utility lines now situated between the northern edge of the existing soundwall and the southern edge of pavement along Almond Avenue. The potential relocation of those utilities is not, however, addressed in the DEIR/S. Similarly, the Department does not indicate the party or parties that would be responsible for that relocation and whether any costs would be passed along to the utility's ratepayers, would be incurred by individual property owners, or would be borne by the Lead Agency as a project-related cost.

In addition, evidence suggests that other information that may be critical to assessing "feasibility" and evaluating the comparative merits of project alternatives has not been included in the DEIR/S and/or is being withheld by the OCTA so as to prevent affected stakeholders from submitting comments thereupon. For example, as indicated in correspondence from William Kempton, OCTA's CEO to OCTA's Highway Committee (Subject: Report on Phase II Feasibility Study – Traffic and Revenue Analysis for the San Diego Freeway [Interstate 405] Improvement Project Between Costa Mesa Freeway [State Route 55] and San Gabriel River Freeway [Interstate 605]), dated April 18, 2011, the CEO stated that OCTA "Staff is recommending further study to look at a more thorough representation and distribution of the <u>value of time on traffic</u>, a more detailed representation of <u>travel time savings</u> than what is calculated using the OCTAM travel demand model, effects of a dynamic tolling structure, and financial mechanisms to leverage additional funding, including private funding, to advance the project" (emphasis added) (p. 3).

Because the DEIR/S contains no information concerning the "value of time on traffic" and/or "travel time savings," it is not possible to comment on any analysis, conclusions, or methodology used in the derivation of that information. Although the City would generally support plans to reduce the time that motorists spend in congested traffic (whether on the freeway or other arterials), available scientific information suggests that those indices do not have merit in assessing transportation investment. As indicated in the World Bank's "Beyond Travel Time Savings: An Expanded Framework for Evaluating Urban Transport Projects" (2011) (see <u>Attachment E</u>), Robert Cervero notes that "[i]n congested, fast-growing cities with a pent-up demand for mobility, unchecked sprawl, and correspondingly high induced-demand elasticities, travel-time savings is likely a poor measure of welfare benefits from transport interventions, policy changes, and capital investments" (p. 28).

In addition, although a detailed "Expression of Interest in Tolling Authority was submitted to FHWA [by OCTA] in July 2010" (p. 1-19), a copy of that document is neither included in the DEIR/S nor available for review on OCTA's website. It is likely that the information contained therein has substantive bearing on the public's understanding of important physical and operational characteristics of Alternative 3. Because it sets in motion certain legislative or regulatory actions, its omission only serves to reinforce public suspicions of intentional misdirection and non-disclosure, the likely presence of inconsistencies between that application and the project's environmental documentation, and possible evidence of a pre-determination concerning the Lead Agency's identification of the "preferred project."

Similarly, with respect to "approval for modified access report to the Interstate system," the DEIR/S states that "[t]he Draft modified access report has been submitted to FHWA for review and comment" (Table 2-2, p. 2-51). As with the "Expression of Interest," it is likely that the information contained therein has substantial bearing on the public's understanding of the proposed action. Public review (during the CEQA/NEPA process) is critical to ensure consistency between that application and the project's environmental documentation, demonstrate objectivity with regards to the manner in which the three build alternatives have been examined, and to demonstrate the absence of any predetermination.

5.14 Lack of Objectivity

CEQA requires that decisions be informed and balanced (14 CCR 15003[j]). The court has noted that "the ultimate decision of whether to approve a project, be that decision right or wrong, is a nullity if based upon an EIR that does not provide the decision-makers, and the public, with the information about the project that is required by CEQA" (Santiago County Water District v. County of Orange, 1981) and "only through an accurate view of the project may the public and interested parties and public agencies balance the proposed project's benefits against its environmental cost, consider appropriate mitigation measures, assess the advantages of terminating the proposal and properly weigh other alternatives" (City of Santee v. County of San Diego, 1989). "If a final EIR does not 'adequately apprise all interested parties of the true scope of the project for intelligent weighing of the environmental consequences of the project,' informed decisionmaking cannot occur under CEQA and the final EIR is inadequate as a matter of law" (City of San Diego v. Board of Trustees of the California State University, 2011, quoting City of Santee v. County of San Diego).

In Sierra Club v. Froehlke (1987), the federal court noted that because "NEPA is concerned with accurate and informed decisionmaking as a general matter[, a]n environmental report that erroneously depicts positive environmental consequences poses as significant an obstacle to informed decisionmakingas one that inadequately assesses adverse circumstances."

The DEIR/S fails to meet the standard of a "balanced" assessment. For example, for the apparent purpose of promoting the proposed action, with regards to the No Build Alternative, the Lead Agency alleges that "[t]his alternative would be inconsistent with many regional and local planning goals and policies. The No Build Alternative, therefore, could result in adverse impacts related to land use" (DEIR/S, p. 3.1.1-20). Conversely, the Lead Agency fails to acknowledge that the No Build Alternative, as least to the degree that it does not promote new lane-miles over other transportation options and does not incentivize SOV trips, might also be consistent with other “regional and local planning goals and policies.

The DEIR/S further notes that “[d]uring construction of the build alternatives, motorists and emergency service providers can expect to experience typical construction-related temporary changes in access, with intermittent delays on I-405 and adjacent local roadways” (p. 3.1.5-13). Although no “construction-related” impacts are associated with the No Build Alternative.

The Lead Agency seeks to assert that, under the No Build Alternative, “congestion” will remain a problem but, under any of the build alternatives, “congestion” will be eliminated or substantially reduced. The DEIR/S, however, notes that none of the build alternatives “will totally alleviate congestion” (Traffic Study, p. ES-4). In what only appears to be an attempt to instill fear in readers toward a build option, the Lead Agency alleges that “[e]mergency response times may increase under the No Build Alternative due to a projected increase in future traffic volumes and a corresponding increase in traffic congestion” (p. 3.1.5-11) but, absent any supporting analysis, “any of the three build alternatives. . .could result in improved response times” (emphasis added) (Ibid.).

As indicated in Appendix A (CEQA Checklist), with regards to whether the proposed action would “[i]mpair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan” (p. 6), the Lead Agency concludes that the resulting impact is “less than significant with mitigation.” Since no comparative analysis of emergency response impacts is presented in Table S-1 (Project Impact Summary Table) (p. S-18), the CEQA checklist, summary table, and corresponding DEIR/S text appear internally inconsistent.

The most glaring example of the document’s lack of objectivity is the allegation that “[r]egional operational emissions would result in a beneficial impact under the build alternatives” (AQR, p. 1). Although information presented by the City refutes that conclusion, this statement is presented as if it was an uncontested fact. While required under the State CEQA Guidelines, the Lead Agency fails to identify this assertion as either an “area of controversy” or an “issue to be resolved” (14 CCR 15123[b).

5.15 Evidence of Predetermination

As indicated in Section 15003 of the State CEQA Guidelines: “The purpose of CEQA is not to generate paper, but to compel government at all levels to make decisions with environmental consequences in mind.” The California Supreme Court, in Laurel Heights Improvement Association v. Regents of the Univ. of California (1988), ruled that “[a] fundamental purpose of an EIR is to provide decision-makers with information they can use in deciding whether to approve a proposed project, not to inform them of the environmental effects of projects that they have already approved. If post approval environmental review were allowed, EIRs would likely become nothing more than post hoc rationalizations to support action already taken. We have expressly condemned this use of EIRs." That same “post hoc rationalization” is apparent herein.

In Concerned Citizens of Costa Mesa v. 32nd District Agricultural Association (1986), the court emphasized the critical role of linking government decisionmaking with public participation. “CEQA compels an interactive process of assessment of environmental impacts and responsive project modifications which must be genuine. It must be open to the public, premised upon a full and meaningful disclosure of the scope, purposes and effect of a consistently described project, with flexibility to respond to unforeseen insights that emerge from the process [Citation]. In short, a project must be open for public discussion and subject to agency modification during the CEQA process [Citation]. This process helps demonstrate to the public that the agency has in fact analyzed and considered the environmental implications of its action."

Under NEPA, "[a]fter publication of the Notice of Intent, the lead agencies, in cooperation with the applicant (if not a lead agency), will begin a scoping process which may take into account any planning work already accomplished, in accordance with 23 CFR 450.212 or 450.318. The scoping process will be used to identify the purpose and need, the range of alternatives and impacts, and the significant issues to be addressed in the EIS and to achieve the other objectives of 40 CFR 1501.7" (23 C.F.R. 771.123[b]) (see also 23 C.F.R. 771.111[h][2][vii]). Alternatives considered in the NEPA process for an EIS (23 U.S.C. 139) must arise from a process where the public and agencies have an opportunity for input in the identification of the range of alternatives considered. As specified, publication of the NOI is intended to initiate a scoping process through which alternatives are identified. In addition, as indicated in "SAFETEA-LU Environmental Review Process, Final Guidance" (Public Law 109-59 [November 15, 2006]): "As early as practicable, the lead agencies must give participating agencies and the public the chance to become involved in defining the range of alternatives" (Question 37).

Although the NOI was released on August 26, 2009, the range of alternatives which were to be examined in the DEIR/S had already been determined. As indicated in correspondence from William Kempton, OCTA's CEO to OCTA's Highway Committee (Subject: Update on Project Alternatives for the San Diego Freeway [Interstate 405] Improvement Project), dated August 26, 2009, "[o]n January 26, 2009, the Orange County Transportation Authority (OCTA) Board of Directors (Board) approved staff's recommendation to consider four alternatives. Alternative 1 proposes to add one general purpose lane in each direction, and Alternative 2 proposes to add two general purpose lanes in each direction. Alternative 3, the high-occupancy toll (HOT) lanes alternative, would add one general purpose lane and one HOT lane in each direction; converting the existing high-occupancy vehicle lane to a HOT lane would result in a total of two HOT lanes in each direction of Interstate 405. From here forward, this alternative will be referred to as the Express Lanes alternative. Alternative 4 would identify improvements related to adding one general purpose lane in each direction that match the currently available funding" (p. 1). With the exclusion of Alternative 4 (designed to "match the currently available funding"), none of the alternatives have changed and no additional alternatives have been included in the Lead Agency's analysis. As a result, even before the DEIR/S was released, it is evident that critical decisions (e.g., exclusion of any subsequently identified alternatives from meaningful consideration) and key determinations had already been made about the proposed action.

As specified in the FHWA's "Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU); Opportunities for State and Other Qualifying Agencies to Gain Authority to Toll Facilities Constructed Using Federal Funds," as issued on January 6, 2006, "[a] public authority that wants to request tolling or pricing authority, or funding, is asked to submit an Expression of Interest to the Tolling and Pricing Team in care of the FHWA Office of Operations in Washington, D.C." The DEIR/S states that "an Expression of Interest in Tolling Authority <u>was submitted</u> to FHWA in July 2010, which is currently being reviewed" (emphasis added) (p. 1-19). Since that document has not be included in the DEIR/S, it is not possible to determine what statements are contained therein, to what extend such submittal constitutes a pre-determination on the part of any public agency, or the relevancy of that document to the proposed action. The OCTA's submission of an "Expression of Interest" does, however, constitutes a formal request for tolling or pricing authority for the I-405 Freeway and constitutes evidence of a possible pre-determination (prior to the completion of the CEAQ/NEPA process) of a particular course of action. The City, therefore, requests that a copy of that document be included in the Lead Agency's written response to these comments.

As further specified in the FHWA's "Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU); Opportunities for State and Other Qualifying Agencies to Gain Authority to Toll Facilities Constructed Using Federal Funds," an application for tolling authority shall include "[a] description of how, if at all, any private entities are involved either in the up-front costs to enact tolling, or the cost sharing or debt retirement associated with revenues." Although the application was submitted prior to the release of the DEIR/S, absent from the DEIR/S are any statements concerning "how, if any all, any private entities are involved" or are likely to be involved "in the up-front costs to enact tolling, or the cost sharing or debt retirement associated with revenues." Since it might result in additional undisclosed impacts, the planned or potential implementation of a "public-private partnership" (P3), including consideration of a "design-build" agreement, likely constitutes a critical (but undisclosed) component of the proposed action.

In addition, as indicated in the RIM, included in the CIA, in a memorandum from Caltrans' Robert Enriquez (Branch Chief, Right of Way Utilities, Local Programs) to Smita Deshpande (Environmental Branch Chief), Ahmad Hindiyeh (Project Manager), and Matthew Cugini (Engineering Manager), as published on State letterhead and dated February 14, 2011, the Department stated: "<u>It has been determined there is no significant impact</u> to owners, tenants, businesses, or persons in possession of real property to be acquired who would qualify for relocation assistance benefits or entitlements under the Uniform Relocation Assistance and Real Property Act of 1970, as amended" (emphasis added)

6.0 CEQA/NEPA COMPLIANCE

6.1 CEQA Compliance

As stipulated under CEQA: "An EIR must include a description of the physical environmental conditions in the vicinity of the project, as they exist at the time the notice of preparation is published, or if no notice of preparation is published, at the time environmental analysis is commenced, from both a local and regional perspective. This environmental setting will normally constitute the baseline physical conditions by which a lead agency determines whether an impact is significant" (14 CCR 15125[a]).

In Communities for a Better Environment v. South Coast Air Quality Management District (2010), the court states that "[n]either CEQA nor the CEQA Guidelines mandates a uniform, inflexible rule for determination of the existing conditions baseline. Rather, an agency enjoys the discretion to decide, in the first instance, exactly how the existing physical conditions without the project can most realistically be measured, subject to review, as with all CEQA factual determinations, for support by substantial evidence." In Madera Oversight Coalition v. County of Madera (2011), the court added that "a baseline. . .must reflect existing physical conditions" and "lead agencies do not have the discretion to adopt a baseline that uses conditions predicted to occur on a date subsequent to the certification of the EIR." However, in Pfeiffer v. City of Sunnyvale City Council (2011), the court found that "appellants contention that a traffic baseline is limited to existing conditions lacks merit because. . .the California Supreme Court has instructed that predicted conditions may serve as an adequate baseline where environmental conditions vary." Based on these somewhat contradictory rulings, a clear understanding of what constitutes the project's "baseline" is important since it serves as the basis for assessing the physical changes to the environment predicated by the proposed action.

The Lead Agency states that the "existing condition" (i.e., baseline) includes "Project EA 0J440K, which would provide continuous ingress and egress from the HOV lanes on the entire length of I-405 in Orange County" (S-10). However, a wide range of other "baseline" conditions are also represented in the DEIR/S. As evidence of an inconsistent "baseline" condition:

(1) "The existing condition is the 'CEQA Baseline' condition" (p. 4-28).

(2) The Traffic Study defines the "baseline" as the "No Project Alternative," inclusive of the WCC (i.e., "No Build (Baseline) Alternative Analysis. The No Build Alternative assumes that no improvements have been made to I-405 with the exception of improvements related to the West County Connectors Project, as described in Section 1 of this report. The following analysis is based on the assumption that I-405 general purpose lanes, HOV lanes, ramps, and collector-distributor geometrics are identical to the Existing Condition geometrics," p. 2-41).

(3) The traffic section defines the "baseline" as Year 2009 traffic conditions (i.e., "Existing (CEQA Baseline) Traffic Conditions – Year 2009," 3.1.6-2).

(4) The air quality analysis defines the "baseline" as "no additional lanes or interchange improvements" (i.e., "The Project Baseline conditions under the No Build Alternative would provide no additional lanes or interchange improvements to the I-405 corridor," p. 3.2.6-50).

(5) The CIA defines the "baseline" as "no additional lane or interchange improvements," except for the WCC and the "Costa Mesa Freeway Improvements" (i.e., The No Build Alternative provides a "baseline" for comparing impacts associated with the build alternatives. The baseline conditions under the No Build Alternative would provide no additional lanes or interchange improvements to the I-405 corridor. The project area would continue to operate with no additional improvements with the exception that the two earlier committed projects (SR-22 West County Connectors [WCC] Project and the Costa Mesa Freeway [SR-55] Improvements would be implemented)," p. S-2).

As a result, it is not possible to know what the "baseline" conditions are, in fact, purported to be. Absence a clear and consistent description of the environmental baseline, it is not possible to accurately characterize the potential impacts attributable to the analyzed alternatives.

In addition, throughout these comments, the City has sought to raise numerous CEQA compliance issues. For brevity, those issues are not again presented herein. There non-inclusion under this heading is not, however, intended to suggest that no CEQA compliance issues have been identified as a result of the City's independent review of the DEIR/S.

6.2 NEPA Compliance

As indicated in the I-710 Corridor DEIR/S: "Per Federal statute, unless otherwise excepted, all Interstate highways must be toll-free. However, current exceptions relating to tolling of Interstate highways include Value Pricing Pilot Program; Express Lanes Demonstration Project; the Interstate System Reconstruction and Rehabilitation Pilot Program; and the Interstate System Construction Toll Pilot Program. Should Alternative 6C [tolling alternative] be selected as the preferred alternative, tolling would be implemented pursuant to one of these exceptions" (pp. ES-11 and 12). Assuming "federal statute" applies equally to the I-405 and I-705 Freeways and that both roadways are part of the same "Interstate highway" system," it can be assumed that the same prohibitions and exceptions apply equally to both projects. Absent from the DEIR/S is any discussion of those four options. If so prohibited, the Lead Agency needs to inform stakeholders how federal authorization will be obtains so that the accompanying statute and regulations can be independently examined to determine both relevancy and eligibility.

As indicated in the FHWA's "Congestion Pricing and NEPA: Environmental Benefits and Considerations" (November 2008): "A major challenge of congestion pricing is determining the level of public involvement. Public opposition poses a significant risk to the implementation of congestion pricing, so it is important that the public and elected officials, who may have their own reservations about congestion pricing, discuss the potential for pricing early in the NEPA process." The FHWA further notes that "transportation agencies should consider pricing during the planning stage of project development, before projects begin to go through the NEPA process. If this is not possible, it would be prudent to introduce pricing when determining the project's purpose and need, to help identify any appropriate pricing and managed-lane techniques. Since pricing and managed-lane techniques often encourage higher occupancy in vehicles, <u>framing the purpose of a project in terms of passenger volume as opposed to vehicle volume</u> can also open the discussion for pricing mechanisms. Alternatively, the project's purpose could be identified as reducing passenger delay or variability of travel times" (emphasis added).

As indicated in the American Association of State Highway and Transportation Officials' (AASHTO) "Practitioner's Handbook: Managing the NEPA Process for Toll Lanes and Toll Roads" (July 2006): "The fundamental NEPA requirements for a toll road project are no different from those applicable to any other project. But the introduction of tolling concepts into a NEPA study creates a series of new issues that give rise to new challenges for project teams. Many of these issues relate to the interplay between the NEPA process and other decision-making arenas, such as the transportation planning process, which precedes NEPA, and the financing and procurement process, which may overlap with or follow NEPA" (p. 2). As further indicated by the AASHTO: "The evaluation of tolled alternatives requires consideration of the effect of tolling on low income users of the transportation network. This analysis is needed in order to satisfy the requirements of the Environmental Justice executive order (E.O. 12898), which requires consideration of a federal action's potential for 'disproportionately high and adverse' effects on minority and low-income populations. Methodologies for considering a project's potential effects on low-income users are continuing to evolve, and should be considered on a project-by-project basis. Depending on the results of the impacts analysis, <u>it may also be appropriate to consider potential measures for mitigating the effects of tolling on low-income users</u>" (emphasis added) (p. 6).

Environmental justice considerations were not addressed in the DEIR/S (i.e., "Build alternatives would not result in environmental justice impacts," p. 3.1.1-30). With regards to potential environmental justice impacts associated with the proposed action, the Lead Agency states that there are "none" (CIA, Table S-1, p. S-4).

Tolling has the potential to affect traffic volumes and, thus, has the potential to affect impacts that are directly dependent on traffic volumes. These types of impacts generally include air quality, noise, and traffic congestion on existing roads. For example, an important issue when considering a tolled alternative is the potential for the toll to divert traffic to alternative routes. One possible approach is to present data (level of service, traffic volumes, etc.) at selected points on the local road network, in addition to presenting traffic data showing operations on the toll road itself. If toll-related diversions would necessitate improvements to other roads, those issues also should be considered" (Ibid.).

In addition, throughout these comments, the City has sought to raise numerous NEPA compliance issues. For brevity, those issues are not again presented herein. There non-inclusion under this heading is not, however, intended to suggest that no NEPA compliance issues have been identified as a result of the City's independent review of the DEIR/S.

7.0 ADDITIONAL ALTERNATIVES

Under the mandate of Measures M/M2, OCTA shall seek to "make best use of available freeway property" (Measure M2). Any discussion of a reasonable range of alternatives, therefore, needs to be premised on defining "best use." The City posits that "vehicle throughput" and "relative speed" are neither the appropriate nor only yardsticks against which "best use" can be defined.

Absent from the project's declared P&N and Lead Agency established objective is any reference to Measures M/M2. As such, the Lead Agency cannot limit and the DEIR/S cannot be bound to only those alternatives that can be argued as furthering the advancement of those actions identified by the voters of Orange County. CEQA and NEPA requires that the State and federal lead agencies act independently and select a range of alternatives that further the objectives of CEQA and NEPA and not solely the self-formulated objectives of the project proponent.

Even if the funding for the proposed action is linked, in whole or in part, to Measures M/M2, at the June 25, 2012 of the OCTA Board of Directors, "OCTA attorney Ken Smart said that Measure M can be amended as long as the entire OCTA board, as well as the tax payer committee, has a two thirds vote" (Molina, Alejandra, Orange County Register, Streetcars, 405 Widening: Adjusting Measure M, July 3, 2012). As such, "best use" and not available funding constitutes the factual bases for the formulation of a reasonable range of project alternatives.

It is not the City's intent to discourage the investment of public funds benefitting the residents and business community within Seal Beach, Orange County, or the SCAG region. These, however, are fugal times where both individual households and government alike need to diligently consider discretionary spending and optimize the public's returns on expended funds. In defining the project's "objectives" only in terms of investment in new lane-miles on the I-405 Freeway, the Lead Agency never presents the more significant and more varied goals of optimizing public investment in transportation facilities and optimization of system performance, thus leading to a broader examination of a wider range of alternatives.

As indicated in the CTC Needs Assessment, "California's transportation system is in jeopardy. Our aging infrastructure includes roads, highways, bridges, public transit vehicles and facilities, passenger and freight rail, airports, harbors, and international ports of entry. Streets and highways carry huge amounts of traffic, and they absorb continual wear from heavy trucks and other vehicles. Other transportation infrastructure is called upon to satisfy increasing demands for public transit and to move people and goods by air and sea, along rail lines, and across borders at United States ports of entry. At the same time, the costs to preserve the infrastructure that serves these needs are soaring, even though construction bids are lower than they have been in years. Ongoing budget shortfalls have forced agencies to defer maintenance, leading to roads and bridges that are in worse shape by the time they are rehabilitated. Investments to preserve transportation systems simply have not kept pace with the demands on them, and this underfunding has led to the decay of one of California's greatest assets. As the transportation system grows increasingly unreliable, the state will become less attractive to businesses, residents, and tourists, exacerbating our revenue problems at a time when we can least afford it. Preserving these systems is an essential investment" (p. 3-4). "Every piece of transportation infrastructure has an expected service life, but these components only will achieve their expected life span when they are properly maintained. By failing to invest in preserving these expensive assets, we fail to fully benefit from the initial investment that taxpayers make. . .Unfortunately, deferred maintenance because of funding shortfalls has caused many elements of the transportation system to fall into poor condition, and they now require expensive reconstruction to bring them back to acceptable operating conditions" (p. 3-8).

The CTC Needs Assessment demonstrates that the State does not have sufficient resources or revenues to fund all its transportation needs. As a result, prudent fiscal management would suggest that prioritization of funding allocation is needed. Arguably, the preservation and maintenance (i.e., preventive maintenance, rehabilitation and reconstruction, and regulatory mandates) of existing transportation infrastructure and investments in public transit (including transportation demand management) should receive a higher priority that non-critical new project development (system expansion). Since the manner in which a question is posited both leads to and limits the range of answers presented, the question that should be asked with regards to the proposed action is not "how many and what type of new lanes should be added to the I-405 freeway" but "how should up to $5.8 billion in public funds be expended to maximize transportation-related and other societal benefits?"

Additionally, it is noted that the proposed action is neither included in Caltrans' "2010 Interregional Transportation Improvement Program" (February 12, 2010) (2010 ITIP) nor does it respond to the objectives and system priorities outlined in Caltrans' "Interregional Transportation Strategic Plan: A Plan to Guide Development of the Interregional Transportation System" (June 1998) (1998 ITSP). That document serves to consolidate and communicate key elements of the State's ongoing short-range and long-range planning and serves as a counterpart to the "Regional Transportation Plans" prepared by the State's 43 regional transportation planning agencies. The six key objectives of the 2008 ITSP include: (1) Complete a trunk system of higher standard (usually expressway/freeway); (2) Connect all urbanized areas, major metropolitan centers, and gateways to the freeway and expressway system to ensure a complete Statewide system for the highest volume and most critical trip movements; (3) Ensure a dependable level of service for movement into and through major gateways of Statewide significance and ensure connectivity to key intermodal transfer facilities, seaports, air cargo terminals, and freight distribution facilities; (4) Connect urbanizing centers and high growth areas to the trunk system to ensure future connectivity, mobility, and access for the State's expanding population; (5) Link rural and smaller urban centers to the trunk system; and (6) Implement an intercity passenger rail program (including interregional commuter rail) that complies with federal and State laws, improves service reliability, decreases running times, and reduces the per passenger operating subsidy.

That segment of the I-405 Freeway examined in the DEIR/S has neither been identified as a "high emphasis route" nor a "focused route" in the 1998 ITSP. In addition, the proposed action has not been included on the "2010 ITIP Highway Project List" in the 2010 ITIP.

With regards to transit, the Lead Agency seeks to employ a "demand management" strategy during construction in order to reduce construction-term impacts. As described in the RCS: "This strategy involves promoting the use of public transit, ride sharing and variable work hours to reduce the amount of traffic using the freeway and roadways in and around construction zone. Through the public awareness campaign, large employers will be urged to consider staggered working hours and encourage their employees to use the OCTA transit system and rideshare resources which includes six park-and-ride lots along the I-405 corridor. Incentive programs such as free transit tickets and free/discounted merchant coupons for rideshare participants could be used to attract participants" (RCS, p. 24; TDM, p. 14).

Unless merely a token effort presented solely to give stakeholders the impression that such a "strategy" could produce tangible results, without any realistic expectations on the part of either the Department or OCTA that such activities could reduce traffic, it is regrettably that this program is not presented as part of a long-term, multi-faceted effort to reduce congestion. If "demand management" actually works, then it must be part of the Lead Agency's arsenal to address not only temporary but also on-going congestion issues. As a result, the Department should document to what extend a "demand management strategy" may aid in reducing congestion during construction and more broadly apply that or a expanded strategy as an alternative to the proposed action.

7.1 System Management Alternative

As perceived by the City, one of the major short-coming of the proposed action is its singular focus on freeway widening (to the detriment of all other transportation system and management alternatives). As outlined in a memorandum from Joan Sollenberger, Chief, Division of Transportation Planning and Cindy McKim, Chief Financial Officer to Chair and Commissioners (Subject: Report on Corridor System Management Plans), dated February 19, 2009, Caltrans' emphasizes "the importance of CSMPs [corridor system management plans] in restoring mobility to California and sustaining mobility gains" (p. 1) As specified therein:

> Corridor System Management Plans (CSMPs) are plans to comprehensively manage and operate urban transportation corridors across jurisdictions and modes. The plans include all major transportation elements in the corridor, such as freeways, major parallel local arterials, and transit and rail. The goal is to maximize total corridor productivity and performance by providing the highest sustained throughput of people and freight, while considering all corridor elements. . . The plans are supportive and complementary to meeting the goals and objectives of the California Regional Blueprint efforts, compliance with Assembly Bill (AB) 32 and Senate Bill (SB) 375 to reduce greenhouse gas emissions, and of the Smart Mobility Framework. The plans will restore and sustain mobility while improving the environment by encouraging smart land use development, compact housing, and increased modal trips (Attachment, p. 1).
>
> The importance of CSMPs to improve and sustain California's mobility can not be overstated. <u>The plans are the way the California Department of Transportation (Department), with regional and local partners, must plan for corridor system management and operations now and in the future</u>. The plans are based upon the concepts presented in the Department's Transportation Management System (TMS) Master Plan that was required by the California State Legislature in 2004. These concepts and this approach are the foundation of the transportation component of the Governor's Strategic Growth Plan (SGP). This approach will restore productivity to the State's transportation system, improve corridor throughput, improve travel time reliability across all corridor elements and ensure economic growth. The SGP is performance-based and outcome-driven. It targets a significant decrease in traffic

> congestion below today's levels. This will occur even while accommodating growth in population and the economy over the decade with comprehensive system management.
>
> The Department and its regional and local partners recognize that addressing congestion requires a multi-pronged approach, referred to as system management. The approach includes: adding new capacity, maintaining its infrastructure, investing in and encouraging the use of alternative modes (such as transit and rail), encouraging smart land use, transportation management systems, incident management, and other strategies. . . System management can significantly improve productivity of all elements of the transportation corridor, improving travel times and reliability for all travelers" (emphasis added) (Attachment, pp. 2 and 3).

It is evident that a CSMP would allow for the attainment of the P&N and project objective, while concurrently focusing on the transportation system as a whole rather than as disconnected and unrelated parts. While the proposed action could become a component of a broader system management strategy, it cannot be presented as the only available solution to reduce congestion.

7.2 Other Corridor Alternatives

As described in the FHWA's "Guidance on Using Corridor and Subarea Planning to Inform NEPA" (April 5, 2011):

> States, metropolitan planning organizations (MPOs), and local governments have primary responsibility for transportation planning. The transportation planning process required by 23 U.S.C. §§ 134 and 135 and 49 U.S.C. §§ 5303-5306 sets the stage for future development of transportation projects. Federally-funded highway and transit projects originate in the statewide and metropolitan transportation planning processes. Corridor and subarea plans are conceptual level planning studies, which focus on a particular corridor or region and can help determine where there is a transportation need. The transportation regulations governing the use of corridor and subarea studies identify products from this type of planning that may be used to inform NEPA, including, the purpose and need or goals and objectives statement(s); the general travel corridor and/or general mode(s) definitions; the preliminary screening of alternatives and elimination of unreasonable alternatives; the basic description of the environmental setting; and/or the preliminary identification of environmental impacts and environmental mitigation. A State, MPO, or public transportation operator may undertake a multimodal, systems-level corridor or subarea planning study as part of the statewide and metropolitan transportation planning process. The results or decisions of this study may be used as part of the overall project development process consistent with NEPA and FHWA regulations. Often, since it happens later in the project development process, the environmental analysis done to meet NEPA requirements for transportation projects is largely disconnected from the planning process. This may result in planning decisions being overlooked or disregarded under NEPA. When decisions are revisited, it can lead to misapprehension, duplication of work, added expense, or confusion for stakeholders.
>
> Corridor and subarea plans are conceptual level planning studies, which focus on a particular corridor or region and can help determine where there is a transportation

> need. . .more detail than area-wide or regional plans. Subarea studies are similar to corridor studies, with the distinction that a subarea study generally addresses more of the total planning context and the broader transportation network for the area (emphasis added) (pp. i and 8).

As indicated in Caltrans' RCR for the I-405 Freeway, the "I-405 serves several purposes in Orange/Los Angeles Counties. It is a bypass route to I-5. It is also an inter-county and intra-regional route which intersects two Interstate Routes (I-5 and I-605) and five State Routes (SR-133, SR-55, SR-73, SR-39, and SR-22) in Orange County. It is a major goods movement facility into and out of Orange and Los Angeles Counties along with significant amount of recreational and commuter trips" (p. 7). Under the heading "Federal/State Functional Classification," the RCR further states that the:

> I-405 is classified as an Interstate Facility (P1P) throughout Orange County. Following are other designations which may affect planning and/or operations on I-405.

Designation	Limits
National Highway System (NHS)	Entire length of I-405
Subsystem of Highway for the Movement of Extra Legal Loads (SHELL)	Entire length of I-405
National Network for STAA Trucks	Entire length of I-405
12 Foot Wide Arterial System	Entire Length of I-405
Lifeline Route	8.74/24.18 (SR-55 to L.A. Co. Line)

Although never represented as such, the only segment of the I-405 Freeway examined in the DEIR/S relates to the "lifeline route." Other corridor alternatives relate to: (1) that segment identified as a "Interstate Facility (P1P) (i.e., the entire length of the I-405 Freeway); (2) that segment included in the "National Highway System" (i.e., the entire length of the I-405 Freeway); (3) that segment included in the SHELL (i.e., the entire length of the I-405 Freeway); and/or (4) that segment included in the "12 Foot Wide Arterial System" (i.e., the entire length of the I-405 Freeway).

As has occurred elsewhere in the State, Caltrans should examine the I-405 Freeway, including that segment extending through Los Angeles County, as an entire corridor and should ascertain the full extend of improvements required throughout that corridor in order to assess future year conditions, improvement needs, and funding priorities. It would appear impossible to successfully accomplish long-range transportation planning "14-miles" (p. 2-20) or "15-miles" (AQR, p. 51) or "16 miles" (p. 1-12) at a time with self-imposed blinders concerning what is occurring or what should occur on the opposite ends of that short-length section. Similarly, it is difficult to envision how transportation planning can occur in the absence of a broader discussion of other interrelated planning elements (e.g., land use).

In addition, as indicated in the FHWA's "Federal-Aid Highway Program Guidance on High Occupancy Vehicle (HOV) Lanes" (August 2008), "degradation" was defined as the following: "The minimum average operating speed is defined at Section 166(d)(2)(A) as 45 miles per hour (mph), for an HOV facility with a speed limit of 50 mph or greater, and not more than 10 mph below the speed limit for a facility with a speed limit of less than 50 mph. Section 166(d)(2)(B) provides that an HOV facility is considered degraded if it fails to maintain a minimum average operating speed 90 percent of the time over a consecutive 180-day period during morning or evening weekday peak hour periods (or both for a reversible facility)" (Chapter IV).

As indicated in Caltrans' "California HOV/Express Lane Business Plan 2009" (May 15, 2009), "nearly 50% of the HOV lanes in the state experience periods of degradation in the peak hour according to the federal definition – meaning that average speeds of 45 mph speed or lower have been measured more than 10% of the time" (p. 9). As of July 2008, the existing HOV lane system had 1,424 existing lane-miles and 124 lane-miles under construction. Future expansion of the network includes 269 programmed lane-miles and 974 proposed lane-miles planned by State and local agencies (p. 5). More than 700 lane-miles of HOV facilities in California are now "degraded." By focusing solely on a 16-mile freeway segment, the Lead Agency ignores the broader problem the proposed action purports to address.

In addition, OCTA/LACMTA's "Orange and Los Angeles Intercounty Transportation Study – Conceptual Alternatives Report" (July 16, 2008) (OC/LA Intercounty Study) noted that "[a] majority of the freeway segments in the OC/LA study area are forecast to operate at a poor level of service during the AM and PM peak periods in the Year 2030. . .Traffic congestion is already a substantial constraint on mobility for all freeways in the OC/LA study area. Forecasted increases in traffic volumes, delay, and travel demand for the Year 2030 condition will only further exacerbate the pressure on the freeway network serving Los Angeles and Orange counties. In 2030, the majority of freeway segments in the OC/LA study area are forecast to operate at poor levels of service (LOS E or F). A range of improvements for the freeway network needs to be explored to meet forecast travel demand. Improving the operating efficiency of the existing freeway infrastructure will be important in order to maximize traffic flow. However, operational improvements alone will not be able to serve forecasted Year 2030 traffic volumes. Additional freeway capacity is necessary to serve anticipated traffic volumes and to ensure the continued economic growth of Southern California" (pp. 6-7).

Freeway system improvements identified in the OC/LA Intercounty Study (p. 13) include:

- I-405 Freeway. I-405 freeway improvements consist of adding one general purpose lane in each direction and auxiliary lanes in several locations in Orange County from Brookhurst Street to the I-605 freeway and adding a second HOV lane in each direction from the SR-22 freeway to the I-605 freeway.

- SR-22 Freeway. Improvements on the SR-22 freeway include constructing HOV direct connectors to the I-405 freeway as part of the West Orange County Connectors project.

- I-605 Freeway. Improvements on the I-605 freeway include improving freeway access and arterial connection in the communities of Cypress and Los Alamitos. New freeway-to-freeway direct connector HOV ramps to I-405 are also planned as part of the West Orange County Connectors project.

- I-5 Freeway. Improvements on this freeway include adding one general purpose lane and one high occupancy vehicle (HOV) lane in each direction in Los Angeles County from Rosemead Boulevard to the OC/LA county line, as well as adding one general purpose lane and one HOV lane in each direction in Orange County from SR-91 to the OC/LA county line. The section between SR-57 and SR-91 in Orange County is also scheduled to be improved through a restriping and minor capacity enhancement that would result in the addition of one more lane in each direction. This additional lane would widen the freeway to a total of 12 lanes (six in each direction) and could be either an additional general purpose lane or an additional HOV lane.

- SR-57 Freeway. Improvements on the SR-57 freeway including the addition of a new northbound truck climbing lane from Lambert Road to Tonner Canyon Road and adding a new northbound general purpose lane from Orangewood Avenue to Lambert Road. Both projects would occur in Orange County. The 2030 Baseline projects also include reconfiguring the existing interchange at Lambert Road and adding a southbound off-ramp lane at that location. The construction of HOV drop ramps to Cerritos Avenue is also included.

- SR-91 Freeway. Baseline improvements on SR-91 include the addition of one westbound general purpose lane in Orange County from I-5 to SR-57.

- SR-60 Freeway. Baseline improvements for SR-60 include the addition of one HOV lane in each direction in Los Angeles County from I-605 to Brea Canyon Road.

One of the "key issues" identified in the OC/LA Intercounty Study is the need for interagency coordination. The study states that "[i]ncreased coordination between agencies is essential for the successful implementation of transportation improvements. There are also significant opportunities for cities located along the county line to use this study effort to increase coordination and cooperation on local transportation issues" (p. 7). Although published in 2008, it is noted that the OC/LA Intercounty Study is neither referenced in nor is its needs assessment and/or alternatives analysis addressed in the DEIR/S. Similarly, no evidence of "interagency coordination" between OCTA and LACMTA is presented in the DEIR/S.

Caltrans' "Corridor System Management Plan (CSMP) – Orange County SR-22 Comprehensive Performance Assessment and Causality Analysis, Final Draft" (May 4, 2009) was prepared as part of the "Orange County State Route 22 Corridor System Management Plan" (CSMP) development process, as required by the California Transportation Commission (CTC) for corridors that have received funding from the Corridor Mobility Improvement Account (CMIA) approved by the voters in 2006. The CMIA will partially fund the construction of HOV connectors between the SR-22 and I-405 Freeways, as well as the I-405 and I-605 Freeways. Since it has already been delineated as part of a previous planning process, those freeway segments comprising the CSMP constitutes a logical "corridor" (including the roadway facility, major interchanges and relative demands at these interchanges, rail and transit services along the freeway facility, major Intermodal facilities around the corridor, and special event facilities/trip generators) for the purpose of the environmental assessment for the proposed action.

As described therein, "[t]he study corridor includes portions of three state routes, SR-22, I-405, and I-605 in Orange County. The corridor begins at an interchange involving all three freeways at the Los Angeles County border. From there, the corridor runs east along SR-22 (Garden Grove Freeway) to SR-55. The corridor also runs southeast along I-405 (San Diego Freeway) unit it reaches I-5 (Golden State Freeway) just outside Irvine. The corridor includes a short, one-mile section of I-605 (San Gabriel River Freeway) as it heads north from the Los Alamitos Curve (SR-22/I-405/I-605) interchange to the Los Angeles County border" (p. 18).

Alternatively, if the OCTA has only "$500 million" dollars available and the estimated cost of the proposed 16-mile improvements are projected at "$1.7 billion," to the extent that the Lead Agency seeks to define the project as containing "independent utility," then a logical corridor-based alternative is to define the project not as an "approximately 16-mile" (p. 1-23) corridor but as a 4.7-mile corridor ($500 million/$1.7 billion x 16 miles = 4.7 miles) constructible with the funding now available.

7.3 Performance-Based Investment Strategies

As indicated in Caltrans' RCR, with regards to the formulation of improvement plans for the I-405 Freeway, the Department notes that the proposed route "concept calls for a new strategy emphasizing system management and operational improvements of our existing freeway system in a way that optimizes the carrying capacity referred to as Traffic Operations Strategies (TOPS). It is an operational strategy that will maximize the utilization of the existing urban freeway system through performance-based investment strategies. Currently, the district with the cooperation of the other southern California districts is developing a system wide concept report for Southern California. If fully implemented, the concept for this route could improve to a Level of Service (LOS) of 'E' which will reduce delay to motorists and the trucking industry" (Summary). As indicated therein: "The RCR contains the Department's goals for the development of each route in terms of Level of Service (LOS). One of the Department's goals is the proposed concept of Traffic Operations Strategies (TOPS). The RCR broadly identifies the nature and extent of improvements needed to reach those goals" (p. 2).

Under the proposed action, the Department's approach appears to be based on a planning concept that starts with "what can we squeeze in" or "what does not appear to cost too much" (although the "preferred project" presently exceeds available funds by 340 percent) and then determining what the level of service become (in this case continuance of primarily LOS "F" conditions). A performance-based approach would start with a specific performance goal (e.g., LOS "E" conditions in all GP lanes) and determining what freeway-improvement and other actions are needed for its attainment. As indicated in the RCR:

> TOPS was proposed by Caltrans Districts 7, 8, 11 and 12 to maximize utilization of the existing urban freeway system through performance-based investment strategies. TOPS recommends improvements for this route, including programming, funding and comprehensive system management. A system wide concept report for Southern California is being developed. Full implementation of TOPS will take place over a 5-10 year span depending on the level of improvement required and available funding. As a result of TOPS, the concept for this route anticipates Level of Service (LOS) of "E" or better with minimal delay to motorists and the trucking industry.
>
> In the past, Caltrans Route Concept Reports focused on adding mixed flow or high occupancy vehicles lanes (HOV) in locations were the existing/projected traffic shows LOS "F" (stop and go condition). <u>Widening alone is no longer the best solution to meet the existing and projected demand on the system</u>.
>
> Transportation professionals, looking for better ways to improve the overall performance of the system, believe the most cost effective and efficient solution is to maximize capacity on the existing facility and maintain a steady flow of traffic by implementing a series of traffic operations strategies. For example, freeway capacity for a 4-lane freeway is 9,200 vehicles per hour (2,300 vehicles per lane). During peak congestion with stop and go conditions, freeway capacity is reduced to about 6,000 vehicles per hour (1,500 vehicles per lane). If smooth, free flowing operational conditions could be maintained throughout the system, a freeway would carry about 30% more vehicles than a congested facility (emphasis added) (pp. 20-21)

Are freeways and arterial streets designed for peak or non-peak-hour periods? What are the specified corresponding "level of service standards" (Ordinance No. 2)? What freeway and non-freeway improvements and other actions would be necessary to generally achieve LOS "E" conditions along the designated "corridor," based not on a 100 percent frequency but based on a reasonable and specified percentile?

7.4 VMT Reduction Alternatives

As indicated in Table 7 (Induced Travel Demand in Increased Vehicle Miles Traveled) herein, the Lead Agency acknowledges that the proposed freeway improvements will increase VMT by 1,013,000 miles/year. Increasing VMT adds both to congestion and mobile source emissions. As a result, other alternative strategies could include those that decrease existing or diminish the projected growth of VMT over the planning period.

7.5 Operational Alternatives

A wide range of operational alternatives should be considered by the Lead Agency. A number of distinct operational strategies are identified below.

- **TMS master plan**. As indicated in "California Interregional State Highways – Major Planning Considerations, Trends, and Implications" (Caltrans, January 2010):

  > Caltrans, in collaboration with regional and local partners, relies on the development of the CSMPs to manage corridor mobility and operations now and in the future. The CSMPs are based upon the concepts in Caltrans' Transportation Management System (TMS) Master Plan that was required by the California State Legislature in 2004. The TMS Master Plan is the foundation of the transportation component of the Governor's Strategic Growth Plan (SGP). This system management approach will restore productivity to the State's transportation system, improve corridor throughput, enhance travel time reliability across all corridor elements, and support economic growth. The TMS Master Plan identifies three principal elements that will help restore productivity. These are: traffic control (such as ramp meters and improved signal timing on local arterials), incident management, and traveler information. These elements must be built on a strong foundation of detection in order to measure freeway performance. Aggressive deployment of these TMS elements could, on the freeway system alone, increase productivity by 20 percent, reduce projected congestion by 20 percent, and improve travel time reliability by 10 percent (p. 3).

  Absent from the DEIR/S is any reference to either Caltrans' TMS Master Plan or to its "three principal elements" (i.e., traffic control, incident management, and traveler information). Since those elements have the potential to increase productivity and reduce congestion (by 20 percent) and improve travel time reliability (by 10 percent), their implementation would appear to allow for the cost-effective attainment of the Lead Agency's P&N and project objective.

- **Conversion of existing GP lanes to HOV lanes**. Section 21655.5 of the California Vehicle Code states that Caltrans and local authorities may "authorize or permit exclusive or preferential use of highway lanes for high-occupancy vehicles" provided that engineering studies are completed on safety, capacity, and delay. Similarly, Section 149 of the California Streets and Highways Code states that "designated lanes on existing highways" may be authorized for bus only or bus and HOV use. Despite that authorization, unaddressed is the relatively inexpensive option of converting existing general purpose (mixed-flow) lanes to HOV lanes.

- **Dual HOV lanes**. In addition, the DEIR/S states that "[a] 'build' option that has been considered is provision of dual HOV lanes in each direction. This option was considered during the MIS phase of project development and eliminated from further consideration as described in Section 2.2.5, Eliminated Alternative Developed after PSR/PDS" (p. 3.1.6-82). There is no "Section 2.2.5" with that title or subject content in the DEIR/S. Section 2.27 (Alternatives Considered but Eliminated from Future Discussion) (p. 2-27) does not appear to includes a discussion of a "dual HOV lane" alternative.

  The Lead Agency asserts that the proposed action is consistent with the (outdated) RTP. However, as indicated in the "Congestion Management Strategy" component of the 2012 RTP/SCS, the following item is included in the "CMP Toolbox": "An HOV lane is a dedicated lane(s) along a freeway or arterial dedicated to vehicles with more than one or two occupants. Increases corridor capacity while at the same time provides an <u>incentive for single-occupied drivers to rideshare</u>. On average, a HOV lane in Los Angeles County accommodates 1,300 vehicles or 3,300 people per hour during peak periods, and the county HOV system serves approximately 331,000 vehicle trips or 780,000 person trips per day" (emphasis added) (p. 27). In furtherance of that strategy, both a "dual HOV lanes in each direction" alternative and prohibition on use of HOT lanes by SOVs considered potentially viable alternatives that warrant the subsequent analysis by the Lead Agency.

- **Truck only toll lanes**. As reported in the Georgia State Road and Tollway Authority's "Truck Only Toll Facilities: Potential for Implementation in the Atlantic Region, Final Report" (July 18, 2005):

  > TOT [truck only toll] lanes offer a variety of potential benefits for commercial vehicles, other travelers and for transportation agencies. Such lanes can: [1] Enhance transportation options. Shippers and service providers will have the option of traveling more reliable routes in the Atlanta region, especially during peak periods. [2] Improve safety and efficiency in the road corridor. By encouraging commercial vehicles to use the TOT lanes, the mix of vehicles remaining in the freeway becomes more uniform. Thus, not as many trucks and personal vehicles will be sharing the same roadway as previously. This should improve the efficiency of travel on the road, as well as reduce the risk of truck/automobile crashes. [3] Improve freight productivity. The efficiency of freight movement in and around major metropolitan areas will likely be even more of a concern to the business community in the future. In addition, for logistics centers like Atlanta, freight mobility and productivity could become an important factor in the competitiveness of Atlanta versus other comparable regions. TOT lanes can greatly improve commercial vehicle productivity. [4] Manage congestion levels for truck travel and improve general purpose highway congestion. By imposing fees when demand levels reach capacity on TOT facilities, the level of congestion on TOT facilities is controlled. If a large number of trucks are removed from the general purpose lanes and the local road network, congestion levels might be reduced for other traffic as well. [5] Generate revenue for TOT lane operation. In order to manage traffic levels on

> the TOT lanes, fees may need to be imposed on facility users. Fees can provide an additional source of revenue to pay for transportation improvements, especially the operations and maintenance of the TOT lanes themselves (pp. v and 1-2).

While the above report is specific to the Atlanta area, it is likely that the reported benefits of TOT lanes would equally apply to the southern California area (particularly in light of the project's proximity to the Ports of Los Angeles and Long Beach, Los Angeles International Airport, and John Wayne Airport). A TOT alternative should, therefore, be considered in combination with any other toll-based options being considered by the Lead Agency.

- **Reversal lanes**. Because peak-hour traffic along the I-405 Freeway is primarily unidirectional (from Orange County toward Los Angeles County in the morning and reversed in the evening), the Lead Agency should also explored a reversible lane design which would allow for adjustments in directionality based on changing demands.

- **Use of shoulder lane**. As indicated in the FWHA's "Efficient Use of Highway Capacity Summary – Report to Congress" (November 2010), in California, "[t]ransit vehicles may use the shoulder when general purpose lane traffic slows to 30 mph or lower. They may travel no more than 10 mph faster than traffic in general traffic lanes. The cross-section of the shoulder is at least 10-ft wide throughout the deployment area. Pavement markings to indicate the operational strategy include text indicating 'Transit Lane Authorized Buses Only'" (p. 23). As further indicated therein, "in response to rising levels of congestion and a lack of right-of-way for contemporary expansion of capacity, many States adopted the use of dedicated shoulder lanes, sometimes in conjunction with or instead of narrowed lane widths" (p. 25).

  As a cost-efficient alternative to the construction of new HOV and GP lanes, the Lead Agency should examine the temporary and/or permanent conversion of existing interior and exterior shoulders to travel lanes.

7.6 Design Alternatives

A wide range of design alternatives should be considered by the Lead Agency. A number of distinct operational strategies are identified below.

- **Design exceptions**. The DEIR/S notes that the existing "HOV lanes on I-405 currently do not meet either FHWA or Caltrans operating criteria" (p. 2-19). Those facilities, however, continue to be operated with relative safety notwithstanding their lack of consistency.

  As indicated in the WCC FEIR/S: "Under the (Enhanced) Reduced Build Alternative, the freeway within the SR-22/WOCC project would be improved to full geometric design standards with the exception of the following: [1] Non-standard inside shoulder on I-605 and I-405 transition areas to join to an existing non-standard shoulder. Also on I-405 and SR-22 at spot locations where California Highway Patrol (CHP) enforcement areas are recommended. [2] Non-standard lane widths 10.8 to 11.8 ft. (3.3 to 3.6 meters) on I-605 and southbound north of the HOV connector, and on Brookhurst Street dual left turn and lanes No. 1 and 2 at eastbound SR-22 ramp. [3] Non-standard median widths on I-

605 north of the HOV connector, on I-405 at I-605, and on I-405 at SR-22" (p. 2-7). In addition, as indicated in the DEIR/S, "the existing lane width" along the I-405 Freeway "varies between 11 and 12 ft." (p. 2-1). Based on those excerpts, it is evident that Caltrans supports and has approved projects involving "non-standard" lane widths and other design deviations.

As reported in the Metropolitan Transportation Commission's and Caltrans' "Regional HOT Lanes Network Feasibility Study" (September 2007): "HOV lanes currently exhibit a wide range of design practices statewide. Lane widths vary from 12 feet to 11 feet in restricted settings. Buffer widths are typically 4 feet, but may be reduced to 1 to 2 feet in restricted settings. Median shoulder widths vary from nominally 10 feet to 4 feet, but outside (right) shoulders on most freeways are 8 to 10 feet even in restricted settings. General purpose lane widths may be reduced to 11 feet, but the rightmost lane(s) are typically 12 feet in restricted settings. The Caltrans HOV Guide offers guidance for design reductions in such settings" (p. 21).

As noted in the DEIR/S: "Design exceptions are necessary when the proposed design deviates from the standard design features presented in the Caltrans Highway Design Manual. For example, the design standard for a freeway left-side shoulder is 10 ft; design exceptions are sought for locations where the columns supporting overcrossing bridges encroach into the shoulder and narrow the shoulder to approximately 7.5 ft beneath the bridge. Nine mandatory and 18 advisory design standards would require design exceptions at one or more locations along the corridor" (p. 2-5). As such, substantial precedence exists to support the introduction of design exceptions where such exceptions can be supported.

- **Active traffic management and restriping**. As noted in FHWA's "Public Roads" (March/April 2009, Vol. 72, No. 5), in an article titled "Congestion Pricing with Lane Reconfigurations to Add Highway Capacity," where statutorily authorized, "[i]f pricing is to become a more widely used tool to reduce congestion or provide reliable travel times in major metropolitan areas, new approaches to implementation must be developed. One potential solution involves the creation of networks of free-flowing express lanes by (1) using active traffic management (AcTM) strategies to dynamically manage freeways with flexible use of shoulders as travel lanes, and (2) restriping of existing pavement into narrower lanes in order to accommodate a new lane within the existing facility footprint. Agencies would operate the left lane as a priced lane, with the right-side shoulder serving as a general-purpose lane either permanently or when needed to accommodate high demand. This approach avoids the need to take away an existing lane to create the new priced lane." Under a restriping option, the FHWA indicates that: (1) no change would occur to the left shoulder; (2) one or more fee lanes could be established on the far left, reduced from a width of 3.7 meters (12 feet) to 3.4 meters (11 feet) to accommodate buffer separation between express and general-purpose lanes, with a 0.6 meter (2 foot) wide buffer; (3) general purpose lanes, reduced in width from 3.7 meters (12 feet) to 3.4 meters (11 feet), if needed to accommodate the buffer and the dynamic shoulder lane; and (4) a 4 meter (13 foot) wide dynamic shoulder lane on the far right. If extra pavement width is needed, pavement could be added or taken from the left shoulder where excess shoulder width exists. On a freeway in which the far left lane is already an HOV lane, the adjacent lane could be modified to create a two-lane fee section. If the shoulder where converted to a general-purpose lane, the number of toll-free, general-purpose lanes would remain the same as before the conversion (Ibid.).

7.7 Transit Alternatives

Under Measure M2, 25 percent of the net revenue are to be dedicated to Countywide transit programs. As a result, the DEIR/S is remiss by failing to consider possible transit alternatives.

As indicated in "Congestion and Accessibility: What's the Relationship?" (Mondschein, Andrew, Taylor, Brian D., and Brumbaugh, Stephen, March 2011), published by the University of California Transportation Center (UCTC), the authors concluded that "public transit likely provides residents of a congested region with alternatives to traveling on clogged roadways; alternatives that facilitate increased activity in the face of ongoing congestion" (p. 38). Although the FHWA's "Technical Advisory T 6640.8A" states that mass transit and transportation system management alternatives should be considered when identifying reasonable alternatives, no transit-based alternatives have been examined in the DEIR/S.

As defined in Caltrans' "California HOV/Express Lane Business Plan 2009" (May 15, 2009), "the term express lanes [is used] synonymously with High Occupancy Tolling (HOT) lanes, where preferential access is provided for high occupancy vehicles or toll payments" (p. 2). The term "corridor" means "a segment of highway that includes all highway lanes and any parallel arterials" (Ibid.). As noted therein: "Currently <u>all express lane facilities in California have a transit component</u> either as part of the customer base or as recipients of annual revenues. These opportunities to integrate and coordinate all modes of travel should continue to be sought. In some cases transit service is being directly increased and transit stops are being revised or redesigned to encourage a shift to transit and thus increase person throughput in the corridor" (emphasis added) (p. 26). In what best appears to an example of agency short-sightedness, notwithstanding that declaration, no "transit component" has been included as part of any of the three build alternatives presented in the DEIR/S and no project-related plans have been formulated to increase or promote transit ridership or to add or expand transit facilities as a component of the proposed action.

At the community meeting conducted in the City on June 26, 2012, the OCTA's representative stated that the proposed "express lanes" (under Alternative 3) would "promote bus rapid transit." In addition, at that same meeting, OCTA's representative stated that bus services were being "cut" based on budgetary considerations. The two statements appear inconsistent.

Absent from the DEIR/S is any discuss concerning how or commitment by the OCTA to utilize the HOV/HOT lanes for "bus rapid transit" purposes. In light of those same budgetary considerations, what concurrent commitments (presented as mitigation measures or integral project features) is the OCTA's Board of Directors making with regards to the provision of expanded bus services? What new transit facilities are being proposed in combination with each of the three build alternatives? Is a reduction in existing bus service a component of the No Build Alternative? How would the implementation of the No Build Alternative and the three build alternatives affect existing bus routes and transit facilities and/or result in the establishment of new or modified routes and/or facilities?

7.8 Impact-Avoidance Alternatives

In order to demonstrate the feasibility of retaining the existing soundwall along Almond Avenue in Seal Beach, the City, working with a highly respected professional traffic engineering firm (W.G. Zimmerman Engineering, Inc.), has developed a number of design alternatives that would not substantially impede the ability of the Department to undertake lane improvements to the I-

405 Freeway. Those design alternatives, prepared specifically to avoid project-related impacts upon the College Park East neighborhood, are presented in Attachment A (Alternative Design Configurations) The City believes that implementation of one or more of those impact-avoidance alternatives, in conjunction with the incorporation of those supplemental mitigation measures presented in Section 2.3 (City-Nominated Mitigation Measures) herein, would substantially lessen the impacts of the proposed action on Seal Beach and its residents.

7.9 Financing Alternatives

The City is concerned about the potential impacts to its residents resulting from the proposed conveyance of management obligations and all future toll revenue to a private for-profit entity. If, as the Lead Agency purports, the entire region benefits from an expansion of freeway capacity, to the extent that project financing will play a part in the Lead Agency's determination, then more equitable financing options need to be explored.

7.10 Other Alternatives

Referencing SCAG's "LAX/South (Orange County) High-Speed Ground Access Study, Final Report" (October 2004) (HSGA Study):

> Transportation planners throughout the Southern California region have long been concerned about mobility and ground access impacts to regional airports given the area's enormous growth in population and jobs. For example, in 1980 Southern California had a population of slightly less than 13 million; it is now anticipated that by the year 2020 the regional population will exceed 22 million. In addition, between now and 2020, the number of people using Los Angeles International Airport (LAX) will grow from 65 million a year to 86 million. That magnitude of growth will affect every Southern California resident and visitor as they attempt to move around the region on the ground or move into and out of the area by air. To help deal with mobility issues associated with that type of growth, the Southern California Association of Governments (SCAG) has adopted a Regional Transportation Plan that includes a strategy for managing airport demand through maximizing the use of all existing airports and airfields in the region. The successful implementation of that strategy requires the development and deployment of one or more high-speed transportation systems connecting regional airports to substantially reduce airport ground access by single-occupant vehicles (SOVs).
>
> In 1999, SCAG secured funding from the Federal Railroad Administration (FRA) and the Federal Aviation Administration (FAA) to begin planning high-speed ground access projects in three of the region's most heavily congested corridors to link many of the area's major airports. Those three corridors are: [1] LAX to March AFB: [2] LAX to Palmdale; and [3] LAX to Orange County [extending between Los Angeles International Airport and the Irvine Ground Transportation Center]. . .A regional multi-modal high-speed ground access (HSGA) system has been identified as a principal means of connecting major regional activity and transportation centers and supporting passenger and cargo demands associated with anticipated growth in Los Angeles, Orange, Riverside, and San Bernardino Counties. The development of regional multi-modal HSGA system alignment alternatives for this study will focus on the LAX/South (Orange County) Corridor, with a potential terminal station at John Wayne Airport (JWA), Long Beach Airport (LBA), the Irvine Ground Transportation

> Center (ITC), as well as other possible intermediary stations. <u>This project is a key component of the 1998 Regional Transportation Plan</u> (RTP) strategy for managing airport demand through maximizing use of existing airports via high-speed transportation system connections (emphasis added) (pp. 1-1 and 1-2).

SCAG's HSGA Study identified "three final recommended alignment alternatives" connecting LAX and the ITC. As described therein: "The Southern Alignment fulfills the primary system role of Airport Connector and Feeder by providing the quickest, most direct connections to all airports in the study area. From LAX, it stays almost entirely within the I-4-05 corridor from I-105 to the Irvine Transportation Center, with a stub track north from the John Wayne Airport area to Anaheim. One alternative alignment uses SR-22 to serve Anaheim directly. The primary alignment using I-405 (and including the stub line to Anaheim) is approximately 58 miles long" (pp. 5-1 and 5-2). Proposed station locations included, but were not limited to, "Seal Beach West" and "Seal Beach East" (p. 4-18). In a separate SCAG-issued "LAX/South (Orange County) High Speed Ground Access Study Status Report" (SCAG, February 2007), with regards to the Southern Alignment, SCAG concluded that the I-405 Freeway alignment produced the: "(1) Best overall performance with least competition (from Orange Line, Metrolink, and others); (2) High number of stations with development potential; (3) Fewer environmental impacts; (4) Best fulfils role of airport connector."

As a result, there already exists extensive SCAG-sponsored analysis identifying the feasibility and traffic and transportation-related benefits associated with the use of the I-405 Freeway ROW for utilization as a light-rail or fixed-rail HSGA system. In recognition of the existence of alternative uses for that ROW, based on SCAG's own acknowledgement that a HSGA system is a "key component" of the 2008 RTP, and the Lead Agency's representation that the proposed action is consistent with the 2008 RTP, a high-speed rail alternative needs to be examined in the DEIR/S.

In addition, in "The Day that People Filled the Freeway: Re-Envisioning the Arroyo Seco Parkway and the Urban Environment in Los Angeles" (Loukaitou-Sideris, Anastasia, UCTC, Spring 2005), the author wrote:

> More than any other city in the world, Los Angeles has come to be symbolized by its freeways. As the most monumental human-made structure in the Los Angeles basin the freeway network has determined a particular spatial order and organization of the city's urban form. Freeways have managed to transport people and goods and link points of origin with points of destination. But when they were superimposed on the smaller, finer grain of residential neighborhoods they tended to split and destroy them. In outlying city areas, the superimposition of the freeway grid on the landscape has epitomized the complete domination of the 'urban' over nature. In a process of urbanization, expansion, and unfettered growth, city fathers have often treated nature as threatening 'other' to be contained, diminished, and built upon. Thus, the city has been associated with the loss of natural habitats and open space and the laying of asphalt and concrete in an ever-expanding process of urbanization and sprawl (p. 3).

The perpetuation and expansion of that freeway network is the only vision espoused in the DEIR/S. Clearly, there are other long-ranging, innovative, and non-auto-centric visions of how best to utilize this and other transportation corridors that would serve to "reduce congestion," "increase mobility," and "minimize environmental impacts." Nowhere in the DEIR/S, however, is anything presented other than the same single-minded transformation of increasingly more space devoted to increasingly more automobile traffic. Reducing vehicle travel by providing individuals and firms with attractive alternative access choices (such as the telecommunting or walking) may serve to reduce traffic delays while increasing productivity.

In addition, as indicated in the FHWA's "Advanced Metropolitan Planning and Operations – An Objective-Driven Performance-Based Approach, A Guidebook" (February 2010): "It is estimated that more than half of congestion experienced by travelers is caused by non-recurring events, such as weather conditions (e.g., snow, ice, rain); work zones; special events; and major incidents and emergencies that are not typically taken into account in the traditional metropolitan transportation planning process" (p. 1-1). Major "sources of congestion" identified by the FHWA include bottlenecks (40%), traffic incidents (25%), work zones (10%), bad weather (15%), poor signal timing (5%), and special events/other (5%) (Figure 2, p. 1-1). Although the Lead Agency purports that the project's P&N is to "reduce congestion," "more than half" on the causes of congestion are never even considered in the DEIR/S.

Since the Lead Agency's P&N includes increasing travel time reliability (for a limited number of motorists), possible capacity-enhancing alternatives relate to both increased enforcement (e.g., vehicle occupancy requirements) and drivers' education (e.g., slower traffic impeding traffic flow). As reported in "HOV Facility Development: A Review of National Trends, Paper No. 02-392," "[e]nforcement continues to be a challenging issue with all HOV systems. Without the proper enforcement of the HOV lane occupancy requirements, the operational effectiveness and efficiency, along with public acceptance suffer" (p. 15). Presently, an unspecified number of SOVs utilize the HOV lane in violation of the California Vehicle Code. Increased enforcement activities of violators (removing SOVs from the HOV) would serve to increase capacity of HOV lanes. As reported in "Out for the Count" (Goodin, Ginger and Wikander, John, Tolltrans 2009):

> It is essentially impossible to consistently verify the correct number of occupants in vehicles with very high accuracy using visual inspection. Many factors, such as high speeds, window tint, poor lighting conditions caused by bad weather or dawn/dusk conditions significantly impair an officer's ability to 'eyeball' occupants. Rear-occupant detection is especially problematic. Anecdotal reports on accuracy suggest that half the time the officer fails to see rear occupants. In addition to the reliability issue is the concern for law enforcement safety. The need for officers to position themselves at the roadside next to moving traffic creates a potentially dangerous enforcement environment. To reduce the exposure of officers to injury, expensive barriers must be built to protect them while observing and apprehending violators (p. 48).

Absent from the DEIR/S is any discussion of HOV/HOT occupancy enforcement, projections concerning lane violators and how that conduct can impact capacity, the role that design plays in enhancing enforcement and protecting the safety of law enforcement personnel, and where that design is manifest in the proposed project.

As a variation of Alternative 3, no explanation is provided why a two-HOV lane (non-toll) alternative, rather than two "express lanes," was neither identified nor evaluated by the Lead Agency. If, as asserted by the Lead Agency, the existing HOV lane is operating over capacity, a second HOV lane (either inclusive or exclusive of other operational modifications) would appear to allow for an increase in HOV ridership while preserving the fundamental benefits of providing an HOV travel option (e.g., "HOV lanes have the potential to move more people in fewer vehicles, improve the person moving capability and reliability, and efficiently utilize the available roadway infrastructure and transit fleet").

8.0 ADDITIONAL ENVIRONMENTAL CONSIDERATIONS

8.1 Land Use

The Lead Agency errors in asserting that land-use impacts relate only to a project's compliance with existing local plans and policies (e.g., "Land use impacts would occur if the proposed project effects would conflict either with General Plan land use designations or zoning, or with applicable environmental plans and policies," p. 3.1.1-20). As specified in the State CEQA Guidelines, "[e]ffects analyzed under CEQA must relate to a physical change" (14 CCR 15358). As such, in the context of CEQA, land use relates to: (1) the existing and potential future physical use of the project site; and (2) the policies, plans, and regulations of both the Lead Agency and other governmental entities governing and defining those uses; and (3) the potential physical changes to existing and reasonably foreseeable future land uses resulting, either directly or indirectly, from the project's implementation.

Although the Lead Agency discusses the proposed action's compliance with the Seal Beach General Plan (deriving conclusions that differ from those of the City), absent from the DEIR/S is a detailed assessment of the proposed action's physical land-use impacts within Seal Beach, focusing specifically upon the following neighborhoods: (1) Leisure World; (2) College Park West; and (3) College Park East.

8.2 Air Quality

Motor vehicles emit large quantities of carbon dioxide (CO_2), carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOx), particulate matter (PM), and substances known as mobile source air toxics (MSATs) or toxic air contaminants (TACs), such as benzene, formaldehyde, acetaldehyde, and 1,3-butadiene. Resuspended road dust, tire wear, and brake wear are sources of noncombustion PM emissions. Each of these, along with secondary by-products, such as ozone (O_3) and secondary aerosols (e.g., nitrates and inorganic and organic acids), can cause adverse effects on human health and the environment.

The EIR must describe, in detail, all the significant effects on the environment of the project. (Sunnyvale West Neighborhood Association v. City of Sunnyvale City Council, 2010). "CEQA compels government first to identify the environmental effects of projects, and then to mitigate those adverse effects through the imposition of feasible mitigation measures or through the selection of feasible alternatives. It permits government agencies to approve projects that have an environmentally deleterious effect, but also requires them to justify those choices in light of specific social or economic conditions [Citation]" (Sierra Club v. State Board of Forestry, 1994).

As previously noted, implementation of the three build alternatives will increase VMT over the No Build Alternative by between 318,000 and 605,000 miles by 2020 and by between 525,000 and 1,013,000 miles by 2040. As a result, it is immediately evident that the proposed action has both an adverse and significant impact relative to GHG emissions. In order to avoid the obvious, the Lead Agency shirks its statutory and regulatory obligations to both "identify and focus on the significant environmental effects" (14 CCR 15126.2[a]) and to "[d]escribe any significant impacts, including those which can be mitigated but not reduced to a level of insignificance" (14 CCR 15126.2[b]). As indicated in the DEIR/S:

> An assessment of the greenhouse gas emissions and climate change is included in the body of environmental document. While Caltrans has included this good faith

> effort in order to provide the public and decision-makers as much information as possible about the project, it is Caltrans determination that in the absence of further regulatory or scientific information related to GHG emissions and CEQA significance, it is too speculative to make a significance determination regarding the project's direct and indirect impact with respect to climate change. Caltrans does remain firmly committed to implementing measures to help reduce the potential effects of the project. These measures are outlined in the body of the environmental document (emphasis added) (DEIR/S, Appendix A, p. 5).

Such declaration is only an attempt at subterfuge both with regards to disclosure and the formulation of project alternatives (e.g., mobility options not involving the construction of additional lane-miles). The City believes that such non-disclosure and avoidance strategy is: (1) inconsistent with CEQA (14 CCR 15064.4), resulting in an inadequate environmental analysis; and (2) inconsistent with Statewide efforts to reduce GHG emissions (e.g., reducing carbon footprint below BAU levels).

To the extent that the Lead Agency seeks to assert its consistency with the 2012 RTP/SCS, then it should be equally bound by the mitigation measures contained in the 2012 RTP/SCS PEIR. As indicated herein, relevant GHG-related measures include: (1) "Local jurisdictions can and should reduce GHG emissions by reducing vehicle miles traveled and by increasing or encouraging the use of alternative fuels and transportation technologies" (MM-TR51); (2) "Local jurisdictions can and should reduce VMT-related emissions by encouraging the use of public transit through adoption of new development standards that would require improvements to the transit system and infrastructure, increase safety and accessibility, and provide other incentives" (MM-TR52); and (3) "Local jurisdictions can and should give priority to transportation projects that would contribute to a reduction in vehicle miles traveled per capita, while maintaining economic vitality and sustainability" (MM-TR53) (pp. ES-68 and 69).

As reported in CARB's "Climate Change Proposed Scoping Plan, A Framework for Change" (October 2008), prepared pursuant to Assembly Bill 32 (The California Global Warming Solutions Act of 2006), "California is the fifteenth largest emitter of greenhouse gases on the planet, representing about two percent of the worldwide emissions" (p. 11). By enacting Senate Bill (SB) 97 in 2007, California's lawmakers expressly recognized the need to analyze greenhouse gas (GHG) emissions as a part of the CEQA process and required the Governor's Office of Planning and Research (OPR) and the Natural Resources Agency to adopt guidelines addressing the analysis and mitigation of GHG emissions. In accordance therewith, effective in 2010, lead agencies must analyze: (1) the GHG emissions of proposed projects and must reach a conclusion regarding the significance of those emissions (14 CCR 15064.4.); and (2) the potentially significant impacts associated with placing projects in hazardous locations, including locations potentially affected by climate change (14 CCR 15126.2[a]). In addition, when a project's GHG emissions may be significant, lead agencies must consider a range of potential mitigation measures to reduce those emissions (14 CCR 15126.4[(c)]). CEQA mandates analysis of a proposed project's potential energy use (including transportation-related energy), sources of energy supply, and ways to reduce energy demand, including through the use of efficient transportation alternatives (Appendix F, State CEQA Guidelines); however, as noted in the DEIR/S, the "quantification of the impacts from induced fuel consumption as a result of traffic congestion is beyond the scope of this CIA" (CIA, p. 6-8).

As indicated in the CEQ's "Draft NEPA Guidelines on Consideration of the Effects of Climate Change and Greenhouse Gas Emissions" (February 18, 2010) (Draft NEPA GHG Guidelines), citing Calvert Cliffs Coordinating Commission, Inc. v. United States Atomic Energy Commission (1971), the CEQ notes:

> Alternatives analysis is an essential element of the NEPA process, both under section 102(2) (C) and in the EA of 'conflicts concerning alternative uses of available resources' under Section 102(2) (E). The requirement of consideration of alternatives is meant to ensure that the agency consider approaches whose adverse environmental effects will be insignificant or at least less significant than those of the proposal. 'This requirement, like the 'detailed statement' requirement, seeks to ensure that each agency decision maker has before him and takes into proper account all possible approaches to a particular project (including total abandonment of the project) which would alter the environmental impact and the cost-benefit balance. Only in that fashion is it likely that the most intelligent, optimally beneficial decision will ultimately be made' (emphasis added).

As required under Section 21002.1(a) of CEQA: "The purpose of an environmental impact report is to identify the significant effects on the environment of a project, to identify alternatives to the project, and to indicate the manner in which those significant effects can be mitigated or avoided" (emphasis added). Section 21100(b) of CEQA states, in part, when an EIR is required, "[t]he environmental impact report shall include a detailed statement setting forth all of the following: (1) All significant effects on the environment of the proposed project. (2) In a separate section: (A) Any significant effects on the environment that cannot be avoided if the project is implemented. (B) Any significant effect on the environment that would be irreversible if the project is implemented" (emphasis added). Section 21100(c) goes on to add: "The report shall also contain a statement briefly indicating the reasons for determining that various effects of the environment of a project are not significant" (emphasis added).

As further required under Section 21081 of CEQA, "no public agency shall approve or carry out a project for which an environmental impact report has been certified which identifies one or more significant effects on the environment that would occur if the project is approved or carried out" unless the agency makes specific findings and finds that the project's specific overriding economic, legal, social, technological, or other benefits outweigh its significant environmental effects. In order to comply with those requirements, the Lead Agency must determine whether the potential direct, indirect, and cumulative impacts of the proposed action will, in fact, produce significant environmental effects and, if so, whether those impacts can be mitigated to a less-than-significant level and present the rationale for those finding (14 CCR 15091[a]).

As indicated in the AQR: "Future greenhouse gas emissions (2020 and 2040) would be greater than existing emissions" (p. 2); however, in what appears directly contrary to both CEQA and NEPA requirements, the DEIR/S states: "It is Caltrans' determination that, in the absence of further regulatory or scientific information related to GHG emissions and CEQA significance, it is too speculative to make a determination regarding the significance [or insignificance] of the project's direct impact and its contribution on the cumulative scale to climate change." (p. 4-57). Although the courts have already found that approach to be inconsistent with CEQA requirements, the Lead Agency seeks to perpetuate the myth that it bears no obligation to identify project-related and cumulative thresholds for the projects it undertakes or to reduce those emissions to the maximum extent feasible. In Environmental Council of Sacramento v. California Department of Transportation, in evaluating the adequacy of Caltrans' GHG emissions analysis, the court rejected the argument that absence of a significance threshold made it impossible to quantify GHG emissions or determine their significance and set aside the EIR's certification, ruling:

> Caltrans should have analyzed and discussed whether the Project may have a significant impact on such emissions notwithstanding the Project's compliance with the federal Clean Air Act conformity standards. . .The EIR recognizes the concern that GHG emissions raise for climate change, but concludes that because there is no accepted federal, state, or regional methodology for GHG emission and climate change impact analysis, analyzing the impacts associated with an increase in GHG emissions at the project level is not currently possible [Citation]. However, as Petitioners point out, nothing in the administrative record supports Caltrans' conclusion that it is not possible to quantify the Project's GHG emissions, at which point, Caltrans could make its own evaluation of their significance. While CEQA does not require an agency to foresee the unforeseeable, CEQA does require an agency to use its best efforts to find put and disclose all that it reasonably can [Citation]. Only after thorough investigation may an agency find that a particular impact is too speculative to evaluation and terminate its discussion of the impact [Citation]. Here, there is no evidence in the record that Caltrans performed any investigation whatsoever. This fell short of Caltrans' duty to make a good faith effort to investigate and disclose all that it reasonably can. Caltrans must meaningfully attempt to quantify the Project's potential impacts on GHG emissions and determine their significance, or at the very least explain what steps it has taken that show such impacts are too speculative for evaluation (Minute Order, pp. 8, 10, and 11).

Similarly, in Center for Biological Diversity v. City of Desert Hot Springs, Riverside County Case No. RIC 464585 (August 6, 2008), the court hold that an environmental impact report (EIR) for a proposed residential and commercial development was insufficient because it failed to make a ''meaningful attempt'' to analyze the project's effects on global warming. The court rejected the lead agency's argument that the absence of Statewide CEQA significance thresholds or guidelines for GHG emissions exonerated the agency of its duty to analyze such emissions in CEQA documents. Quoting from the Ninth Circuit's statement in Center for Biological Diversity v. National Highway Traffic Safety Administration (2007), the federal court stated that "[t]he impact of greenhouse gas emissions on climate change is precisely the kind of cumulative impacts analysis that NEPA requires agencies to conduct." The court emphasized that even though it could be true that projects' effects on global warming are too speculative in the absence of guidance from the CARB or USEPA, the agency could not simply assert this speculation without first making some attempt to determine whether the project would have a significant effect on climate change. Drawing from those cases, Caltrans' failure to determine the significance of GHG emissions has rendered the DEIR/S analysis inadequate.

The Lead Agency alleges that "NEPA does not require that a determination of significant impacts be stated in the environmental documents" (p. 4-1). However, as indicated under the CEQ Regulations, the significance of an identified effect must be determined based on both context and intensity. As indicated in Section 1508.27(a) of the CEQ Regulations, "the significance of an action must be analyzed in several contexts such as society as a whole (human, national), the affected region, the affected interests, and the locality. Significance varies with the setting of the proposed action." Under NEPA, intensity is evaluated by considering the degree to which: (1) a proposed action will affect public health or safety; (2) the effects on the environment are likely to be highly controversial; (3) the possible effects on the human environment are highly uncertain or pose unique or unknown risks; (4) the action may establish a precedent for future actions with significant effects, or represent a decision in principle about a future consideration; (5) the action is related to other actions with individually insignificant but cumulatively significant impacts; and (6) the action may adversely affect an endangered or threatened species or its habitat (Center for Biological Diversity v. National Highway Traffic Safety Administration). In recognition of those factors (e.g., health and safety affects, level of controversy, and unknown risk), potential impacts attributable to project-related and cumulative GHG emissions would be deemed significant under NEPA.

Despite substantial evidence to the contrary, this same failing also holds true with regards to the assessment of potential health risks. As indicated in the AQR, "it is not possible to make a determination of whether any of the alternatives would have 'significant adverse impacts on the human environment'" (p. 77). Based only upon a "qualitative analysis, ignoring the existence of abutting single-family properties within Seal Beach, the Lead Agency asserts that "[a] A qualitative diesel particulate matter was completed for the proposed project. It was determined that while diesel exhaust may pose potential cancer risks to receptors spending time on or near high risk diesel particulate matter facilities, <u>most receptors</u>' short term exposure would only cause minimal harm" (AQR, p. 2).

Health risks are not examined on a "majority rules" basis. Regulations promulgated by the California Health and Welfare Agency, under Proposition 65, define a significant cancer risk as any risk exceeding ten in one million (10×10^{-6}). As stipulated in the SCAQMD's "CEQA Air Quality Handbook" (April 1993), a project would normally be deemed to be significant if it were to emit carcinogenic or toxic air contaminants (TACs) that individually or cumulatively exceed the maximum individual cancer risk of 10 in 1 million (pp. 6-2 and 6-3).

The AQR notes that "[t]he <u>SCAQMD has jurisdiction</u> over an area of 10,743 square miles, consisting of Orange County; the non-desert portions of Los Angeles, Riverside, and San Bernardino counties; and the Riverside County portion of the Salton Sea Air Basin and Mojave Desert Air Basin" (emphasis added) (p. 44). As indicated in separate correspondence submitted to Seal Beach in response to the City's release of a "Notice of Preparation of a CEQA Document for the Department of Water and Power Specific Plan Amendment" (SCH No. 2011061018), in correspondence dated June 29, 2011, the SCAQMD make the following declaration: "The SCAQMD adopted its California Environmental Quality Act (CEQA) Handbook in 1993 to assist other public agencies with the preparation of air quality analyses. The SCAQMD recommends that the Lead Agency use this Handbook as guidance when preparing its air quality analysis" (p. 1). It has to be assumed that the SCAQMD has presented the Department with a similar declaration.

In April 2005, the CARB published the "Air Quality and Land Use Handbook" (CARB Handbook) which included recommended minimum separation distances serving as a general guide for considering health effects associated with siting sensitive receptors in proximity to facilities emitting TACs. The CARB's recommended minimum separation distance between potentially incompatible land uses is presented, in part, in <u>Table 16</u> California Air Resources Board Recommendations on Siting Sensitive Land Uses).

To characterize health risks posed by TACs in the SCAB, the SCAQMD conducted the "Multiple Air Toxics Exposure Study, Final Report" (March 2000) (MATES-II). The MATES-II study concluded that the Basinwide average cancer risk was about 1,400 in one million ($1,400 \times 10^{-6}$) (assuming continuous exposure 24-hours per day for a 70-year lifetime) (Source: SCAQMD, Final 2007 Air Quality Management Plan, June 1, 2007). Mobile sources (e.g., automobiles, trucks, trains, ships, aircraft) were reported to be the largest contributors and about 70 percent of the cancer risk was attributed to diesel PM; another 20 percent was attributed to other TACs associated with mobile sources (including benzene, 1,3-butadiene, and formaldehyde). The remaining 10 percent was attributed to stationary sources (e.g., industry, certain businesses such as dry cleaners and chrome plating operations). In the MATES-II study, the SCAQMD found that cancer risk across the SCAB ranged from about 1,120 (1,120 x 10^{-6}) to 1,740 in one million (1,740 x 10^{-6}) among eight fixed sites. In 2008, the SCAQMD's "Multiple Air Toxics Exposure Study" (MATES-III) found that the Basinwide cancer risk was about 1,200 in one million (1,200 x 10^{-6}), with TACs from mobile sources accounting for 94 percent of this risk on average.

Table 16
California Air Resources Board Recommendations on Siting Sensitive Land Uses

Source Category	Advisory Recommendations	Range of Cancer Risks[1,2]	Summary of Basis for Advisory Recommendations
Freeway and High-Traffic Roads	Avoid siting new sensitive land uses within 500 feet of a freeway, urban roadway with 100,000 vehicles/day, or rural roadway with 50,000 vehicles/day.	300-1,700	The additional non-cancer health risk attributable to proximity was seen within 1,000 feet and was strongest within 300 feet. Studies show about 70% drop off in PM pollution levels at 500 feet.

Notes:
1. For cancer health effects, risk is expressed as an estimate of the increased chances of getting cancer due to facility emissions over a 70-year lifetime. This increase in risk is expressed as chances in a million.
2. The estimated cancer risks are a function of proximity to the specific category and were calculated independent of the regional health risk for air pollution. For example, the estimated regional cancer risk from air toxics in the Los Angeles Region (SCAB) is approximately 1,000 in one million (1,000 x 10^{-6}).

Source: California Air Resources Board, Air Quality and Land Use Handbook: A Community Health Perspective, April 2005, Tables 1-1 and 1-2, pp. 4, 6 and 7.

As indicated in Appendix A (CEQA Checklist) in the DEIR/S, the proposed action would be deemed to produce a significant environmental effect if the project where to "[e]mit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school" (p. 5); and/or (2) "cause substantial adverse effects on human beings, either directly or indirectly" (p. 10). Although the "CEQA Checklist" concludes that "effects on human beings" would constitute a "potentially significant impact," neither air quality nor human health effects were explicitly identified as a basis for that conclusion. Instead of assessing potential project-related and cumulative health risks relative to identified threshold of significant standards, the Department states:

> In FHWA's view, information is incomplete or unavailable to credibly predict the project-specific health impacts due to changes in MSAT emissions associated with a proposed set of highway alternatives. The outcome of such an assessment, adverse or not, would be influenced more by the uncertainty introduced into the process through assumption and speculation rather than any genuine insight into the actual health impacts directly attributable to MSAT exposure associated with a proposed action. . . Because of the limitations in the methodologies for forecasting health impacts described, any predicted difference in health impacts between alternatives is likely to be much smaller than the uncertainties associated with predicting the impacts. Consequently, the results of such assessments would not be useful to decision makers, who would need to weigh this information against project benefits,

> such as reducing traffic congestion, accident rates, and fatalities plus improved access for emergency response, that are better suited for quantitative analysis. . . Because of the uncertainties outlined above, a reliable quantitative assessment of the effects of air toxic emissions impacts on human health cannot be made at the project level. While available tools do allow us to reasonably predict relative emissions changes between alternatives for larger projects, the amount of MSAT emissions from each of the project alternatives and MSAT concentrations or exposures created by each of the project alternatives cannot be predicted with enough accuracy to be useful in estimating health impacts. As noted above, the current emissions model is not capable of serving as a meaningful emissions analysis tool for smaller projects. Therefore, the relevance of the unavailable or incomplete information is that it is not possible to make a determination of whether any of the alternatives would have "significant adverse impacts on the human environment." (pp. 74, 76, and 77).

By failing to determine significance and asserting, as its rational, “unavailable or incomplete information,” the Lead Agency is violating the CEQ Regulations. Citing Section 1502.22 therein:

> When an agency is evaluating reasonably foreseeable significant adverse effects on the human environment in an environmental impact statement and there is incomplete or unavailable information, the agency shall always made clear that such information is lacking. (a) If the incomplete information relevant to reasonably foreseeable significant adverse impacts is essential to a reasoned choice among alternatives and the overall costs of obtaining it are not exorbitant, the agency shall include the information in the environmental impact statement. (b) If the information relevant to reasonably foreseeable significant adverse impacts cannot be obtained because the overall costs of obtaining it are exorbitant or the means to obtain it are not known, the agency shall include within the environmental impact statement: (1) a statement that such information is incomplete or unavailable; (2) a statement of the relevance of the incomplete or unavailable information to evaluate reasonably foreseeable significant adverse impacts on the human environment; (3) a summary of existing credible scientific evidence which is relevant to evaluating the reasonably foreseeable significant adverse impacts on the human environment; (4) the agency’s evaluation of such impacts based upon theoretical approaches or research methods generally accepted in the scientific community. For the purpose of this section, “reasonably foreseeable” includes impacts which have catastrophic consequences, even if their probability of occurrence is low, provided that the analysis of the impacts is supported by credible scientific evidence, is not based on pure conjecture, and is within the rule of reason.

As reported in the National Research Council’s “Surface Transportation Environmental Research: A Long-Term Strategy, Special Report 268” (2002): “Fuel burning due to transportation activities, whether under congested or uncongested conditions, has the potential to increase the risk of death from respiratory and cardiovascular disease; raise the risk of developing certain chronic diseases [including cancer; chronic bronchitis; and, according to very recent evidence, asthma]; aggravate various existing chronic conditions; and lead to acute cardiopulmonary symptoms, such as cough, a runny nose, and other signs of a cold. Burning gasoline still leads to significant emissions of volatile organic compounds (VOCs) (some of which are carcinogenic), CO, nitrogen oxide (NOx), and particulate matter” (p. 34).

Heavily-travelled roadways are a key contributor to diesel particulate matter (diesel PM) MATES-III concluded that 84 percent of the total cancer risk from TACs within the region comes from diesel PM. High volume roadway emissions are also associated with higher levels of ultrafine particles which are associated with adverse health impacts. Although there is no federal or State ambient air quality standard for ultrafine particles, based on the growing knowledge of their potential health risks, critical assessment of projects that increase exposure of those pollutants by sensitive receptors needs to be conducted.

The following relevant studies, included in Attachment F herein, address the health risks attributable to ultrafine particles are included herein and made a part of the City's comments: (1) Grahame, Thomas J. and Schlesinger, Richard B, Cardiovascular Health and Particulate Vehicular Emissions: A Critical Evaluation of the Evidence, Air Quality, Atmosphere and Health, 3:3-27, 2010; (2) Knibbs, Luke D., Cole-Hunter, Tom, and Morawska, Lidia, A Review of Commuter Exposure to Ultrafine Particles and its Health Effects, Atmospheric Environment 25:2611-2622, 2011; (3) Zhu, Yifang et al., Study of Ultrafine Particles Near a Major Highway with Heavy-Duty Diesel Traffic, Atmospheric Environment 36:4323-4335, 2002; (4) Hu, Shishan et al., A Wide Area of Air Pollutant Impact Downwind of a Freeway during Pre-Sunrise Hours, Atmospheric Environment 43:2541-2549, 2009; (5) Araujo, Jesus A. et al., Ambient Particulate Pollutants in the Ultrafine Range Promote Early Atherosclerosis and Systemic Oxidative Stress, Circulation Research, March 14, 2008, p. 589; (6) Li, Ning et al., Ultrafine Particulate Pollutants Induce Oxidative Stress and Mitochondrial Damage, Environmental Health Perspectives, Vol. 111, No. 4, April 2003, p. 455; (7) Delfino, Ralph J. et al., Association of Biomarkers of Systemic Inflammation with Organic Components and Source in Quasi-Ultrafine Particles, Environmental Health Perspectives, Vol. 118, No.. 6, June 2010, p. 756; and (8) Hankey, Steve, Marshall, Julian D., and Brauer, Michael, Health Impacts of the Build Environment: Within-Urban Variability in Physical Inactivity, Air Pollution, and Ischemic Heart Disease Mortality, Environmental Health Perspectives, Vol. 120, No. 2, February 2012, p. 247.

As indicated in "Near Highway Pollutants in Motor Vehicle Exhaust: A Review of Epidemiologic Evidence of Cardiac and Pulmonary Health Risks" Brugge, Doug, et al, Environmental Health 6:23, 2007), included in Attachment G herein:

> There is growing evidence of a distinct set of freshly-emitted air pollutants downwind from major highways, motorways, and freeways that include elevated levels of ultrafine particulates (UFP), black carbon (BC), oxides of nitrogen (NOx), and carbon monoxide (CO). People living or otherwise spending substantial time within about 200 m of highways are exposed to these pollutants more so than persons living at a greater distance, even compared to living on busy urban streets. Evidence of the health hazards of these pollutants arises from studies that assess proximity to highways, actual exposure to the pollutants, or both. Taken as a whole, the health studies show elevated risk for development of asthma and reduced lung function in children who live near major highways. Studies of particulate matter (PM) that show associations with cardiac and pulmonary mortality also appear to indicate increasing risk as smaller geographic areas are studied, suggesting localized sources that likely include major highways. Although less work has tested the association between lung cancer and highways, the existing studies suggest an association as well. While the evidence is substantial for a link between near-highway exposures and adverse health outcomes, considerable work remains to understand the exact nature and magnitude of the risks. . .The plausibility of near-highway pollution causing lung cancer is bolstered by the presence of known carcinogens in diesel PM. The US EPA

> has concluded after reviewing the literature that diesel exhaust is 'likely to be carcinogenic to humans by inhalation.'

As further indicated in "Effects of Exposure to Traffic on Lung Development from 10 to 18 Years of Age: A Cohort Study" (Gauderman, James W., et al, Lancet, 2006), included in Attachment H herein: "Reduced lung-function growth was independently associated with both freeway distance and with regional air pollution. Statistically significant joint models of regional pollution with distance to freeway were seen for nitrogen dioxide , acid vapour, elemental carbon, and particulate matter with aerodynamic diameter less than 10 μm and less than 2·5 μm. . .This study shows that residential proximity to freeway traffic is associated with substantial deficits in lung-function development in children."

As indicated in the I-710 Corridor DEIR/S, in summarizing written correspondence submitted by the USEPA to Caltrans, the document states, in part:

> Executive Order 13045 on Children's Health and Safety directs that each Federal agency shall make it a high priority to identify and assess environmental health and safety risks that may disproportionately affect children, and shall ensure that its policies, programs, activities, and standards address these risks. Analysis and disclosure of these potential effects under NEPA is necessary because some physiological and behavioral traits of children render them more susceptible and vulnerable than adults to health and safety risks. Children may be more highly exposed to contaminants because they generally eat more food, drink more water, and have higher inhalation rates relative to their size. Also, children's normal activities, such as putting their hands in their mouths or playing on the ground, can result in higher exposures to contaminants as compared with adults. Children may be more vulnerable to the toxic effects of contaminants because their bodies and systems are not fully developed and their growing organs are more easily harmed. Based on current EPA policy and guidance, an analysis of impacts to children should be included in a NEPA analysis if there is a possibility of disproportionate impact on children related to the proposed action. EPA views childhood as a sequence of life stages, from conception through fetal development, infancy, and adolescence. Therefore, exposures to children at each life stage, as well as pregnant and nursing women, are relevant and should be considered when addressing health and safety risks for children. Because children can be more susceptible to mobile source air pollution and generally experience higher exposures to air pollution than adults, we [USEPA] recommend that the Draft EIR/EIS further address the potential direct, indirect, and cumulative impacts of the proposed project on children's health, including consideration of prenatal exposures (exposures that may be experienced by pregnant women) (Appendix J, pp. 21-22).
>
> Assess the project's impact to children's environmental health by incorporating child-specific exposure factors using EPA's Child Specific Exposure Factors Handbook, 2008, or an equivalent source recommended by the State of California, in the analysis of exposures at schools, daycares, and parks. In addition, we recommend using the recommended age groupings provided in EPA's Guidance on Selecting Age Groups for Monitoring and Assessing Childhood Exposures to Environmental Contaminants, 2005. The document describes a set of age groupings that can be used, and when necessary adapted, for purposes of designing monitoring studies and conducting risk assessments focused on children (Appendix J, p. 24).

> Research has demonstrated that traffic-related air pollution can exacerbate asthma and may be associated with the onset of childhood asthma. In the EPA Region 9 letter sent to the California Department of Transportation District 7 on August 20, 2010, EPA recommended that the air quality and health risk assessment protocol consider existing asthma rates and asthma severity among children and the general community within the project area. EPA recommended that the Risk Characterization, Cumulative Impacts Analysis, and EJ Analysis identify impacts of the proposed project on asthma rates and severity in children near the project site and should quantify the costs associated with these impacts, to the extent feasible (Appendix J, p. 25).

The Seal Beach Tennis Center, Blue Bell Park and Almond Park are all located in close proximity to the I-405 Freeway ROW, as well as the College Park East and College Park West residential neighborhoods. Although large concentrations of children exist in each of those areas, absent from the DEIR/S is any analysis of the proposed project's impacts on either children's health, including prenatal exposure.

The DEIR/S indicates that, with regards to the proposed action, written correspondence was received from the USEPA (i.e., "EPA commented on water and air quality, environmental justice issues, and suggested a refinement of the project's scope, purpose and need, and explanation of the range of alternatives," p. 5-13); however, neither a copy of nor further information concerning the USEPA's correspondence submitted in response to the NOP/NOI is presented therein. The City requests that a copy of both the USEPA's correspondence addressing the proposed action and separately addressing the I-710 Corridor DEIR/S be included in the Lead Agency's written response to these comments and, with regards to the proposed action, that the Department specifically respond to each of the items and recommendations presented therein. In addition, the Department should explain why the USEPA's comments on the I-705 Corridor Project would not have equal relevancy to the CEQA and NEPA assessment of the I-405 Freeway improvement project? Why was the level of analyses (e.g., health risk assessment) included in the DEIR/S and in the I-705 Corridor DEIR/S not reasonably consistent?

If, as the Lead Agency asserts, due to higher vehicle speeds under the build alternatives, "[r]egional emissions would be less than baseline conditions in years 2020 and 2040" (AQR, p. 1), then the converse must also be true (i.e., reductions in speed due to bottlenecks would effectively increase the concentration of air pollutants and the exposure of near source receptors). Because the Lead Agency ignores the reality of what happens directly to the north of the identified corridor, absent from the DEIR/S is any discussion of the merging of northbound traffic from a widened freeway to a link with fewer HOV and GP lanes and the bottleneck that will most certainly result therefrom.

As illustrated in Figures ES-1 and 1.3-1 (pp. ES-2 and 1-9) in the Traffic Study, travelling northbound on the I-405 Freeway, north of Seal Beach Boulevard, there are seven GP lanes and one HOV lane (total of seven lanes). As proposed, under Alternative 3, there will be seven GP lanes, one auxiliary lane, and two HOV/HOT lanes (total of ten lanes). As a result of that bottleneck, the diminishment of travel lanes will add to congestion in that area and cause northbound traffic to slow in proximity to College Park East. Under the Lead Agency's own set of assumptions, mobile source emissions adjacent to that residential area will increase. Since post-project congestion will likely be worse in the vicinity of Seal Beach Boulevard, localized air quality impacts will be greater under the build scenarios than under the No Build Alternative.

Independent of the Lead Agency's assertion that increased vehicle speeds reduce idling emissions (e.g., "Regional emissions would be less than baseline conditions in years 2020 and 2040. This decrease is due to higher vehicle speeds under the build alternatives," AQR, p. 1), the projected increase in both traffic volumes along the I-405 Freeway and project-related VMT results, directly and/or indirectly, in increased exposure to sensitive near-freeway receptors to additional mobile source emissions. For example, by manipulating vehicle throughput to maintain travel speeds, trucks and other commercial vehicles transporting perishable items and/or otherwise dependent on time are being induced to utilize the proposed HOT lanes. Because "[d]iesel trucks contribute more than half of the total diesel combustion sources" (DEIR/S, p. 3.2.6-50), unaccounted for increases in toxic air contaminants (TACs) will likely be the consequence.

8.3 Noise and Vibration

Absent from the DEIR/S is any discussion of noise vibration, both as it may relate to construction impacts and freeway operations. A number of City residents located in proximity to the I-405 Freeway have indicated that vibration is an on-going problem which is likely only to be further exacerbated as a result of the proposed action.

As indicated in DEIR/S, with regards to "exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels" (Appendix A, p. 7), the Lead Agency states that the proposed action would generate a "less than significant impact" (Ibid.). No analysis (including the identification of reasonable threshold of significance criteria) is, however, to support that conclusion.

8.4 Environmental Justice

As reported in the Los Angeles Times on July 1, 2012 ("O.C. Tollways to Stop Taking Cash"), in an article about toll roads in Orange County, the author (Mike Reicher) notes:

> [A] rate hike takes effect Sunday. Cash tolls will increase 25 to 50 cents at most toll plazas and FasTrak tolls will increase 5% to 10%. Rate hikes depend on the time of day. The changes, which will eliminate about 100 tollbooth jobs, comes about a year after the 73 toll road project restructured its roughly $2.1 billion in debt. An agreement with bondholders requires the agency to <u>raise tolls whenever feasible</u>. As ridership continues to fall below projections, leaders are looking for long-term money-saving measures. Without tollbooths, even casual users will have to register beforehand or else pay a fine for using the public road. Cameras will capture license plate numbers, and motorists who have set up pre-paid accounts registered to the photographed number will be billed. . .Drivers who use the toll roads but have not registered their license plate numbers will receive a violation unless they pay the toll online within 48 hours. . .The fine is currently $57.50, plus the toll amount. . .The San Joaquin Hills agency has increased toll rates 12 times since fiscal year 1997 (emphasis added) (p. A-27).

As indicated in FHWA's "Income-Based Equity Impacts of Congestion Pricing, A Primer" (December 2008): "Equity concerns with regard to income have often been raised about congestion pricing. The benefits of congestion pricing may not be distributed equally among all users. High-income users are more likely to remain on the highway, pay the congestion fee, and benefit from a faster trip. Low-income users may be worse off if they choose other less-expensive times, routes, or modes. When public use of infrastructure assets is deliberately made more expensive at certain times, low-income people and those concerned about their welfare may raise legitimate concerns about equity" (p. 4).

SCAG notes that "[b]ecause congestion pricing imposes a cost on something that was previously considered 'free,' it can raise issues of equity. Some say that those with lower incomes would pay a higher percentage of their income or be priced out of driving" (Express Travel Choices Study, Frequently Asked Questions, January 13, 2011, p. 5). As further indicated therein: "A paper by the Rand Corporation and Volpe National Transportation Systems Center (2007) indicated that household surveys suggest that rush-hour travelers who travel in the busier direction - and thus are more likely to pay congestion charges - are the most affluent group within the larger category of street and highway users" (p. 7).

Referencing FHWA's "Environmental Justice Emerging Trends and Best Practices Guidebook" (November 1, 2011): "While road pricing has the potential to meet the needs of disadvantaged communities, pricing strategies also have the potential to violate environmental justice principles if not implemented with thorough consideration of equity impacts. The perceived "cost" of a toll or congestion charge in proportion to income is higher for a low-income traveler. In the absence of alternative free routes that could be used by these travelers, concerns regarding monetary egalitarianism could arise because low-income people may continue to be stuck in traffic while the wealthy are able to pay for and use the priced roads or lanes. For this reason, high-occupancy toll (HOT) lanes, implemented in several regions by introducing pricing on former high-occupancy vehicle (HOV) lanes, sometimes encounter criticism as 'Lexus Lanes' that cater to the wealthy and impose unfair burdens on the poor. . .In addition to the charge itself, low-income populations can sometimes be excluded from accessing the technology required to use priced roads. This occurs because of the need for drivers to own transponders that are typically purchased in advance. Transponders must also be linked to reliable bank or credit card accounts that can be used to deduct charges; at least 20 percent of U.S. households do not have credit cards and 10 percent do not have bank accounts" (pp. 56-57).

As further indicated therein: "A region that is considering implementation of road pricing should undertake studies to measure and assess potential impacts on disadvantaged communities at an early stage in the planning process. Not only must this information be shared during communications with decision makers and the public, but it is also important for purposes of NEPA documentation during planning and environmental review. Also, lessons regarding the acceptability of road pricing strategies show that it is important to reference data on equity impacts of successful road pricing programs during public outreach" (p. 61). "There are some reports from San Diego and Minneapolis that high-income travelers are more likely to own transponders, use HOT lanes, and benefit from faster trips than low-income travelers. However, with reinvestment of revenues in significantly improved transit services and other travel alternatives, these effects have been mitigated to some extent" (p. 69).

As indicated in the "California HOV/Express Lane Business Plan," "[t]here is an impression by the general public, as experienced by regional transportation agencies that have been planning and designing express lanes within existing capacity, that express lanes reinforce social inequities for users. Express lanes are perceived as 'Lexus lanes' that are only affordable to motorists with high incomes. . .It is important to address perception and engage in public communication (including surveys) consistently and on a large scale in order to enable future development of express lanes in California" (pp. 20-21).

Although the DEIR/S itself makes reference to the "California HOV/Express Lane Business Plan" (p. S-38), absent from the DEIS/R is any discussion or analysis of environmental justice, including "studies to measure and assess potential impacts on disadvantaged communities."

Presidential Executive Order 12898 (Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations) (59 Fed. Reg. 7629 [1994]) provides that "each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations." In the memorandum to heads of departments and agencies that accompanied Executive Order 12898 (EO 12898), the President specifically recognized the importance of procedures under NEPA for identifying and addressing environmental justice concerns. The memorandum states that "each Federal agency shall analyze the environmental effects, including human health, economic and social effects, of Federal actions, including effects on minority communities and low-income communities, when such analysis is required by [NEPA]."

EO 12898: (1) requires the development of agency-specific environmental justice strategies; (2) recognizes the importance of research, data collection, and analysis, particularly with respect to multiple and cumulative exposures to environmental hazards for low-income populations, minority populations, and Indian tribes; (3) provides for agencies to collect, maintain, and analyze information on patterns of subsistence consumption of fish, vegetation, or wildlife; and (4) requires agencies to work to ensure effective public participation and access to information. In addition, the memorandum accompanying the EO 12898 identifies the following four important ways to consider environmental justice under NEPA: (1) each Federal agency should analyze the environmental effects, including human health, economic, and social effects of Federal actions, including effects on minority populations, low-income populations, and Indian tribes, when such analysis is required by NEPA; (2) mitigation measures identified as part of an environmental assessment (EA), a finding of no significant impact (FONSI), an environmental impact statement (EIS), or a record of decision (ROD), should, whenever feasible, address significant and adverse environmental effects of proposed Federal actions on minority populations, low-income populations, and Indian tribes; (3) each Federal agency must provide opportunities for effective community participation in the NEPA process, including identifying potential effects and mitigation measures in consultation with affected communities and improving the accessibility of public meetings, crucial documents, and notices; and (4) review of NEPA compliance must ensure that the lead agency preparing NEPA analyses and documentation has appropriately analyzed environmental effects on minority populations, low-income populations, or Indian tribes, including human health, social, and economic effects.

In April 1997, the DOT issued "DOT Order on Environmental Justice to Address Environmental Justice in Minority Populations and Low-Income Populations" (DOT Order 5610.2) to summarize and expand upon the requirements of EO 12898. As specified therein: "It is the policy of DOT to promote the principles of environmental justice (as embodied in the Executive Order) through the incorporation of those principles in all DOT programs, policies, and activities. This will be done by fully considering environmental justice principles throughout planning and decision-making processes in the development of programs, policies, and activities, using the principles of the National Environmental Policy Act of 1969 (NEPA), Title VI of the Civil Rights Act of 1964 (Title VI), the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, as amended (URA), the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and other DOT statutes, regulations and guidance that address or affect infrastructure planning and decisionmaking; social, economic, or environmental matters; public health; and public involvement." As further indicated therein: "Statutes governing DOT operations will be administered so as to identify and avoid discrimination and avoid disproportionately high and adverse effects on minority populations and low-income populations by: (1) identifying and evaluating environmental, public health, and interrelated social and economic effects of DOT programs, policies and activities, (2) proposing measures to avoid, minimize and/or mitigate disproportionately high and adverse environmental and public health effects and interrelated social and economic effects, and providing offsetting benefits and opportunities to enhance communities, neighborhoods, and individuals affected by DOT programs, policies and activities, where permitted by law and consistent with the Executive Order, (3) considering alternatives to proposed programs, policies, and activities, where such alternatives would result in avoiding and/or minimizing disproportionately high and adverse human health or environmental impacts, consistent with the Executive Order, and (4) eliciting public involvement opportunities and considering the results thereof, including soliciting input from affected minority and low-income populations in considering alternatives."

In December 1998, the FHWA issued "FHWA Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" (DOT Order 6640.23) requiring the FHWA to implement the principles of the DOT Order 5610.2 and EO 12898 by incorporating environmental justice principles in all FHWA programs, policies and activities. The following definitions are provided therein: (1) "'low-Income" means a household income at or below the Department of Health and Human Services poverty guidelines; (2) "low-income population" means any readily identifiable group of low-income persons who live in geographic proximity, and, if circumstances warrant, geographically dispersed/transient persons who would be similarly affected by a proposed FHWA program, policy, or activity; (3) "adverse effects" means the totality of significant individual or cumulative human health or environmental effects, including interrelated social and economic effects, which may include, but are not limited to: bodily impairment, infirmity, illness or death; air, noise, and water pollution and soil contamination; destruction or disruption of man-made or natural resources; destruction or diminution of aesthetic values; destruction or disruption of community cohesion or a community's economic vitality; destruction or disruption of the availability of public and private facilities and services; vibration; adverse employment effects; displacement of persons, businesses, farms, or nonprofit organizations; increased traffic congestion, isolation, exclusion or separation of minority or low-income individuals within a given community or from the broader community; and the denial of, reduction in, or significant delay in the receipt of, benefits of FHWA programs, policies, or activities; (4) "disproportionately high and adverse effect on minority and low-Income populations" means an adverse effect that: (a) is predominately borne by a minority population and/or a low-income population; or (b) will be suffered by the minority population and/or low-income population and is appreciably more severe or greater in magnitude than the adverse effect that will be suffered by the nonminority population and/or non low-income population; and (5) "programs, policies, and/or activities" means all projects, programs, policies, and activities that affect human health or the environment, and that are undertaken, funded, or approved by FHWA. DOT and FHWA orders identify NEPA as an existing requirement, through which environmental justice should be considered for transportation projects with federal involvement.

As reported in the USEPA's "Opportunities to Improve Air Quality through Transportation Pricing Programs" (September 1997): "Minority groups are often disproportionately affected by the inequity of the current transportation system because they tend to represent a relatively large percentage of the lower income population. . .Tolls, fees and taxes will affect different income groups in different ways. Under a pricing scheme, those with high-income enjoy the benefits of less congested roads (e.g., shorter commutes) and may only need to eliminate 'discretionary' driving. . .While lower-income individuals tend to drive (and park) less than higher-income individuals, transportation pricing measures such as tolls, fees, and taxes have a greater impact for low-income groups if they do have to pay them. Low-income people may be forced to forgo 'necessary' trips. Those most likely to be hurt are those who are employed in 9-to-5 jobs with inflexible schedules" (pp. 83-85).

The Urban Land Institute, in "Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions" (July 2009) notes that ""[l]ower income groups spend as much as four times more than higher income groups of their income on transportation" (Executive Summary, p. 8).

As indicated in Caltrans' "California Transportation Plan 2025," in relationship to transportation, "social equity" is defined as "ensuring that no group receives disproportionate burdens or benefits from transportation investment decisions" (pp. 4 and A-50). However, as noted in the DEIR/S, "Alternative 3 would allow motorists to choose between congestion in the GP lanes and high-speed travel with reliable trip time in the Express Lanes in exchange for payment of a toll" (Table 3.1.1-1, p. 3.1.1-30). As a result, under Alternative 3 a disparity is created. "High-speed travel" and "reliable trip time" shall only be available to those "groups" (e.g., economically advantaged) able to pay the toll. Conversely, those groups (e.g., economically disadvantaged) unable to pay the toll shall only receive "congestion."

In acknowledging the potentially significant environmental justice impacts resulting from the implementation of "I-10 and I-110 High Occupancy Toll lanes for the LA County Congestion Reduction Demonstration Project," the LACMTA, as a responsible agency under CEQA, deemed the mitigation measures contained in "Final Environmental Impact Report/Environmental Assessment with Finding of No Significant Impact – The Interstate 10 (San Bernardino Freeway/El Monte Busway) High Occupancy Toll Lanes Project, SCH No. 2009061060" (April 2010) and "Final Environmental Impact Report/Environmental Assessment with Finding of No Significant Impact – The Interstate 110 (Harbor Freeway/Transitway) High Occupancy Toll Lanes Project, SCH No. 2009061059" (April 2010) to be inadequate and adopted the following additional "mitigation measures": (1) "All revenue generated as a result of collecting tolls from SOV will be reinvested into the corridor where generated. This includes transit services and operations and maintenance of the facility"; (2) "As a part of the project's operational plan, LACMTA will offer a toll credit in the form of a Low-Income Commuter Discount that will credit the accounts of qualifying low-income households $25 for account set-up/establishment fees that can be applied to the transponder deposit or pre-paid toll balance, and waive the monthly non-use fee for qualifying low income households"; and (3) "Throughout project construction, coordination will occur with local emergency providers to keep them informed of the project construction schedule and any detour routes so as to avoid or minimize any impacts to emergency service response time" (Ad Hoc Congestion Pricing Committee, I-10 and I-110 Hot Lanes California Environmental Quality Act Findings of Responsible Agency, July 14, 2010, pp. 1-2). Although the long-term effectiveness and consequences of these measures remains uncertain, the LACMTA's acknowledgement of the existence of potentially significant environmental justice impacts on proximal HOT lane projects in the southern California area suggests a disparity in the manner in which like-kind projects are assessed and evaluated.

8.5 Other Considerations

Federal transportation programs are currently funded under SAFETEA-LU, as enacted in August 2005. It is the City's understanding that the current federal transportation funding bill is set to expire on June 30, 2012. In response, federal lawmakers are presently discussing the prospects of new legislation that could potentially affect the environmental review of many highway, bridge and other surface transportation projects. The United States House of Representatives (House) and United States Senate (Senate) passed differing transportation bills earlier this year and has appointed a committee of legislators to reconcile the differences between those two bills.

House Resolution (H.R.) 4338 contains a series of provisions intended to streamline and reduce the review of transportation infrastructure projects under NEPA. In its declaration of policy, the legislation states: "[I]t is in the national interest to expedite the delivery of surface transportation projects by substantially reducing the average length of the environmental review process" (Section 602). The bill provides that if NEPA review is not completed with 270 days of the notice of project initiation, "the project shall be considered to have no significant impact to the human environment for purposes of the National Environmental Policy Act" (Section 618). The bill further limits the alternatives required to be considered for transportation projects and states that federal funding of less than $10,000,000, or less than 15 percent of a transportation project's anticipated costs, shall not trigger NEPA review (Section 608). The bill would authorizes certain pre-construction activities prior to the completion of the NEPA process. Based on the significant and potentially significant impacts of the proposed action, implementation of any blanket timeframe should not be deemed to be retroactive to this project. Because of its potential project-specific significant, the Lead Agency should discuss the potential impact of this proposed legislation (or subsequent versions thereon) on the proposed project.

Similarly, although Senate Bill 1813 does not include the same broad changes to CEQA, it would require agencies with permitting authority over transportation projects to render decisions within 180 days of a completed application or the lead agency's final determination under NEPA, whichever is later (Section 1313[6]). Agencies that miss that deadline could be required to pay penalty fees to the agency charged with rendering an ultimate decision on the underlying project (Ibid.). Like the House bill would authorizes certain pre-construction activities prior to the completion of the NEPA process. Because of its potential project-specific significant, the Lead Agency should discuss the potential impact of this proposed legislation (or subsequent versions thereon) on the proposed project.

As reported in a report prepared by the Brookings Institute and University of California Berkeley, entitled "The Effect of Government Highway Spending on Road Users' Congestion Costs, Final Report to the Federal Highway Administration" (October 2004), the authors (Clifford Winston and Ashley Langer) concluded:

> [W]e estimate that one dollar of highway spending in the last year of our sample, 1996, reduced motorists' congestion costs only 3.3 cents in that year (2000 dollars). Note that this benefit is not an ongoing return, but only applies to the year in which spending occurred.17 Although highway spending serves many purposes, policymakers frequently cite reducing congestion as among the most important. Thus, our estimate seriously questions the cost-effectiveness of current spending priorities if policymakers wish to achieve this goal. As noted, we did not include several variables

in the model that affected congestion costs but were arguably affected to some extent by highway spending. If we included any of these variables in the model, the effect of highway spending on congestion costs would be even lower (pp. 13-14).

9.0 DRAFT ENVIRONMENTAL IMPACT REPORT/STATEMENT

The following comments are presented in response to statements and other information presented in specific sections of the DEIR/S. For the purpose of brevity, comments which have been previously raised by the City with regards to the Lead Agency's environmental analysis are not again repeated herein. Time and other constraints have prevented the City from reviewing the totality of the DEIR/S to a similar degree. As a result, the comments presented herein primarily focus on certain topical issues deemed by the City to have the greatest potential environmental effect. The City's independent election not to reference and describe some of the project's potential impacts and document's potential defects (e.g., discussion of redevelopment agencies and agency plans when redevelopment agency activities have ceased in California) should not be construed as Seal Beach's concurrence with the information and analysis presented therein. The City reserves the right to submit additional comments concerning the proposed action and its potential environmental impacts and to avail itself of other relevant comments as may be submitted to the Lead Agency by other stakeholders.

The City believes that there may exist some confusion as to where, how, and to which agency and/or entity written comments on the DEIR/S should be submitted. For example, the front matter of the document identifies Caltrans' address as "3347 Michelson Drive, Suite 100, Irvine, CA 92612-1692" but states that "comments via postal mail" shall be delivered to "2201 Dupont Drive, Irvine, CA 92612." In contrast, "comments via email" shall be sent not to Caltrans but to "404.dedcomments.Parsons@parsons.com." Since "Parsons" is neither a governmental agency nor appears to be contracted directly by the Lead Agency, it is unclear why comments would be delivered to a representative of the "project sponsor" rather than delivery to the Lead Agency. Because of this confusion, the City requests that the Lead Agency accept any written comments received within a reasonable time period extending beyond July 17, 2012 that may have been delivered to Caltrans, to the OCTA, and/or to Parsons, including those that may have been transmitted to addresses other than those specified. In addition, an explanation is requested as to why the Lead Agency is specifying that comments should be delivered to "Parsons" in lieu of Caltrans and what role "Parsons" will play or has played in the preparation of responses to those comments.

9.1 Traffic and Transportation/Pedestrian and Bicycle Facilities

9.1.1 Traffic Study

The following additional comments are submitted in response to the information presented in the "Traffic Study – San Diego Freeway (I-405) Improvement Project SR-73 to I-605, Orange and Los Angeles Counties" (Caltrans, May 2011). Because there is no reference to or discussion of SOVs in the Traffic Study, potential capacity and other traffic-related impacts related to or resulting from the use of the HOV lane by single-occupant vehicles has not been addressed. As a result, the traffic analysis does not adequately address the proposed action.

- **Page ES-3** (Traffic Study). A basis of the traffic study is throughput, which is "the number of vehicles able to pass a fixed point along the corridor during the greatest hour of demand." This analysis approach focuses on vehicles passing particular points on the freeway but ignores a more critical measure of a transportation improvement, movement of person trips, particularly given the region's overburdened transportation system. Vehicle throughput does not provide complete disclosure of transportation impacts and mitigations (e.g., accommodation of added SOVs can actually result in impacts to the overall transportation system by reducing overall mobility). The Lead Agency's focus on throughput analysis results in a failure to consider other related transportation and environmental impacts.

- **Page ES-4** (Traffic Study). Figure ES-2 shows added "throughput capacity" for Alternative 3 but the "express lanes" will likely cause MOVs to be exchanged for SOVs. Given the portion of "throughput capacity" associated with the "2 Express" lanes (as shown in Figure ES-2), there may be significant shifts from MOVs to SOVs, resulting in a net decrease in mobility, and an overall increase in environmental impacts (e.g., increased air quality impacts, reductions in the number of persons being served even though added vehicles are being accommodated, added traffic impacts to other areas caused by former carpool travelers now driving alone).

  As indicated in the FHWA's "Consideration for High Occupancy Vehicle Lane to High Occupancy Toll Lane Conversion Guidebook" (June 2007) (HOV2HOT Conversion Guidebook), "[i]t is critical to fully understand the impact of creating added capacity to HOV lanes and potentially creating unexpected, new congestion hot spots" (p. 6-2).

  For Alternative 3 when toll lanes take the place of existing free HOV lanes there is the potential for drivers who are now carpooling to change their driving patterns to SOVs to avoid the added toll costs and congestion in the GP lanes. Alternative 3, therefore, has the potential to cause increased traffic impacts to routes (including arterial travel routes) other than the I-405 Freeway. The number of vehicles traveling other parallel routes could be significant. If added SOVs are added to the arterial roadways due to Alternative 3, those vehicles, not previously on the street system would also result in added noise and air quality impacts.

The Traffic Study contains numerous inconsistencies, resulting in the presentation of inaccurate information and analyses in the DEIR/S. For example:

- **Page 2.1-3** (Traffic Study). The study indicates that "zero flow rate occurs. . .when density becomes so high that all vehicles must stop – the speed is zero and the flow rate is zero. . .vehicles cannot pass a point on the roadway." Yet, in Table 2.3.1, (Existing [2009] I-405 Mainline Peak Hour Level of Service), LOS "F" conditions result in extremely large traffic volumes that exceed "capacity" but, based on the accompanying discussion (p. 2.1-3), the traffic volumes (passing a point) should be extremely low. The high traffic volumes indicated for the LOS "F" locations (shown in Table 2.3.1) must be erroneous since bumper-to-bumper traffic would allow very few cars to pass a particular point during a one-hour period (since they are stopped and their speeds approach zero).

  The Traffic Study indicates the "Highway Capacity Manual" (HCM) was used to analyze the traffic conditions. That methodology is not, however, reliable for freeway breakdown (LOS "F") conditions. As a result, the methodology employed in the Traffic Study was improper for the traffic conditions encountered throughout the study area. A more sophisticated analysis methodology should have been utilized so that an adequate analysis (and full disclosure) of traffic-related impacts can have been provided. For example, some type of traffic simulation procedure is needed to correctly identify the traffic impacts.

- **Page 2.1-9** (Traffic Study). The Traffic Study indicates that analyses for freeway ramps and ramp-freeway junctions were performed under both "constrained" and "unconstrained" mainline freeway conditions. The ramp analysis tables (Table 2.4.5, p. 2.4-20), however, show the same traffic volumes for both constrained and unconstrained conditions. Additionally, different densities are indicated; however, pursuant to the Traffic Study, this is not possible since the traffic flows would change as a function of density variations (Figure 2.1.1, p 2.1-4).

  It does not appear the effects of ramp metering have been included in the traffic evaluations. Ramp metering assumptions and evaluations would be critical to every aspect of the traffic analyses. Current ramp meter effects, including reasonable assumptions of future ramp meter conditions, must be incorporated throughout the Traffic Study, including (but not limited to) the analyses for the mainline freeway, the ramp merge points, the ramp intersections, queuing on the ramps, the ramp traffic volumes, and freeway mainline traffic volumes. Given the overburdened transportation systems (freeways, arterials, and other modes of transportation) ramp meter assumptions will have a "ripple effect" through the surrounding areas. Many of those effects were not analyzed in the Traffic Study.

Each project alternatives would be expected to generate unique transportation travel patterns within and surrounding the study areas. The project's alternative improvements (e.g., on the I-405 Freeway mainline), therefore, would create differing levels of congestion and cause people to make differing transportation choices (i.e., varying mode choices and travel patterns) causing differing traffic impacts for each of the build alternatives and affecting areas. For example:

- **Page 2.1-5** (Traffic Study). The Traffic Study indicates that it is "important to note that while speed varies by alternative, it is only predictable as relative differences between alternatives."

  Since it can only predict "relative differences," it must be assumed that the analytical approach employed by the Lead Agency cannot provide accurate analyses of future traffic conditions. An analogy would be that a person believes they should not receive a ticket because they were going slower than another vehicle, however, if the driver was going 80 mph and the other vehicle 82 mph, the "relative differences" are meaningless.

  Is there an analysis methodology that could be used to more accurately assess future freeway mainline traffic and/or ramp traffic, operations?

  Why is use of a "Speed Index" necessary? It appears that "Appendix A1" only serves to validate that the traffic on the study roadways follow typical traffic patterns, resulting in generalized conclusions.

- **Page 2.2-3** (Traffic Study). The Traffic Study indicates that "a single demand forecast was prepared. Forecasts for each of the alternatives utilize the same total traffic volumes on a segment." Traffic projections and associated analyses for each alternative are, therefore, not unique to each alternative, including the considerations of the unique area travel patterns that would be associated with each alternative. How could the "same total traffic volumes" on the freeway segments result from significantly different improvement measures?

If separate traffic model runs were used, the potential impacts (including beneficial impacts) on the surrounding areas could have been evaluated. Why were separate traffic model runs not prepared for each project alternative condition?

Having one traffic model run serve to translate everything to a very narrow perspective, namely moving a given number of vehicles through one section on one travel route. From an environmental perspective this approaches results in the impacts on other areas, outside this project corridor, to be ignored. This approach further serves to unreasonably limit the discussion and analysis whether other alternatives could be formulated which would not only benefit the project freeway sections but also benefit the surrounding areas by focusing on the movement of people throughout various corridors (rather than the movement of vehicles through one freeway section).

The HCM contains various statements which indicate that the HCM's specified procedures are inadequate and inappropriate for analysis of the proposed action. For example, the HCM includes (but is not limited to) the following examples:

- **Page 22-1** (HCM). The "Scope of the Methodology" presented in Chapter 22 deals with "freeway facilities." As indicated therein, "[f]ree-flow conditions must exist at the upstream and downstream ends of the freeway facility" for the application of the HCM procedures. Since the project study area does not meet this requirement, the use of the HCM methodology is not valid for the project's alternatives (e.g., Traffic Study, Table 2.3.1, pp. 2.3-6 and 7).
- **Page 22-1** (HCM). Under "Limitations of the Methodology," the HCM indicates that "[c]ertain freeway traffic conditions cannot easily be analyzed by the methodology," an example being multiple overlapping bottlenecks. The HCM states that other tools may be more appropriate (e.g., "Refer to Part V of this manual for a discussion of simulation and other models").
- **Page 22-1** (HCM). The procedures address only local oversaturated flow situations and not system-wide oversaturated flow conditions.

Caltrans' "Guide for the Preparation of Traffic Impact Studies" (December 2002) states that "[w]hen a State highway has saturated flows, the use of a micro-simulation model is encouraged for the analyses (please note however, the micro-simulation model must be calibrated and validated for reliable results)" (p. 5). As a result, reliance upon the HCM methodology is both problematic and likely to lead to erroneous results.

9.1.2 Major Investment Study

The MIS Study reveals failure to provide adequate environmental analyses and information from the outset, in part due to erroneous study parameters. The MIS evaluations are inadequate for reasons that include, but are not limited to, the following:

- The study corridor has been limited to a relatively narrow area and short section of the I-405 Freeway that currently experiences significant traffic impacts. By narrowing the study corridor to, essentially, this one section of one freeway, it eliminates the possibility of identifying more dynamic and environmentally sensitive solutions. The causes of the traffic impacts (e.g., congestion) obviously extended to a regional level but the alternatives (and mitigation measures) are severely constrained to this one study area.

- Only 13 alternative solutions were considered. The more salient point, however, rather than the number of alternatives are the types of solutions considered. The multitude of environmental documents indicates the area's traffic problems are caused by regional and subregional (County) transportation needs, yet no regional or subregional solutions are considered. Essentially the project alternatives have been predetermined to exist only within the narrow study corridor. Conversely, the solutions to those problems require a regional or subregional approach. There is no evidence that any serious considerations were given to the formulation of broader solutions.

- The approach taken in the MIS could be compared to the invention of the airplane, then only driving it on the ground, making the case it can travel at increased speeds and carry more passengers. While those arguments would be true, the more important factor (i.e., airplanes can fly) is completely ignored. The MIS makes a similar oversight due to its self-limiting approach (i.e., to consider only increased capacity along this section of the I-405 Freeway). In order to provide complete and thorough analyses of environmentally sensitive solutions, alternative solutions must include projects beyond the current study area.

- There is significant information provided in the environmental documents regarding the increased sophistication of the available traffic models. The analyses procedure is essentially backwards in the MIS, namely potential alternatives are selected, then tested by the model. The model needs to be utilized to first analyze the problem and then solutions developed by testing multitudes of complex scenarios. Utilization of an antiquated approach of guessing a solution then using the model to justify the "best" of the limited alternatives only serves to produce short-sighted solutions. The current problems and impacts are complex and require full use of the available tools, otherwise full environmental disclosure is not possible.

9.2 Air Quality

9.2.1 Draft Environmental Impact Report/Statement

The following additional comments are submitted in response to the information presented in Section 3.2.6 (Air Quality) in the DEIR/S.

- **Page 3.2.6-10**. The analysis makes use of the North Coastal (SRA 18) monitoring data and supplements this with the Saddleback (SRA 19) monitoring data for particulate matter (PM). Basically, the entirety of the project represents the dividing line between the North Coastal (SRA 18) and Central Orange County (SRA 17) monitoring areas and the analysis is remiss in not providing the Central Orange County data, especially in that these data do include both PM_{10} and $PM_{2.5}$ that are lacking in the North Coastal data set. Furthermore, because the general wind direction is characterized by an on-shore flow pattern, emissions generated along the length of the corridor are more apt to be carried to the north into SRA 17. As such, these data should also be presented and, where applicable, these background concentrations used to present a reasonable worst-case scenario in the air quality analysis.

- **Page 3.2.6-12** (Table 3.2.6-3). Only 2007-2009 data has been presented. The 2010 data set is available and the analysis should be updated to include the most current data for the applicable receptor areas.

- **Page 3.2.6-12**. In accordance with the SCAQMD, the Lead Agency's definition of "sensitive receptors" does not go far enough so many are excluded from the analysis. According to the SCAQMD's "Final Localized Significance Threshold Methodology" (Methodology) (June 2003, Revised July 2008), the SCAQMD notes "receptor locations" as "off-site locations where persons may be exposed to the emissions from project activities. Receptor locations include residential, commercial and industrial land use areas; and any other areas where persons can be situated for an hour or longer at a time" (p. 3-2). As further indicated therein, "[f]or the purposes of CEQA analysis, the SCAQMD considers a sensitive receptor to be to be [sic] a receptor such as residence, hospital, convalescent facility were [sic] it is possible that an individual could remain for 24 hours. Commercial and industrial facilities are not included in the definition of sensitive receptor because employees do not typically remain onsite for a full 24 hours, but are present for shorter periods of time, such as eight hours" (Ibid.).

  Applying a 24-hour standard for particulates to these uses is not appropriate because, according to the SCAQMD's definition, a "sensitive receptor" would need to be present at the location for the full 24-hour period; however, because CO emissions are based on 1- and 8-hour standards, the ambient air quality standards would apply and the analysis is remiss for not including proximate commercial and, where appropriate, industrial uses in the CO analysis.

- **Page 3.2.6-22**. EMFAC2007 has now been replaced with EMFAC2011 and the analysis should be redone using the most current model available.

- **Page 3.2.6-29** (Table 3.2.6-8). The air quality analysis fails to include the "localized significance" analysis necessary for the construction and operation of the project. Based on the data included in the analysis, however, it can be concluded that the proposed action will result in significant localized construction impacts and present the following information to document this conclusion.

  The analysis specifically notes that grading activities will be limited to no more than 4.5 acres per day (p. 3.2.6-27). The analysis also notes that, including the proposed dust suppression; this construction would result in 139 pounds per day for PM_{10} and 31 pounds per day for $PM_{2.5}$ (Table 3.2.6-8, p. 3.2.6-29). The SCAQMD screening tables for localized Impacts for a 5-acre construction site located in the Saddleback Valley area (as was used in the analysis) notes that PM_{10} would present a significant impact is just 12 pounds were produced per day with receptors located at 25 meters. Based on 4.5 acres of disturbance, the impacts associated with 139 pounds of PM_{10} per day would be significant out to 500 meters. With respect to $PM_{2.5}$, a 5-acre construction site in Saddleback Valley would be significant at just 8 pounds per day with receptors at 25 meters. A value of 31 pounds per day on a 4.5-acre site would be significant to beyond 200 meters.

As illustrated in Figure 2-1 (Sensitive Receptor Locations) in the AQR (p. 39) and Figure 3.2.6-3 in the DEIR/S (p. 3.2.6-13), which illustrates “sensitive receptors within 500 ft of the ROW” (p. 3.2.6-12), numerous “sensitive receptors” are located in Seal Beach directly adjacent to or in close proximity to the I-405 Freeway. Since there are many sensitive receptors located within these “localized significance” threshold distances, construction-term impacts would be deemed significant for both PM_{10} and $PM_{2.5}$.

The DEIR/S, therefore, erroneously concludes that: (1) “Construction emissions would be temporary and not result in any long-term impacts; therefore, Alternative 2 would not result in an adverse impact related to construction emissions” (p. 3.2.6-29); and (3) “Construction emissions would be temporary and not result in any long-term impacts; therefore, Alternative 3 would not result in an adverse impact related to construction emissions” (p. 3.2.6-30). The presence of significant construction-term air quality impacts were not previously disclosed in the DEIR/S.

- **Page 3.2.6-29** (Table 3.2.6-8). With regards to projected daily construction emissions, the table shows 106 pounds per day for NOx. The SCAQMD CEQA construction threshold for NOx is 100 pounds per day. Since the 106 pounds/day projections exceeds the SCAQMD threshold, the resulting impact is significant impact and must be so noted. Contrary to CEQA, no mitigation has been proposed for this significant impact.

  In addition, the DEIR/S notes that construction results in 1.2 tons per acre per month for soil disturbance (p. 3.2.6-28). Based on 22 workdays per month, this results in about 110 pounds per day per acre. Using a Lead Agency’s own cited control efficiency of 50 percent for site watering (p. 3.2.6-28), soil disturbance is projected to result in 55 pounds per day per acre. Based on a maximum of 4.5 acres disturbed per day (p. 3.2.6-27), PM_{10} emissions would be 194 pounds per day based on the following calculations:

  4.5 acres per day x 55 pounds per acre per day = 245 pounds per day for PM_{10}.

  Even if 61% control efficiency is used as was used in the table:
  110 pounds per acre per day x (1 – 0.61) = 43 pounds per acre per day
  4.5 acres per day x 43 pounds per acre per day = 194 pounds per day for PM_{10}

  These values are well above the 139 pounds per day presented in the table and also in excess of SCAQMD’s 150 pound/day CEQA threshold, thus resulting in a previously undisclosed significant air quality impact for both Alternative 2 and Alternative 3.

- **Page 3.2.6-33** (Table 3.2.6-9 and Table 3.2.6-10). While the analyses include local intersections, they fails to include a “link” analysis for the freeway itself and those receptors located proximate thereto. Furthermore, the analysis fails to include the contribution of the CO emissions from the freeway at the local intersections.

- **Page 3.2.6-38**. The text states that “[i]t was determined that the inland Anaheim Monitoring Station meteorological conditions do not accurately represent the project area.” Because the I-405 Freeway serves as the border between the Costa Mesa and Anaheim areas and because the majority of the emissions will manifest themselves in the Anaheim area, what is the source and factual basis of that “determination”?

- **Page 3.2.6-38**. The analysis of respirable particulate matter is based on "the recorded period of 2000 to 2009" (p. 3.2.6-38). Since Year 2010 data are available, the analysis needs to be revise accordingly.

- **Page 3.2.6-41**. The text states "Tables 3.2.6-5 through 3.2.6-7 present emissions, including PM_{10} and $PM_{2.5}$, from vehicles traveling along the project corridor for the years 2009, 2020, and 2040 (i.e., existing, opening, and design years, respectively). Estimates of PM_{10} and $PM_{2.5}$ emissions for opening, and horizon years show that project implementation would not generate significant additional daily emissions" (p. 3.2.6-41).

  Under CEQA, the project must be compared with the "existing setting." Under the existing setting, $PM_{2.5}$ and PM_{10} are projected at 258 and 426 pound per day, respectively (Table 3.2.6-5, p. 3.2.6-24). Under Alternative 1, the proposed action would result in 508 and 559 pounds per day, respectively (Table 3.2.6-6, p. 3.2.6-25). These then represent increases of 250 and 133 pounds per day, for $PM_{2.5}$ and PM_{10}, respectively. The SCAQMD's significance threshold (i.e., adding to an existing violation) for these operational emissions is 2.5 $\mu g/m^3$. The analysis simply dismisses this threshold and makes no attempt to determine its potential relevancy to the proposed action.

The following additional comments are submitted in response to the information presented in Chapter 4.0 (California Environmental Quality Act Evaluation) in the DEIR/S.

- **Page 4-5**. The analysis bases the impact on the future "no build" versus future "build" and finds no significant impacts. Under CEQA, however, the analysis must compare the future "build" versus the "existing" volumes of traffic. When this is done, the project shows a significant impact for $PM_{2.5}$ (the addition of 354 pounds per day versus 55 pounds per day threshold) and PM_{10} (the addition of 243 pounds per day versus a 150 pound per day threshold).

- **Page 4-6**. Contrary to the text, the analysis indicates that NOx would exceed the SCAQMD's daily threshold, thus resulting in a significant construction impact. However, the analysis fails to identify the SCAQMD threshold values or compare the project to these values. Furthermore, the analysis fails to consider the SCAQMD's localized threshold limitations. The analysis, therefore, needs to be redone relative to SCAQMD's CEQA thresholds for mass daily emissions and localized concentration levels. When this is done, the resulting impacts are significant and remain unmitigable to less-than-significant level.

- **Page 4-6**. The text states that the potential for increased particulate emissions associated with increases in average daily traffic (ADT) would be offset by projected increases in vehicle speed and would, therefore, not have a significant effect on proximal sensitive receptors. The analysis fails to state that much of the PM is generated as a result of re-entrained road dust. Contrary to the text, this value increases with speed. While emissions decrease with increased speed, this is only to a certain point and further increases in speed result in increased emissions due to increased vehicle, road, and air friction.

- **Page 4-7**. Contrary to the text, the analysis has failed to conduct the "localized significance analysis" as required by the SCAQMD. Because construction emissions have been demonstrated to exceed threshold values for PM, the project would be expected to expose sensitive receptors to substantial emissions concentrations.

9.2.2 Appendix J (Air Quality)

The following additional comments are submitted in response to the information presented in Appendix J (Air Quality) in the DEIR/S.

- **Page 3.1-5**. With regards to the EPA's "Transportation Conformity Guidance for Quantitative Hot-Spot Analyses in $PM_{2.5}$ and PM_{10} Nonattainment and Maintenance Areas" (December 2010) (Conformity Guidance), citing the Transportation Conformity Working Group of the Southern California Association of Governments January 25, 2011 minutes, the DEIR/S notes: "Update on EPA's Quantitative PM Hot-Spot Guidance: The FR [Federal Register] notice starting the grace period was published on December 20th and the final guidance was posted on the EPA, OTAQ web site. The grace period ends on December 20th, 2012" (p. 3.1-5).

  In accordance with the Conformity Guidance, a "[q]uantitative PM hot-spot analyses will be required at the end of the conformity grace period for applying motor vehicle emissions models for such analysis. . .A hot-spot analysis is defined in 40 CFR 93.101 as an estimate of likely future localized pollutant concentrations and a comparison of those concentration to the relevant NAAQS [National Ambient Air Quality Standards]. A hot-spot analysis assesses the air quality impacts on a scale smaller than an entire nonattainment or maintenance area, including, for example, congested highways or transit terminals. Such an analysis of the area substantially affected by the project demonstrates that CAA [Clean Air Act] conformity requirements are met for the relevant NAAQS in the 'project area.' When a hot-spot analysis is required, it is included within a project-level conformity determination" (emphasis added) (p. 2).

  As noted in Table S-3 (Project Schedule) in the DEIR/S, the "Record of Decision" (ROD) for the proposed action is not scheduled until "Spring 2014" (p. S-6) and "[s]ubsequent to circulation of the DEIR/EIS and selection of the preferred alternative, an Air Quality Conformity Analysis will be prepared and submitted to FHWA" (p. 3.2.6-21).

  The AQR notes that "[a] qualitative particulate matter hotspot analysis was completed that concluded that the proposed project would not cause new or delay timely attainment of the National Ambient Air Quality Standards" (emphasis added) (p. 1) and that, based on that analysis, "[t]he proposed project would be consistent with transportation conformity requirements" (p. 2). It appears that the "chicken is cooked and in the pot" (e.g., "Alternative 3 is not consistent with the current RTP or FTIP. OCTA is currently pursing revisions to both documents. This will be completed prior to the Final EIR/EIS, which will include the revised description and reference to the conforming documents," DEIR/S, p. S-13).

  As required under CEQ's "Considering Cumulative Effects under the National Environmental Policy Act" (January 1997), "decisions must be supported by the best analysis based on the best data we have or are able to collect" (p. 3) and include "rigorous analyses" (p. 46). While acknowledging that the Lead Agency has a "grace period" extending until December 2012, as a public agency for a regionally significant project, because the USEPA's guidance document was release well in advance of the performance of the air quality analysis, because the final CEQA and NEPA document may not be certified until after December 2012, because construction is not scheduled to commence prior to 2015, and because a conformity determination must be conducted, Caltrans has a responsibility (to its constituents and stakeholders) to provide the "best" information it can. In this case, that would include a quantitative analysis of projected PM_{10} and $PM_{2.5}$ emissions conducted in accordance with the USEPA's guidelines rather than to simply "opt out" based solely on a technicality.

9.2.3 Air Quality Report

The following additional comments are submitted in response to the information presented in the "Air Quality Report - San Diego Freeway (I-405) Improvement Project SR-73 to I-605, Orange and Los Angeles Counties" (Caltrans, May 2011).

- **Appendix C** (Regional Construction Emissions). The model run show a project length of just 14 miles; however, the project description states that the project is 16 miles. It is, therefore, possible that the model underestimates construction impacts by approximately 14.3 percent.

- **Appendix F** (CO Hotspot Analysis). The model runs show that the modeling was performed incorrectly. The analysis gives each direction of traffic (i.e., N, S, E, and W) an "approach volume," a "departure volume," and a "turning volume." This is incorrect and under-predicts these emissions. In accordance with Caltrans' "Transportation Project-Level Carbon Monoxide Protocol" (revised December 1997) (CO Protocol), each direction should have an "external approach volume," an "approach volume," (accompanied by a lower speed and higher emissions), a "departure volume" (accompanied by a lower speed and higher emissions), an "external departure volume," and a "turning volume." According to the CO Protocol (Figure B.2), each "external approach" and "external departure" distance is to be 600 meters. The "approach" and "departure" distances are each to be 150 meters. As such, the entire analysis covers a distance of 1,500 meters for each lane. The analysis under-predicts emissions because it considers a lesser distance (i.e., 1,000 meters versus the requisite 1,500 meters per lane) and does not consider that the vehicles slow and accelerate leading to higher emissions proximate to the intersection.

9.3 Noise

Pursuant to 23 C.F.R. 772, the proposed action constitutes a "Type I project" in that it proposes the addition of one or more: (1) through-traffic lanes that function as a high-occupancy vehicle lane, high-occupancy toll lane, bus lane, or truck climbing lane; or (2) auxiliary lanes, except for when the auxiliary lane is a turn lane; or (3) interchange lanes or ramps. If any component of a proposed project is determined to be a Type I project, as defined in the environmental document, the entire project area constitutes a Type I project.

9.3.1 Draft Environmental Impact Report/Statement

The following additional comments are submitted in response to the information presented in Section 3.2.7 (Noise) in the DEIR/S.

While discussion of FHWA requirements may satisfy the NEPA requirement, under a joint CEQA/NEPA document the analysis must also look at impacts based on local standards. The CEQA Checklist inquires: "Would the project result in exposure of persons to or generate noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?" As such, the analysis is deficient in that it does not discuss the standards of the various municipalities that the project lies within or how the proposed action potentially impacts those local standards at the local general plan and municipal code level. Similarly, while discussion of FHWA thresholds (including the use of peak hour traffic and a 12-dBA increase in noise) may satisfy the NEPA requirement, under a joint CEQA/NEPA document, the analysis must also look at threshold levels, including the 24-hour CNEL (as opposed to just peak hour noise), and any substantial increase (e.g., 3 dBA) imposed at the local level.

In many places the analysis notes that while a sound wall could mitigate the noise impact, it is not considered because it does not meet Caltrans' cost/benefit margin. Under CEQA, if feasible, mitigation cannot be rejected based only on cost considerations. Additionally, in many places the analysis notes that while a sound wall could mitigate the noise impact, but could not achieve 5 dBA of noise reduction and is, therefore, not considered as feasible. Under CEQA, if the impact is significant, mitigation must be provided to the extent feasible, even if it does not meet some performance standard.

As indicated in the NSR, Caltrans' "Traffic Noise Analysis Protocol for New Highway Construction and Reconstruction Projects" (Protocol) "defines a noise increase as substantial when the predicted noise levels with project implementation exceed existing noise levels by 12 dB" (p. 19). Independent of that Protocol, a sound wall is generally "acoustically feasible" if it attains a decrease of 5 dBA (e.g., "Noise abatement is considered to be acoustically feasible if it provides noise reduction of at least 5-dB at receivers subject to noise impacts," NADR, p. 1); however, the impact would not be significant unless the noise increased by 12 dBA. As such, the residual noise could be 7-dBA above the ambient noise and, in accordance with the methodology presented, would be considered mitigated and/or less than significant. As a result, based on the continued fragmentation of improvement projects into short-term horizons, each separate project could produce a 12 dBA increase over then existing noise levels but never be deemed significant. Conversely, under CEQA (although the Department seeks to avoid its application), if this 7-dBA increase remains above that prescribed for a significant increase at the local level, the measure would be considered ineffective and the resulting impact would remain significant.

- **Page 3.2.7-4**. While the text notes that these readings were 24-hours in duration, the data does not support this statement. For example, the reading at 3077 Yukon Avenues (reported to be a 24-hour reading) actually ran from 10:50 AM to 9:53 AM the following morning. Thus, the measurement failed to cover the 10:51 to 9.52 AM period, as is shown in the technical study.

- **Page 3.2.7-9**. The text states: "With consideration of the acoustic benefit and the incremental cost, Sound wall S708 is <u>recommended"</u> (emphasis added) (p. 3.2.7-9). The analysis carries similar "recommendations" throughout the text. Under CEQA, mitigation measures are not merely "recommendations" but are enforceable actions and binding obligations (see 14 CCR 15126.4[a][2]).

With regards to Soundwall S733, the text further states: "The estimated total construction cost of this soundwall is $112,000, which exceeds the reasonable allowance of $43,000. With consideration of the acoustic benefit and the incremental cost, construction of Sound wall S733 is not reasonable; therefore, it is not recommended" (p. 3.2.7-9). As a result, it is evident that the Lead Agency's decision to install, fortify, or replace a soundwall is not related to the quantifiable acoustical impact of the proposed action but the cost of the wall required to reduce project-related noise to affected receptors. The Department seeks to assert that its obligations to avoid, minimize, or mitigate the impacts of its actions under CEQA and NEPA are limited to a predetermined cost-benefit ratio above which it has no obligation. That approach is not consistent with CEQA.

As stipulated under Section 15126.4(a)(3) of the State CEQA Guidelines, mitigation measures are not required for effects which are not found to be significant. It is, therefore, the Lead Agency's significant determination rather than cost considerations that determine whether mitigation needs to be incorporated.

- **Page 3.2.7-43**. The analysis fails to quantify the impacts of construction noise or provide a discussion of the projected levels at proximate receptor locations. The analysis never concludes whether construction noise impacts are significant but nevertheless imposes mitigation. In addition, the analysis never discloses as to whether the mitigation reduces the impact to a less-than-significant level.

The following additional comments are submitted in response to the information presented in Chapter 4.0 (California Environmental Quality Act Evaluation) in the DEIR/S.

- **Page 4-12**. The text states that temporary noise impacts are to be anticipated. However, the text never establishes the criteria to determine if the impacts are significant or less than significant. The analysis then requires measures in order to minimize noise, stating that those measures would reduce noise to a less-than-significant level. The impact must be held to some quantitative standard and the impact reassessed after application of the mitigation to determine if it is then less than significant.

- **Page 4-12**. The text notes that a change of 5 dBA is considered as the minimum perceptible change in noise levels. However, the NSR states that "it is widely accepted that people are able to begin to detect sound level increases of 3 dB in typical noisy environments. Further, a 5 dB increase is generally perceived as a distinctly noticeable increase and a 10 dB increase is generally perceived as a doubling of loudness. Therefore, a doubling of sound energy (e.g., doubling the volume of traffic on a highway) that would result in a 3 dB increase in sound, would generally be perceived as detectable by the average person" (p. 14).

  The I-405 Freeway passes through a number of municipalities having their own definition of perceptibility and/or significant change. The Seal Beach General Plan (Noise Element) notes that "[a] 3-dBA increase in noise levels is often noticeable to residents." With regards to a 3-dBA increase, the Noise Element further notes that "residents will perceive the noise as increasing significantly."

  The CEQA Checklist inquires: "Would the project result in exposure of persons to or generate noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?" As such, the analysis must address these impacts in accordance with local standards and thresholds.

- **Page 4-13**. The analysis notes that it includes the "recommended noise abatement" measures. Under CEQA, the analysis must be compiled showing the project as described. "Recommended measures" have no meaning or place in CEQA. If these are project "commitments," they must be noted as such and disclosed in the project description. If they are to be mitigation measures, then the analysis must first be compiled without them to assess the impact of the project. They are then imposed and the analysis redone with their inclusion to demonstrate their effectiveness and whether the residual impact remains significant

9.3.2 Noise Abatement Decision Report

The following additional comments are submitted in response to the information presented in the "Noise Abatement Decision Report – San Diego Freeway (I-405) Improvement Project SR-73 to I-605, Orange and Los Angeles Counties" (Caltrans, September 2011).

- **Soundwall S1162**. As indicated in the NSR: "Soundwall S1162 would be located at the edge of shoulder along the northbound side of I-405. It would provide abatement for the City of Seal Beach Tennis Court Center, an area that already experiences some noise reduction from a combination of an existing property wall and berm. The noise analysis indicates that a 5 dB noise reduction would only be achieved at one of the two modeled receivers positioned behind this barrier. Figures 22 and 23 in Appendix A1 show the minimum heights and location of Soundwall S1162 to achieve at least 5 dB noise reduction at this tennis facility" (p. 62). As indicated in Table 7-21 (Summary of Reasonableness Determination Data – Alternative 1 0 Soundwall S1162), a 12-foot or a 14-foot barrier would produce a 5 decibel (dB) noise reduction (p. 66). As indicated in the NADR, with regards to the area located between Valley View Street and Seal Beach Boulevard, the following information is presented regarding "Soundwall S1162":

  > Soundwall S1162 would be located at the edge of shoulder along the northbound side of I-405 and would extend an existing soundwall 700 feet to the north. The total construction cost of this wall is estimated to be from $225,000 which exceeds the reasonable allowance of $43,000. Figure 23 in Appendix A2 of NSR shows the height and length of Soundwall S1162 to provide feasible abatement. With consideration of the acoustic benefit and the incremental cost, the construction of Soundwall S1162 is not reasonable and therefore not recommended. However, this area is already partially protected by a 6-foot high private wall on top of a berm (p. 53).

  As illustrated on Figures 22 and 23 (February 23, 2011) in the NSR, Soundwall S1162 is located in the vicinity of the Seal Beach Tennis Center, extending from the parking area located on the west side of that facility to Aster Street. As indicated by the above excerpt, although the Lead Agency acknowledges the tennis center as a "sensitive receptor" (e.g., AQR, Figure 2-1, p. 39; DEIR/S, Figure 3.2.6-3, p. 3.2.6-13), no additional sound attenuation is being proposed in that area. As a result, although a perceptible 5 dB noise reduction could be achieved, Caltrans does not believe the expenditure to be justified.

Presented in Table 17 (Noise Abatement Information [Alternative 3]) is information extracted from Table 3 (Noise Abatement Information [Alt-3]) in the NADR. The City believes that rejecting alternatives and/or an avoidance, minimization, or mitigation measure based on cost considerations and/or a cost-benefit ratio is inconsistent with the Lead Agency's obligations under CEQA. If authorized, the Department may seek to apply a similar cost-benefit rational to the mitigation of GHG emissions and cancer deaths attributable to air pollutants.

Table 17
Noise Abatement Information (Alternative 3)

Noise Barrier No.	Height (feet)	Acoustically Feasible?	Number of Benefitting Residences	Total Reasonable Allowance	Estimated Construction Cost	Cost Less Than Allowance	Preliminary Noise Abatement Decision
S1116	18	No	N/A	N/A	N/A	N/A	Replace In-Kind
S1132	18	No	N/A	N/A	N/A	N/A	Replace In-Kind
S1162	12	Yes	2	$90,000	$225,000	No	Not Reasonable

Source: California Department of Transportation, Noise Abatement Decision Report – San Diego Freeway (I-405) Improvement Project SR-73 to I-605, Orange and Los Angeles Counties, September 2011, Table 15 (Noise Abatement Information [Alt-3]), unpaginated

Presented in Table 18 (Anticipated Major Retaining Wall Locations and Heights for All Alternatives) is information extracted from Table 11-2D (Anticipated Major Retaining Wall Locations and Heights for All Alternatives) in the VIA. Although Soundwall S1116 and S1132 are identified therein, there is no reference to Soundwall S1162. When considered in combination with Table 17 (Noise Abatement Information [Alternative 3]), the absence of any reference to Soundwall S1162 suggesting that the Department has no plans to modify, replace, or relocate that wall under any of the three build alternatives. Similarly, should Alternative 1 be selected, no modifications, replacement, or relocation activities affecting Soundwall S1116 and Soundwall S1132 would appear to be proposed.

As indicated in Table 18 (Anticipated Major Retaining Wall Locations and Heights for All Alternatives) above, should Alternative 2 be selected, no modifications, replacement, or relocation activities affecting Soundwall S1132 would appear to be proposed. That assumption would contradict the information presented in Table 17 (Noise Abatement Information [Alternative 3]) above which contains no similar stipulation. As such, it is not possible to clearly ascertain from the information presented in the DEIR/S what are the Department's actual plans for Soundwall S1116 and Soundwall S1132, including the Lead Agency's definition of "edge of shoulder" in the context of the existing location of those two soundwalls.

The City seeks clarification from the Department as to the precise nature of all noise mitigation strategies being considered with Seal Beach, including more specificity as to the location and design of any new, modified, fortified, and/or replacement soundwalls, the rational for the rejection of any soundwall under consideration, the noise mitigation anticipated to result therefrom, any additional noise reduction resulting from a minor modification to wall height, the Departments post-construction monitoring plans to assess the actual mitigation resulting from those improvements, and any remedial actions that are proposed should the implemented measures fail to attain their projected efficacy.

Table 18
Anticipated Major Retaining Wall Locations and Heights for All Alternatives

Sound Wall No.	Side of Freeway		Soundwall Location & Side of Highway	Alternative			Approx. Wall Height (feet)	Approx. Wall Length (feet)
	NB	SB		1	2	3		
S1116	X		Replaces an existing soundwall with the same height at the edge of shoulder along the NB mainline between Springdale and Seal Beach Dr.		X	X	18	470[2] 400[3]
S1132	X		Replaces and existing soundwall with the same height at the edge of shoulder along the NB mainline between Sprindale and Seal Beach Dr.			x	18	1553

Footnotes:
1. Alternative 1
2. Alternative 2
3. Alternative 3

Source: Visual Impact Assessment – San Diego Freeway (I-405) Improvement Project SR-73 to I-605, Orange and Los Angeles Counties" (Caltrans and Parsons, May 2011, Table 11-2D (Anticipated Major Retaining Wall Locations and Heights for All Alternatives), p. 125

- **Soundwalls S1132 and S1116**. As illustrated on Figures 21 and 22 (February 23, 2011) in the NSR, Soundwall S1132 extends from east of Aster Street to west of Jasmin Circle (east of Shapel Park) and Soundwall S1116 extends further eastward to Violet Street. Between Violet Street and the City boundaries, no soundwall is illustrated in the NSR. As indicated in Table 16 (Noise Abatement Information [Alternative 3]), extracted from Table 3 (Noise Abatement Information [Alt-3]) in the NADR, the Department proposes to replace both soundwalls "in-kind." No reference is made is to whether any portion of those soundwalls will be relocated from a location inset from the existing edge of Caltrans' ROW to a replacement location further to the north.

  The City seeks clarification from the Department as to Caltrans' current proposal with regards to Soundwalls S1132 and S1116, including additional information concerning whether those existing walls will be moved from their current locations and more specificity as to the design of those "in-kind" facilities, the timing of proposed demolition and construction, the anticipated length of the construction period, the projected timeframe when no or only partial soundwalls will be in place, and any short-term or long-term strategies to attenuate both construction and operational impacts at the affected residences. How would increases in wall height enhance noise mitigation (e.g., would a higher wall provide greater noise abatement)?

10.0 RECIRCULATION/SUPPLEMENTATION REQUIRED

Section 21005(a) of CEQA states: "The Legislature finds and declares that it is the policy of the state that noncompliance with the information disclosure provisions of this division which precludes relevant information from being presented to the public agency, or noncompliance with substantive requirements of this division, may constitute a prejudicial abuse of discretion within the meaning of Sections 21168 and 21168.5, regardless of whether a different outcome would have resulted if the public agency had complied with those provisions." The courts have determined that "'[t]he failure to comply with the law subverts the purposes of CEQA if it omits material necessary to informed decisionmaking and informed public participation. Case law is clear that, in such cases, the error is prejudicial [Citations.]'" (Sunnyvale West Neighborhood Assn. v. City of Sunnyvale City Council [2010], quoting County of Amador v. El Dorado County Water Agency (1999)

As indicated by the CEQ, should "a commentor point out an alternative which is not a variation of the proposal or of any alternative discussed in the draft impact statement, and is a reasonable alternative that warrants serious agency response," then the federal lead "agency must issue a supplement to the draft EIS that discusses this new alternative. . .If the permitting agency has failed to consider that approach in the Draft EIS, and the approach cannot be dismissed by the agency as unreasonable, a supplement to the Draft EIS, which discusses that alternative, must be prepared" (CEQ Question, Question 29b).

Pursuant to Section 15088.5 of the State CEQA Guidelines, a lead agency is required to recirculate a previously circulated EIR when "significant new information is added to the EIR" after release of the NOC but before certification. New information added to an EIR is not "significant" unless the EIR is changed in a way that deprives the public of a meaningful opportunity to comment upon a substantive adverse environmental effect of the project or a feasible way to mitigate or avoid such an effect (including a feasible project alternative) that the project proponents have declined to implement. "Significant new information requiring recirculation includes, but is not limited to, a disclosure that: (1) a new significant environmental impact would result from the project or from a new mitigation measure proposed to be implemented; (2) a substantial increase in the severity of an environmental impact would result unless mitigation measures are adopted that reduce the impact to a level of insignificance; (3) a feasible project alternative or mitigation measure considerably different from others previously analyzed would clearly lessen the environmental impacts of the project but the project's proponents decline to adopt it; and (4) the draft EIR was so fundamentally and basically inadequate and conclusory in nature that meaningful public review and comment were precluded."

Pursuant to Section 15151 of the State CEQA Guidelines: an EIR must provide a degree of analysis and detail about environmental impacts that will enable decision makers to make intelligent judgments in light of the environmental consequences of their decisions. The sufficiency of the EIR is to be reviewed in light of what is reasonably feasible (Kings County Farm Bureau v. City of Hanford [1990]). The Lead Agency must make a good faith effort at full disclosure of environmental impacts. In order to accomplish this requirement, it is essential that the project is adequately described and that existing setting information is complete (County of Inyo v. City of Los Angeles [1977]). Decisionmakers and other stakeholders need to fully understand the implications of the choices that are presented relative to the proposed action and to feasible mitigation measures and alternatives thereto (Laurel Heights Improvement Association v. Regents of University of California [1988]). As indicated in Village Laguna of Laguna Beach, Inc. v. Board of Supervisors (1982), an EIR is "an environmental 'alarm bell' whose purpose it is to alert the public and its responsible officials to environmental changes <u>before</u> they have reached ecological points of no return" (emphasis added).

The absence of any meaningful analysis of project-specific and cumulative environmental and socioeconomic ramifications of the proposed action, including the document's failure to consider a reasonable range of alternatives and to identify feasible mitigation measures, has effectively "deprives the public of a meaningful opportunity to comment upon a substantial adverse environmental effect of the project or a feasible way to mitigate or avoid such an effect" (14 CCR 15088.5). The totality of comments presented herein provides substantial evidence supporting the need to recirculate and supplement the DEIR/S.

11.0 DOCUMENTS CITED

(Partial Listing)

11.1 Publications

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Attachment A

W.G. Zimmerman Engineering, Inc.
Alternative Design Configurations
July 2012

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REVISED DESIGN:

1. 4' WIDE INSIDE SHOULDER
2. TWO HOV LANES (ONE 12' WIDE + ONE 12' OR 13' WIDE)
3. EIGHT 12' WIDE REGULAR LANES
4. 10' WIDE OUTSIDE SHOULDER

N

SCALE
1"=200'

REVISED ALTERNATIVE 2

REVISED DESIGN:

1. 4' WIDE INSIDE SHOULDER
2. TWO HOV LANES (ONE 12' WIDE + ONE 12' OR 13' WIDE)
3. EIGHT 12' WIDE REGULAR LANES
4. 10' WIDE OUTSIDE SHOULDER

N

SCALE
1"=200'

REVISED ALTERNATIVE 2

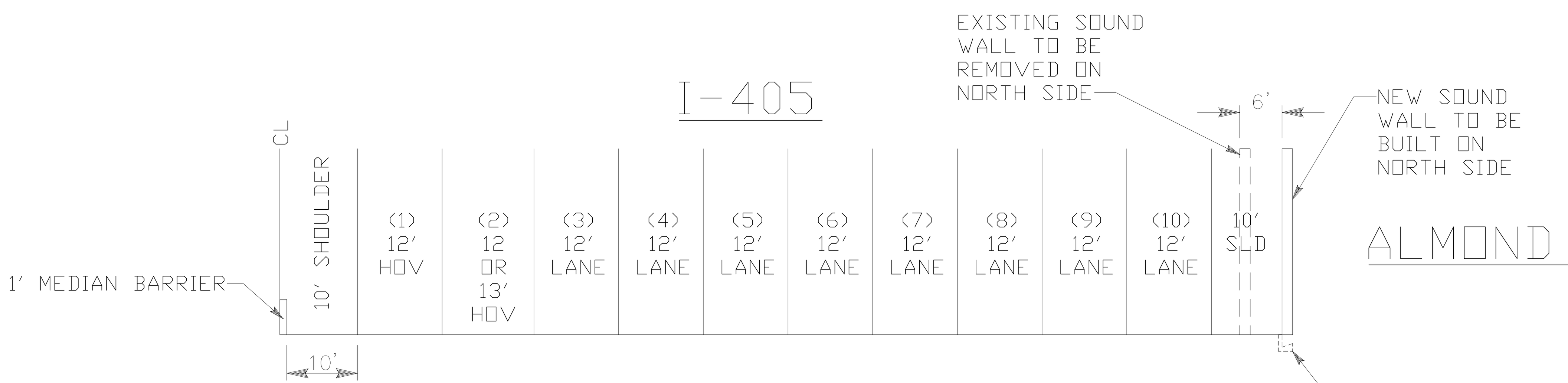
REVISED DESIGN:

1. 4' WIDE INSIDE SHOULDER
2. TWO HOV LANES (ONE 12' WIDE + ONE 12' OR 13' WIDE)
3. EIGHT 12' WIDE REGULAR LANES
4. 10' WIDE OUTSIDE SHOULDER

SCALE
1"=200'

REVISED ALTERNATIVE 2

ALTERNATIVE 2



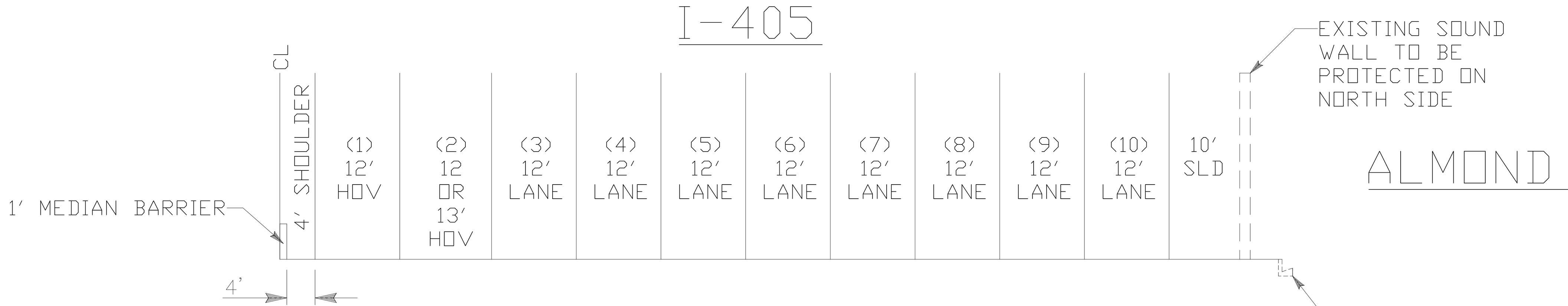
ORIGINAL DESIGN BY PARSONS

STATION 1127+17 TO 1156+00

TYPICAL SECTION

LOOKING WEST

NO TO SCALE



REVISED DESIGN BY WGZE

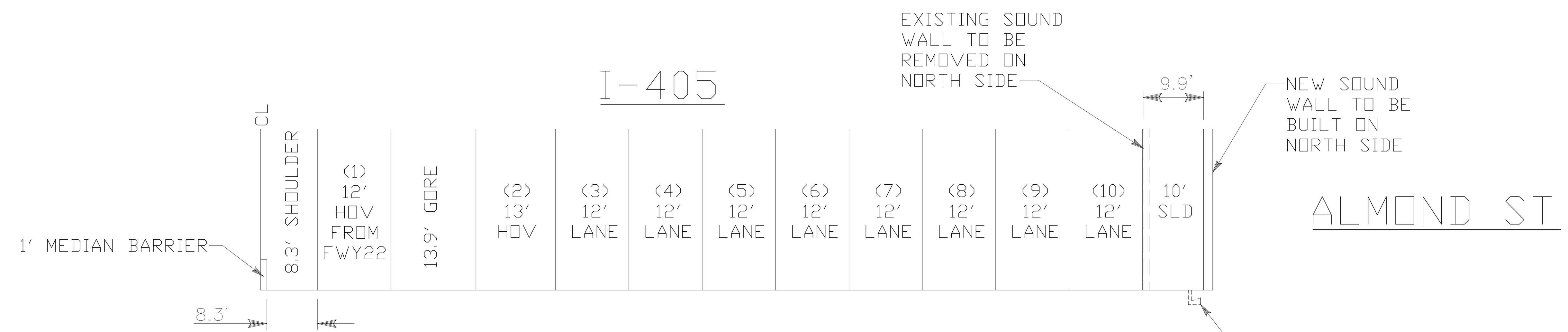
STATION 1127+17 TO 1156+00

TYPICAL SECTION

LOOKING WEST

NO TO SCALE

ALTERNATIVE 2



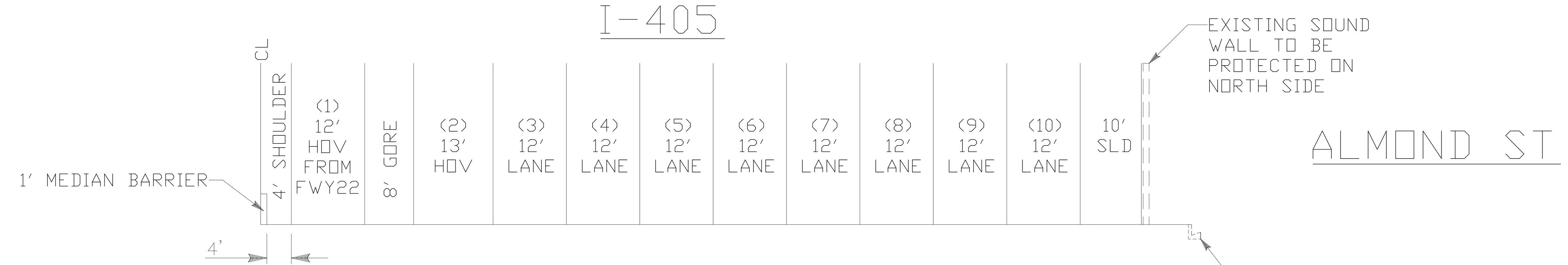
ORIGINAL DESIGN BY PARSONS

STATION 1115+82.83

TYPICAL SECTION

LOOKING WEST

NO TO SCALE



REVISED DESIGN BY WGZE

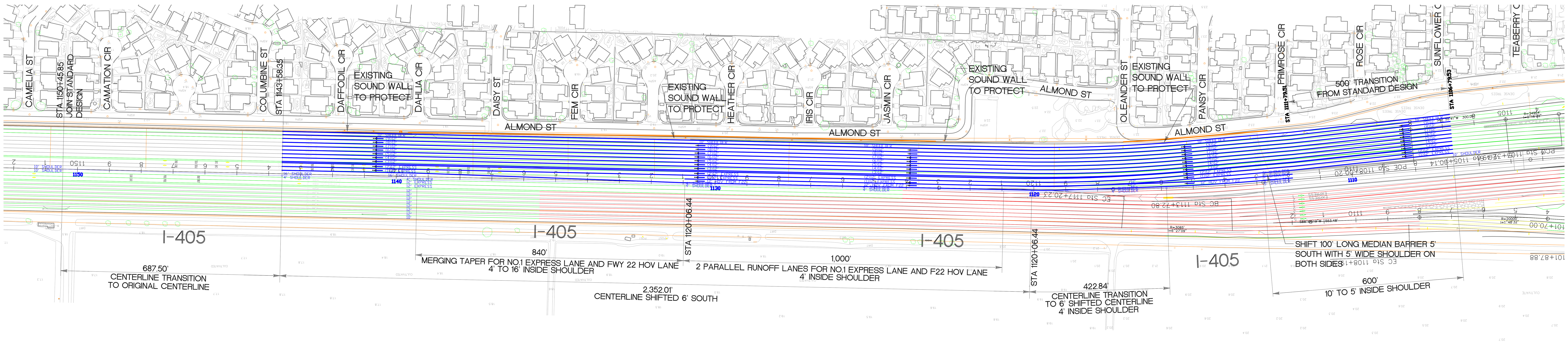
STATION 1115+82.83

TYPICAL SECTION

LOOKING WEST

NO TO SCALE

REVISED ALTERNATIVE 2



REVISED DESIGN:

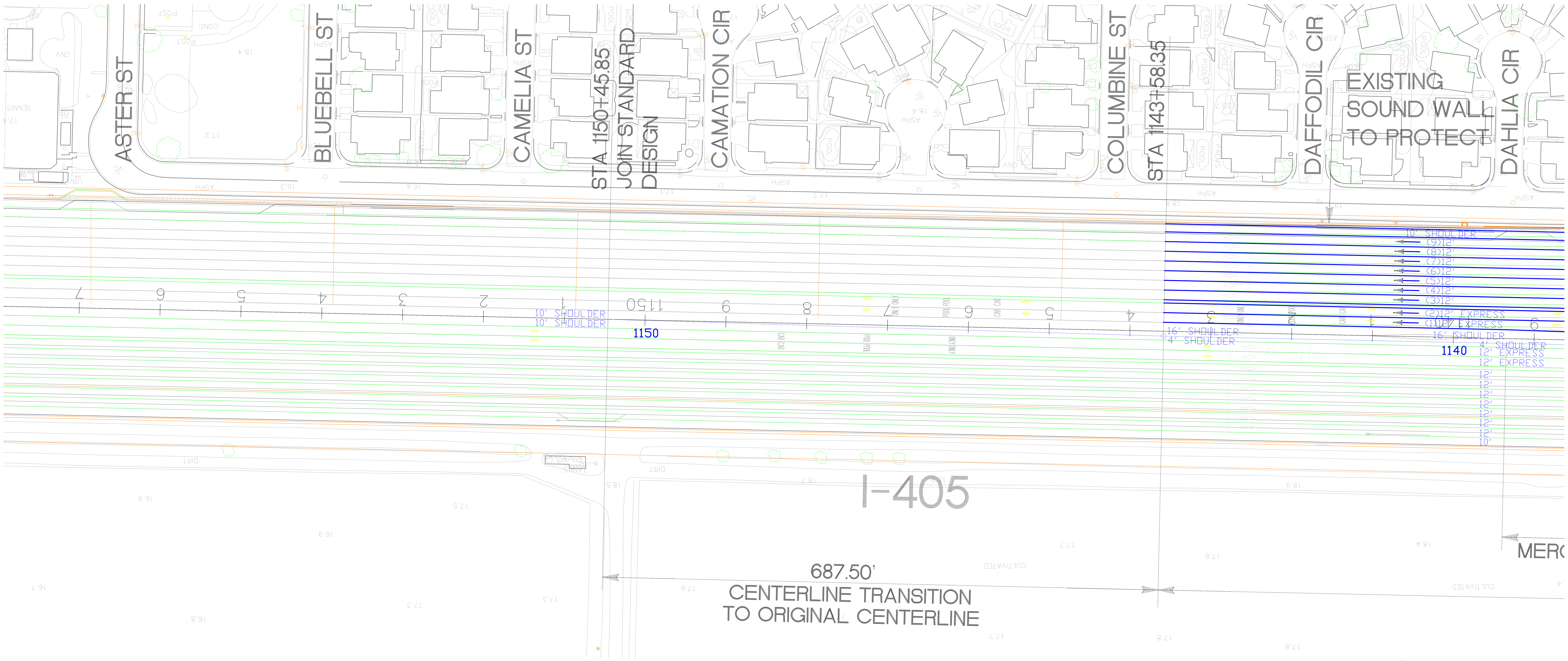
1. 2,352.01' LONG CENTERLINE SHIFTED 6' SOUTH (FROM STA 1120+06.44 TO 1143+58.35)
2. 4' WIDE INSIDE SHOULDERS FOR NB AND SB I-405 (FROM STA 1120+06.44 TO 1130+94.44)
3. WESTERLY 100' OF 405/22 MEDIAN BARRIER SHIFTED 5' SOUTH WITH 5' INSIDE SHOULDER ON BOTH SIDES
4. EASTERLY REMAINING 500' OF 405/22 MEDIAN BARRIER ANGLED TO CONNECT TO EXISTING BARRIER WITH INSIDE SHOULDER TAPERING FROM 5' TO 10' WIDTH
5. TWO EXPRESS LANES (12' WIDE EACH) AS ORIGINALLY DESIGNED
6. SEVEN 12' WIDE REGULAR LANES AS ORIGINALLY DISIGNED
7. 10' WIDE OUTSIDE SHOULDER AS ORIGINALLY DESIGNED
8. EXISTING NORTH SIDE SOUND WALL TO REMAIN IN PLACE

REVISED ALTERNATIVE 3

N

SCALE
1"=150'

1



REVISED DESIGN:

1. 2,352.01' LONG CENTERLINE SHIFTED 6' SOUTH (FROM STA 1120+06.44 TO 1143+58.35)
2. 4' WIDE INSIDE SHOULDERS FOR NB AND SB I-405 (FROM STA 1120+06.44 TO 1130+94.44)
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4. EASTERLY REMAINING 500' OF 405/22 MEDIAN BARRIER ANGLED TO CONNECT TO EXISTING BARRIER WITH INSIDE SHOULDER TAPERING FROM 5' TO 10' WIDTH
5. TWO EXPRESS LANES (12' WIDE EACH) AS ORIGINALLY DESIGNED
6. SEVEN 12' WIDE REGULAR LANES AS ORIGINALLY DISIGNED
7. 10' WIDE OUTSIDE SHOULDER AS ORIGINALLY DESIGNED
8. EXISTING NORTH SIDE SOUND WALL TO REMAIN IN PLACE

N

SCALE
1"=60'

REVISED ALTERNATIVE 3

REVISED DESIGN:

1. 2,352.01' LONG CENTERLINE SHIFTED 6' SOUTH (FROM STA 1120+06.44 TO 1143+58.35)
2. 4' WIDE INSIDE SHOULDERS FOR NB AND SB I-405 (FROM STA 1120+06.44 TO 1130+94.44)
3. WESTERLY 100' OF 405/22 MEDIAN BARRIER SHIFTED 5' SOUTH WITH 5' INSIDE SHOULDER ON BOTH SIDES
4. EASTERLY REMAINING 500' OF 405/22 MEDIAN BARRIER ANGLED TO CONNECT TO EXISTING BARRIER WITH INSIDE SHOULDER TAPERING FROM 5' TO 10' WIDTH
5. TWO EXPRESS LANES (12' WIDE EACH) AS ORIGINALLY DESIGNED
6. SEVEN 12' WIDE REGULAR LANES AS ORIGINALLY DISIGNED
7. 10' WIDE OUTSIDE SHOULDER AS ORIGINALLY DESIGNED
8. EXISTING NORTH SIDE SOUND WALL TO REMAIN IN PLACE

N

SCALE
1"=60'

REVISED ALTERNATIVE 3

REVISED DESIGN:

1. 2,352.01' LONG CENTERLINE SHIFTED 6' SOUTH (FROM STA 1120+06.44 TO 1143+58.35)
2. 4' WIDE INSIDE SHOULDERS FOR NB AND SB I-405 (FROM STA 1120+06.44 TO 1130+94.44)
3. WESTERLY 100' OF 405/22 MEDIAN BARRIER SHIFTED 5' SOUTH WITH 5' INSIDE SHOULDER ON BOTH SIDES
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5. TWO EXPRESS LANES (12' WIDE EACH) AS ORIGINALLY DESIGNED
6. SEVEN 12' WIDE REGULAR LANES AS ORIGINALLY DISIGNED
7. 10' WIDE OUTSIDE SHOULDER AS ORIGINALLY DESIGNED
8. EXISTING NORTH SIDE SOUND WALL TO REMAIN IN PLACE

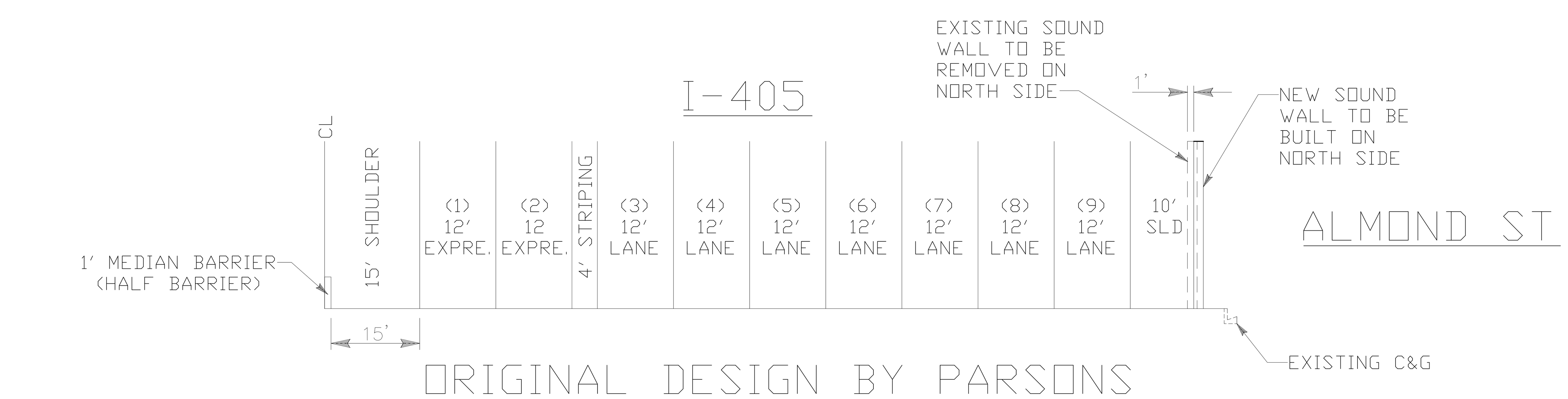
N

SCALE
1"=60'

4

REVISED ALTERNATIVE 3

ALTERNATIVE 3



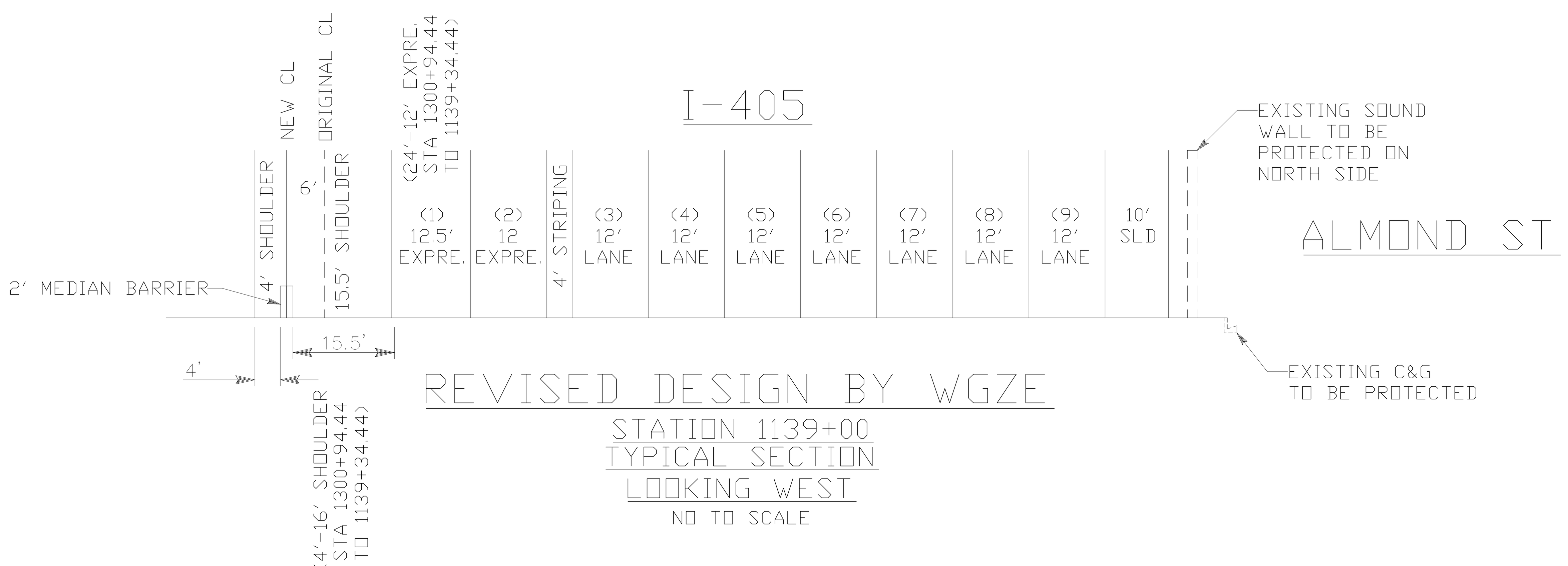
ORIGINAL DESIGN BY PARSONS

STATION 1139+00

TYPICAL SECTION

LOOKING WEST

NO TO SCALE



REVISED DESIGN BY WGZE

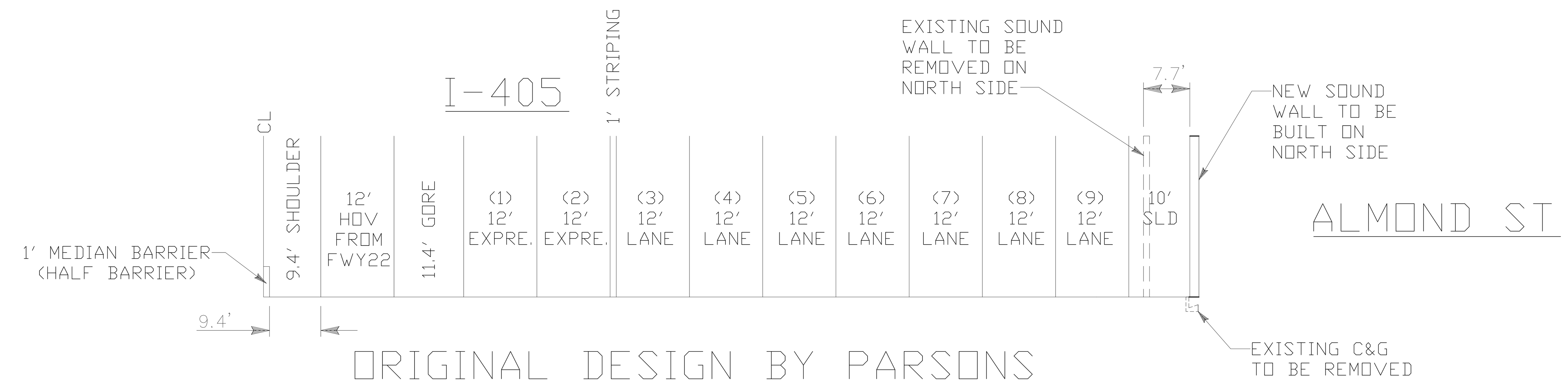
STATION 1139+00

TYPICAL SECTION

LOOKING WEST

NO TO SCALE

ALTERNATIVE 3



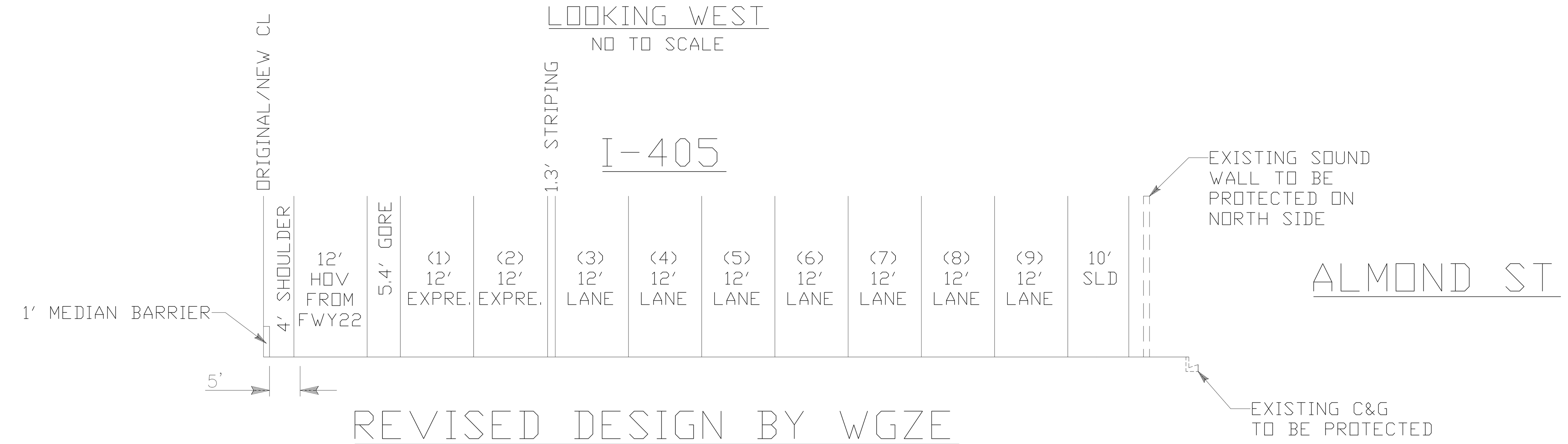
ORIGINAL DESIGN BY PARSONS

STATION 1115+86.55

TYPICAL SECTION

LOOKING WEST

NO TO SCALE



REVISED DESIGN BY WGZE

STATION 1115+86.55

TYPICAL SECTION

LOOKING WEST

NO TO SCALE

5

REVISED ALTERNATIVE 3

Attachment B

Council on Environmental Quality
Appropriate Use of Mitigation and Monitoring and Clarifying the
Appropriate Use of Mitigated Findings of No Significant Impact
January 14, 2011

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EXECUTIVE OFFICE OF THE PRESIDENT
COUNCIL ON ENVIRONMENTAL QUALITY
WASHINGTON, D.C. 20503

January 14, 2011

MEMORANDUM FOR HEADS OF FEDERAL DEPARTMENTS AND AGENCIES

FROM: NANCY H. SUTLEY
Chair

SUBJECT: Appropriate Use of Mitigation and Monitoring and Clarifying the Appropriate Use of Mitigated Findings of No Significant Impact

The Council on Environmental Quality (CEQ) is issuing this guidance for Federal departments and agencies on establishing, implementing, and monitoring mitigation commitments identified and analyzed in Environmental Assessments, Environmental Impact Statements, and adopted in the final decision documents. This guidance also clarifies the appropriate use of mitigated "Findings of No Significant Impact" under the National Environmental Policy Act (NEPA). This guidance is issued in accordance with NEPA, 42 U.S.C. § 4321 et seq., and the CEQ Regulations for Implementing the Procedural Provisions of NEPA (CEQ Regulations), 40 CFR Parts 1500-1508.[1] The guidance explains the requirements of NEPA and the CEQ Regulations, describes CEQ policies, and recommends procedures for agencies to use to help them comply with the requirements of NEPA and the CEQ Regulations when they establish mitigation planning and implementation procedures.[2]

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[1] The Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act (CEQ Regulations) are available on www.nepa.gov at ceq.hss.doe.gov/ceq_regulations/regulations.html.

[2] CEQ is issuing this guidance as an exercise of its duties and functions under section 204 of the National Environmental Policy Act (NEPA), 42 U.S.C. § 4344, and Executive Order No. 11,514, 35 Fed. Reg. 4,247 (Mar. 5, 1970), as amended by Executive Order No. 11,991, 42 Fed. Reg. 26,927 (May 24, 1977). This guidance is not a rule or regulation, and the recommendations it contains may not apply to a particular situation based upon the individual facts and circumstances. This guidance does not change or substitute for any law, regulation, or other legally binding requirement and is not legally enforceable. The use of language such as "recommend," "may," "should," and "can" is intended to describe CEQ policies and recommendations. The use of mandatory terminology such as "must" and "required" is intended to describe controlling requirements under the terms of NEPA and the CEQ Regulations, but this document does not independently establish legally binding requirements.

NEPA was enacted to promote efforts that will prevent or eliminate damage to the human environment.[3] Mitigation measures can help to accomplish this goal in several ways. Many Federal agencies and applicants include mitigation measures as integral components of a proposed project's design. Agencies also consider mitigation measures as alternatives when developing Environmental Assessments (EA) and Environmental Impact Statements (EIS). In addition, agencies have increasingly considered mitigation measures in EAs to avoid or lessen potentially significant environmental effects of proposed actions that would otherwise need to be analyzed in an EIS.[4] This use of mitigation may allow the agency to comply with NEPA's procedural requirements by issuing an EA and a Finding of No Significant Impact (FONSI), or "mitigated FONSI," based on the agency's commitment to ensure the mitigation that supports the FONSI is performed, thereby avoiding the need to prepare an EIS.

This guidance addresses mitigation that an agency has committed to implement as part of a project design and mitigation commitments informed by the NEPA review process. As discussed in detail in Section I, below, agencies may commit to mitigation measures considered as alternatives in an EA or EIS so as to achieve an environmentally preferable outcome. Agencies may also commit to mitigation measures to support a mitigated FONSI, so as to complete their review of potentially significant environmental impacts without preparing an EIS. When agencies do not document and, in important cases, monitor mitigation commitments to determine if the mitigation was implemented or effective, the use of mitigation may fail to advance NEPA's purpose of ensuring informed and transparent environmental decisionmaking. Failure to document and monitor mitigation may also undermine the integrity of the NEPA review. These concerns and the need for guidance on this subject have long been recognized.[5] While

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[3] 42 U.S.C. § 4321 (stating that the purposes of NEPA include promoting efforts which will prevent or eliminate damage to the environment).

[4] This trend was noted in CEQ's Twenty-Fifth Anniversary report on the effectiveness of NEPA implementation. *See* CEQ, "NEPA: A Study of its Effectiveness After Twenty-Five Years" 20 (1997), *available at* ceq.hss.doe.gov/nepa/nepa25fn.pdf.

[5] *See, e.g.*, CEQ, 1987-1988 Annual Report, *available at* www.slideshare.net/whitehouse/august-1987-1988-the-eighteenth-annual-report-of-the-council-on-environmental-quality (stating that CEQ would issue guidance on the propriety of an Environmental Assessment (EA) and Finding of No Significant Impact (FONSI) rather than requiring an Environmental Impact Statement (EIS) when the environmental effects of a proposal are significant but mitigation reduces those impacts to less than significant levels). In 2002, CEQ convened a Task Force on Modernizing NEPA Implementation, which recommended that CEQ issue guidance clarifying the requirements for public involvement, alternatives, and mitigation for actions that warrant longer EAs including those with mitigated FONSIs. CEQ NEPA Task Force, "Modernizing NEPA Implementation" 75 (2003), *available at* ceq.hss.doe.gov/ntf/report/totaldoc.html. NEPA experts and public stakeholders have expressed broad support for this recommendation, calling for consideration of monitoring and public involvement in the use of mitigated FONSIs. CEQ, "The Public and Experts'

this guidance is designed to address these concerns, CEQ also acknowledges that NEPA itself does not create a general substantive duty on Federal agencies to mitigate adverse environmental effects.[6]

Accordingly, in conjunction with the 40th Anniversary of NEPA, CEQ announced that it would issue this guidance to clarify the appropriateness of mitigated FONSIs and the importance of monitoring environmental mitigation commitments.[7] This new guidance affirms CEQ's support for the appropriate use of mitigated FONSIs, and accordingly amends and supplements previously issued guidance.[8] This guidance is intended to enhance the integrity and credibility of the NEPA process and the information upon which it relies.

CEQ provides several broad recommendations in Section II, below, to help improve agency consideration of mitigation in EISs and EAs. Agencies should not commit to mitigation measures considered in an EIS or EA absent the authority or expectation of resources to ensure that the mitigation is performed. In the decision documents concluding their environmental reviews, agencies should clearly identify any mitigation measures adopted as agency commitments or otherwise relied upon (to the extent consistent with agency authority or other legal authority), so as to ensure the integrity of the NEPA process and allow for greater transparency.

Review of the National Environmental Policy Act Task Force Report 'Modernizing NEPA Implementation'" 7 (2004), *available at* ceq.hss.doe.gov/ntf/CEQ_Draft_Final_Roundtable_Report.pdf; *see also* CEQ, "Rocky Mountain Roundtable Report" 8 (2004), *available at* ceq.hss.doe.gov/ntf/RockyMtnRoundTableReport.pdf (noting that participants in a regional roundtable on NEPA modernization identified "developing a means to enforce agency commitments to monitoring and mitigation" as one of the top five aspects of NEPA implementation needing immediate attention); "Eastern Round Table Report" 4 (2003), *available at* ceq.hss.doe.gov/ntf/EasternRoundTableReport.pdf (reporting that, according to several panelists at a regional roundtable, "parties responsible for monitoring the effects of . . . mitigation measures are rarely identified or easily held accountable," and that a lack of monitoring impedes agencies' ability to address the cumulative effects of EA actions).

6 *Robertson v. Methow Valley Citizens Council*, 490 U.S. 332, 352 (1989).

7 CEQ, "New Proposed NEPA Guidance and Steps to Modernize and Reinvigorate NEPA" (Feb. 18, 2010), *available at* www.whitehouse.gov/administration/eop/ceq/initiatives/nepa.

8 This previous guidance is found in CEQ, "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations," 46 Fed. Reg. 18,026 (Mar. 23, 1981), *available at* ceq.eh.doe.gov/nepa/regs/40/40P1.htm (suggesting that the existence of mitigation measures developed during the scoping or EA stages "does not obviate the need for an EIS").

Section III emphasizes that agencies should establish implementation plans based on the importance of the project and its projected effects. Agencies should create new, or strengthen existing, monitoring to ensure that mitigation commitments are implemented. Agencies should also use effectiveness monitoring to learn if the mitigation is providing the benefits predicted. Importantly, agencies should encourage public participation and accountability through proactive disclosure of, and provision of access to, agencies' mitigation commitments as well as mitigation monitoring reports and related documents.

Although the recommendations in this guidance are broad in nature, agencies should establish, in their NEPA implementing procedures and/or guidance, specific procedures that create systematic accountability and the mechanisms to accomplish these goals.[9] This guidance is intended to assist agencies with the development and review of their NEPA procedures, by specifically recommending:

- How to ensure that mitigation commitments are implemented;
- How to monitor the effectiveness of mitigation commitments;
- How to remedy failed mitigation; and
- How to involve the public in mitigation planning.

Finally, to assist agencies in the development of their NEPA implementing procedures, an overview of relevant portions of the Department of the Army NEPA regulations is appended to this guidance as an example for agencies to consider when incorporating the recommendations of this guidance as requirements in their NEPA programs and procedures.[10]

I. THE IMPORTANCE OF MITIGATION UNDER NEPA

Mitigation is an important mechanism Federal agencies can use to minimize the potential adverse environmental impacts associated with their actions. As described in the CEQ Regulations, agencies can use mitigation to reduce environmental impacts in several ways. Mitigation includes:

- Avoiding an impact by not taking a certain action or parts of an action;
- Minimizing an impact by limiting the degree or magnitude of the action and its implementation;
- Rectifying an impact by repairing, rehabilitating, or restoring the affected environment;
- Reducing or eliminating an impact over time, through preservation and maintenance operations during the life of the action; and

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[9] 40 CFR § 1507.3 (requiring agencies to issue, and continually review, policies and procedures to implement NEPA in conformity with NEPA and CEQ Regulations).

[10] *See id.*; *see also id.* § 1507.2 (requiring agencies to have personnel and other resources available to implement NEPA reviews and meet their NEPA responsibilities).

- Compensating for an impact by replacing or providing substitute resources or environments.[11]

Federal agencies typically develop mitigation as a component of a proposed action, or as a measure considered in the course of the NEPA review conducted to support agency decisionmaking processes, or both. In developing mitigation, agencies necessarily and appropriately rely upon the expertise and experience of their professional staff to assess mitigation needs, develop mitigation plans, and oversee mitigation implementation. Agencies may also rely on outside resources and experts for information about the ecosystem functions and values to be protected or restored by mitigation, to ensure that mitigation has the desired effects and to develop appropriate monitoring strategies. Any outside parties consulted should be neutral parties without a financial interest in implementing the mitigation and monitoring plans, and should have expert knowledge, training, and experience relevant to the resources potentially affected by the actions and—if possible—the potential effects from similar actions.[12] Further, when agencies delegate responsibility for preparing NEPA analyses and documentation, or when other entities (such as applicants) assume such responsibility, CEQ recommends that any experts employed to develop mitigation and monitoring should have the kind of expert knowledge, training, and experience described above.

The sections below clarify practices Federal agencies should use when they employ mitigation in three different contexts: as components of project design; as mitigation alternatives considered in an EA or an EIS and adopted in related decision documents; and as measures identified and committed to in an EA as necessary to support a mitigated FONSI. CEQ encourages agencies to commit to mitigation to achieve environmentally preferred outcomes, particularly when addressing unavoidable adverse environmental impacts. Agencies should not commit to mitigation, however, unless they have sufficient legal authorities and expect there will be necessary resources available to perform or ensure the performance of the mitigation. The agency's own underlying authority may provide the basis for its commitment to implement and monitor the mitigation. Alternatively, the authority for the mitigation may derive from legal requirements that are enforced by other Federal, state, or local government entities (e.g., air or water permits administered by local or state agencies).

A. Mitigation Incorporated into Project Design

Many Federal agencies rely on mitigation to reduce adverse environmental impacts as part of the planning process for a project, incorporating mitigation as integral components of a proposed project design before making a determination about the

[11] *Id.* § 1508.20 (defining mitigation to include these activities).

[12] *See id.* § 1506.5 (providing that agencies are responsible for the accuracy of environmental information submitted by applicants for use in EISs and EAs, and requiring contractors selected to prepare EISs to execute disclosure statement specifying that they have no financial or other interest in the outcome of the project).

significance of the project's environmental impacts.[13] Such mitigation can lead to an environmentally preferred outcome and in some cases reduce the projected impacts of agency actions to below a threshold of significance. An example of mitigation measures that are typically included as part of the proposed action are agency standardized best management practices such as those developed to prevent storm water runoff or fugitive dust emissions at a construction site.

Mitigation measures included in the project design are integral components of the proposed action, are implemented with the proposed action, and therefore should be clearly described as part of the proposed action that the agency will perform or require to be performed. Consequently, the agency can address mitigation early in the decisionmaking process and potentially conduct a less extensive level of NEPA review.

B. Mitigation Alternatives Considered in Environmental Assessments and Environmental Impact Statements

Agencies are required, under NEPA, to study, develop, and describe appropriate alternatives when preparing EAs and EISs.[14] The CEQ Regulations specifically identify procedures agencies must follow when developing and considering mitigation alternatives when preparing an EIS. When an agency prepares an EIS, it must include mitigation measures (not already included in the proposed action or alternatives) among the alternatives compared in the EIS.[15] Each EIS must contain a section analyzing the environmental consequences of the proposed action and its alternatives, including "[m]eans to mitigate adverse environmental impacts."[16]

When a Federal agency identifies a mitigation alternative in an EA or an EIS, it may commit to implement that mitigation to achieve an environmentally-preferable outcome. Agencies should not commit to mitigation measures considered and analyzed in an EIS or EA if there are insufficient legal authorities, or it is not reasonable to foresee the availability of sufficient resources, to perform or ensure the performance of the mitigation. Furthermore, the decision document following the EA should—and a Record of Decision (ROD) must—identify those mitigation measures that the agency is adopting

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[13] CEQ NEPA Task Force, "Modernizing NEPA Implementation" at 69.

[14] 42 U.S.C. § 4332(2)(C) (mandating that agencies' detailed statements must include alternatives to the proposed action); *id.* § 4332(E) (requiring agencies to study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources).

[15] 40 CFR § 1502.14(f) (listing mitigation measures as one of the required components of the alternatives included in an EIS); *id.* § 1508.25(b)(3) (defining the "scope" of an EIS to include mitigation measures).

[16] *Id.* § 1502.16(h).

and committing to implement, including any monitoring and enforcement program applicable to such mitigation commitments.[17]

C. Mitigation Commitments Analyzed in Environmental Assessments to Support a Mitigated FONSI

When preparing an EA, many agencies develop and consider committing to mitigation measures to avoid, minimize, rectify, reduce, or compensate for potentially significant adverse environmental impacts that would otherwise require full review in an EIS. CEQ recognizes the appropriateness, value, and efficacy of providing for mitigation to reduce the significance of environmental impacts. Consequently, when such mitigation measures are available and an agency commits to perform or ensure the performance of them, then these mitigation commitments can be used to support a FONSI, allowing the agency to conclude the NEPA process and proceed with its action without preparing an EIS.[18] An agency should not commit to mitigation measures necessary for a mitigated FONSI if there are insufficient legal authorities, or it is not reasonable to foresee the availability of sufficient resources, to perform or ensure the performance of the mitigation.[19]

Mitigation commitments needed to lower the level of impacts so that they are not significant should be clearly described in the mitigated FONSI document and in any other relevant decision documents related to the proposed action. Agencies must provide for appropriate public involvement during the development of the EA and FONSI.[20]

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[17] *Id.* § 1505.2(c) (providing that a record of decision must state whether all practicable means to avoid or minimize environmental harm from the alternative selected have been adopted, and if not, why they were not; and providing that a monitoring and enforcement program must be adopted and summarized where applicable for any mitigation).

[18] This guidance approves of the use of the "mitigated FONSI" when the NEPA process results in *enforceable* mitigation measures. It thereby amends and supplements previously issued CEQ guidance that suggested that the existence of mitigation measures developed during the scoping or EA stages "does not obviate the need for an EIS." *See* CEQ, "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations," 46 Fed. Reg. 18,026 (Mar. 23, 1981), *available at* ceq.eh.doe.gov/nepa/regs/40/40P1.htm.

[19] When agencies consider and decide on an alternative outside their jurisdiction (as discussed in 40 CFR § 1502.14(c)), they should identify the authority for the mitigation and consider the consequences of it not being implemented.

[20] 40 CFR § 1501.4(b) (requiring agencies to involve environmental agencies, applicants, and the public, to the extent practicable); *id.* § 1501.4(e)(1) (requiring agencies to make FONSIs available to the affected public as specified in § 1506.6); *id.* § 1501.4(e)(2) (requiring agencies to make FONSIs available for public review for thirty days before making any final determination on whether to prepare an EIS or proceed with an action when the proposed action is, or is closely similar to, one which normally requires the

Furthermore, in addition to those situations where a 30-day public review of the FONSI is required,[21] agencies should make the EA and FONSI available to the public (e.g., by posting them on an agency website). Providing the public with clear information about agencies' mitigation commitments helps ensure the value and integrity of the NEPA process.

II. ENSURING THAT MITIGATION COMMITMENTS ARE IMPLEMENTED

Federal agencies should take steps to ensure that mitigation commitments are actually implemented. Consistent with their authority, agencies should establish internal processes to ensure that mitigation commitments made on the basis of any NEPA analysis are carefully documented and that relevant funding, permitting, or other agency approvals and decisions are made conditional on performance of mitigation commitments.

Agency NEPA implementing procedures should require clear documentation of mitigation commitments considered in EAs and EISs prepared during the NEPA process and adopted in their decision documents. Agencies should ensure that the expertise and professional judgment applied in determining the appropriate mitigation commitments are described in the EA or EIS, and that the NEPA analysis considers when and how those mitigation commitments will be implemented.

Agencies should clearly identify commitments to mitigation measures designed to achieve environmentally preferable outcomes in their decision documents. They should also identify mitigation commitments necessary to reduce impacts, where appropriate, to a level necessary for a mitigated FONSI. In both cases, mitigation commitments should be carefully specified in terms of measurable performance standards or expected results, so as to establish clear performance expectations.[22] The agency should also specify the

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preparation of an EIS under agency NEPA implementing procedures, or when the nature of the proposed action is one without precedent); *id.* § 1506.6 (requiring agencies to make diligent efforts to involve the public in preparing and implementing their NEPA procedures).

[21] *Id.* § 1501.4(e)(2).

[22] In 2001, the Committee on Mitigating Wetland Losses, through the National Research Council (NRC), conducted a nationwide study evaluating compensatory mitigation, focusing on whether the process is achieving the overall goal of "restoring and maintaining the quality of the nation's waters." NRC Committee on Mitigating Wetland Losses, "Compensating for Wetland Losses Under the Clean Water Act" 2 (2001). The study's recommendations were incorporated into the 2008 Final Compensatory Mitigation Rule promulgated jointly by the U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency. *See* U.S. Army Corps of Engineers & U.S. Environmental Protection Agency, "Compensatory Mitigation for Losses of Aquatic Resources," 73 Fed. Reg. 19,594 (Apr. 10, 2008).

timeframe for the agency action and the mitigation measures in its decision documents, to ensure that the intended start date and duration of the mitigation commitment is clear. When an agency funds, permits, or otherwise approves actions, it should also exercise its available authorities to ensure implementation of any mitigation commitments by including appropriate conditions on the relevant grants, permits, or approvals.

CEQ views funding for implementation of mitigation commitments as critical to ensuring informed decisionmaking. For mitigation commitments that agencies will implement directly, CEQ recognizes that it may not be possible to identify funds from future budgets; however, a commitment to seek funding is considered essential and if it is reasonably foreseeable that funding for implementation of mitigation may be unavailable at any time during the life of the project, the agency should disclose in the EA or EIS the possible lack of funding and assess the resultant environmental effects. If the agency has disclosed and assessed the lack of funding, then unless the mitigation is essential to a mitigated FONSI or necessary to comply with another legal requirement, the action could proceed. If the agency committing to implementing mitigation has not disclosed and assessed the lack of funding, and the necessary funding later becomes unavailable, then the agency should not move forward with the proposed action until funding becomes available or the lack of funding is appropriately assessed (*see* Section III, below).

A. Establishing a Mitigation Monitoring Program

Federal agencies must consider reasonably foreseeable future impacts and conditions in a constantly evolving environment. Decisionmakers will be better able to adapt to changing circumstances by creating a sound mitigation implementation plan and through ongoing monitoring of environmental impacts and their mitigation. Monitoring can improve the quality of overall agency decisionmaking by providing feedback on the effectiveness of mitigation techniques. A comprehensive approach to mitigation planning, implementation, and monitoring will therefore help agencies realize opportunities for reducing environmental impacts through mitigation, advancing the integrity of the entire NEPA process. These approaches also serve NEPA's goals of ensuring transparency and openness by making relevant and useful environmental information available to decisionmakers and the public.[23]

Adaptive management can help an agency take corrective action if mitigation commitments originally made in NEPA and decision documents fail to achieve projected environmental outcomes and there is remaining federal action. Agencies can, in their NEPA reviews, establish and analyze mitigation measures that are projected to result in the desired environmental outcomes, and can then identify those mitigation principles or measures that it would apply in the event the initial mitigation commitments are not implemented or effective. Such adaptive management techniques can be advantageous to both the environment and the agency's project goals.[24] Agencies can also, short of

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[23] 40 CFR § 1500.1(b).

[24] *See* CEQ NEPA Task Force, "Modernizing NEPA Implementation" at 44.

adaptive management, analyze specific mitigation alternatives that could take the place of mitigation commitments in the event the commitment is not implemented or effective.

Monitoring is fundamental for ensuring the implementation and effectiveness of mitigation commitments, meeting legal and permitting requirements, and identifying trends and possible means for improvement. Under NEPA, a Federal agency has a continuing duty to ensure that new information about the environmental impact of its proposed actions is taken into account, and that the NEPA review is supplemented when significant new circumstances or information arise that are relevant to environmental concerns and bear on the proposed action or its impacts.[25] For agency decisions based on an EIS, the CEQ Regulations explicitly require that "a monitoring and enforcement program shall be adopted . . . where applicable for any mitigation."[26] In addition, the CEQ Regulations state that agencies may "provide for monitoring to assure that their decisions are carried out and should do so in important cases."[27] Accordingly, an agency should also commit to mitigation monitoring in important cases when relying upon an EA and mitigated FONSI. Monitoring is essential in those important cases where the mitigation is necessary to support a FONSI and thus is part of the justification for the agency's determination not to prepare an EIS.

Agencies are expected to apply professional judgment and the rule of reason when identifying those cases that are important and warrant monitoring, and when determining the type and extent of monitoring they will use to check on the progress made in implementing mitigation commitments as well as their effectiveness. In cases that are less important, the agency should exercise its discretion to determine what level of monitoring, if any, is appropriate. The following are examples of factors that agencies should consider to determine importance:

- Legal requirements of statutes, regulations, or permits;
- Human health and safety;
- Protected resources (e.g., parklands, threatened or endangered species, cultural or historic sites) and the proposed action's impacts on them;
- Degree of public interest in the resource or public debate over the effects of the proposed action and any reasonable mitigation alternatives on the resource; and
- Level of intensity of projected impacts.

Once an agency determines that it will provide for monitoring in a particular case, monitoring plans and programs should be described or incorporated by reference in the

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[25] 40 CFR § 1502.9(c) (requiring supplementation of EISs when there are substantial changes to the proposed action, or significant new information or circumstances arise that are relevant to the environmental effects of the proposed action).

[26] *Id.* § 1505.2(c).

[27] *Id.* § 1505.3.

agency's decision documents.[28] Agencies have discretion, within the scope of their authority, to select an appropriate form and method for monitoring, but they should identify the monitoring area and establish the appropriate monitoring system.[29] The form and method of monitoring can be informed by an agency's past monitoring plans and programs that tracked impacts on similar resources, as well as plans and programs used by other agencies or entities, particularly those with an interest in the resource being monitored. For mitigation commitments that warrant rigorous oversight, an Environmental Management System (EMS), or other data or management system could serve as a useful way to integrate monitoring efforts effectively.[30] Other possible monitoring methods include agency-specific environmental monitoring, compliance assessment, and auditing systems. For activities involving third parties (e.g., permittees or grantees), it may be appropriate to require the third party to perform the monitoring as long as a clear accountability and oversight framework is established. The monitoring program should be implemented together with a review process and a system for reporting results.

Regardless of the method chosen, agencies should ensure that the monitoring program tracks whether mitigation commitments are being performed as described in the NEPA and related decision documents (i.e., implementation monitoring), and whether the mitigation effort is producing the expected outcomes and resulting environmental effects (i.e., effectiveness monitoring). Agencies should also ensure that their mitigation monitoring procedures appropriately provide for public involvement. These recommendations are explained in more detail below.

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[28] The mitigation plan and program should be described to the extent possible based on available and reasonably foreseeable information in cases where the NEPA analysis and documentation are completed prior to final design of a proposed project.

[29] The Department of the Army regulations provide an example of this approach. *See* 32 CFR part 651 App. C. These regulations are summarized in the Appendix to this guidance.

[30] An EMS provides a systematic framework for a Federal agency to monitor and continually improve its environmental performance through audits, evaluations of legal and other requirements, and management reviews. The potential for EMS to support NEPA work is further addressed in CEQ, "Aligning National Environmental Policy Act Processes with Environmental Management Systems" 4 (2007) *available at* ceq.hss.doe.gov/nepa/nepapubs/Aligning_NEPA_Processes_with_Environmental_Management_Systems_2007.pdf (discussing the use of EMSs to track implementation and monitoring of mitigation). In 2001, the Department of the Army announced that it would implement a recognized environmental management standard, ISO 14001, across Army installations. ISO 14001 represents a standardized system to plan, track, and monitor environmental performance within the agency's operations. To learn more about how EMS implementation has resulted in an effective EMS for monitoring purposes at an Army installation, see the Sustainability website for the Army's Fort Lewis installation, *available at* sustainablefortlewis.army.mil.

B. Monitoring Mitigation Implementation

A successful monitoring program will track the implementation of mitigation commitments to determine whether they are being performed as described in the NEPA documents and related decision documents. The responsibility for developing an implementation monitoring program depends in large part upon who will actually perform the mitigation—the lead Federal agency or cooperating agency; the applicant, grantee, or permit holder; another responsible entity or cooperative non-Federal partner; or a combination of these. The lead agency should ensure that information about responsible parties, mitigation requirements, as well as any appropriate enforcement clauses are included in documents such as authorizations, agreements, permits, financial assistance awards, or contracts.[31] Ultimate monitoring responsibility rests with the lead Federal agency or agencies to assure that monitoring is occurring when needed and that results are being properly considered. The project's lead agency can share monitoring responsibility with joint lead or cooperating agencies or other entities, such as applicants or grantees. The responsibility should be clearly described in the NEPA documents or associated decision documents, or related documents describing and establishing the monitoring requirements or expectations.

C. Monitoring the Effectiveness of Mitigation

Effectiveness monitoring tracks the success of a mitigation effort in achieving expected outcomes and environmental effects. Completing environmental data collection and analyses prior to project implementation provides an understanding of the baseline conditions for each potentially affected resource for reference when determining whether the predicted efficacy of mitigation commitments is being achieved. Agencies can rely on agency staff and outside experts familiar with the predicted environmental impacts to develop the means to monitor mitigation effectiveness, in the same way that they can rely on agency and outside experts to develop and evaluate the effectiveness of mitigation (*see* Section I, above).

When monitoring mitigation, agencies should consider drawing on sources of information available from the agency, from other Federal agencies, and from state, local, and tribal agencies, as well as from non-governmental sources such as local organizations, academic institutions, and non-governmental organizations. Agencies should especially consider working with agencies responsible for overseeing land management and impacts to specific resources. For example, agencies could consult with the U.S. Fish and Wildlife and National Marine Fisheries Services (for information to evaluate potential impacts to threatened and endangered species) and with State Historic Preservation Officers (for information to evaluate potential impacts to historic structures).

[31] Such enforcement clauses, including appropriate penalty clauses, should be developed as allowable under the applicable statutory and regulatory authorities.

D. The Role of the Public

Public involvement is a key procedural requirement of the NEPA review process, and should be fully provided for in the development of mitigation and monitoring procedures.[32] Agencies are also encouraged, as a matter of transparency and accountability, to consider including public involvement components in their mitigation monitoring programs. The agencies' experience and professional judgment are key to determining the appropriate level of public involvement. In addition to advancing accountability and transparency, public involvement may provide insight or perspective for improving mitigation activities and monitoring. The public may also assist with actual monitoring through public-private partnership programs.

Agencies should provide for public access to mitigation monitoring information consistent with NEPA and the Freedom of Information Act (FOIA).[33] NEPA and the CEQ Regulations incorporate the FOIA by reference to require agencies to provide public access to releasable documents related to EISs, which may include documents regarding mitigation monitoring and enforcement.[34] The CEQ Regulations also require agencies to involve the public in the EA preparation process to the extent practicable and in certain cases to make a FONSI available for public review before making its final determination on whether it will prepare an EIS or proceed with the action.[35] Consequently, agencies should involve the public when preparing EAs and mitigated FONSIs.[36] NEPA further requires all Federal agencies to make information useful for restoring, maintaining, and

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[32] 40 CFR § 1506.6 (requiring agencies to make diligent efforts to involve the public in preparing and implementing their NEPA procedures).

[33] 5 U.S.C. § 552.

[34] 42 U.S.C. § 4332(2)(C) (requiring Federal agencies to make EISs available to the public as provided by the FOIA); 40 CFR § 1506.6(f) (requiring agencies to make EISs, comments received, and any underlying documents available to the public pursuant to the provisions of the FOIA without regard to the exclusion for interagency memoranda where such memoranda transmit comments of Federal agencies on the environmental impact of the proposed action).

[35] 40 CFR § 1501.4(b) (requiring agencies to involve environmental agencies, applicants, and the public, to the extent practicable); *id.* § 1501.4(e)(1) (requiring agencies to make FONSIs available to the affected public as specified in § 1506.6); *id.* § 1501.4(e)(2) (requiring agencies to make a FONSI available for public review for thirty days before making its final determination on whether it will prepare an EIS or proceed with the action when the nature of the proposed action is, or is similar to, an action which normally requires the preparation of an EIS); *id.* § 1506.6 (requiring agencies to make diligent efforts to involve the public in preparing and implementing their NEPA procedures).

[36] *Id.* § 1501.4.

enhancing the quality of the environment available to States, counties, municipalities, institutions, and individuals.[37] This requirement can include information on mitigation and mitigation monitoring.

Beyond these requirements, agencies are encouraged to make proactive, discretionary release of mitigation monitoring reports and other supporting documents, and to make responses to public inquiries regarding mitigation monitoring readily available to the public through online or print media. This recommendation is consistent with the President's Memorandum on Transparency and Open Government directing agencies to take affirmative steps to make information public without waiting for specific requests for information.[38] The Open Government Directive, issued by the Office of Management and Budget in accordance with the President's Memorandum, further directs agencies to use their web sites and information technology capabilities to disseminate, to the maximum extent practicable, useful information under FOIA, so as to promote transparency and accountability.[39]

Agencies should exercise their judgment to ensure that the methods and media used to provide mitigation and monitoring information are commensurate with the importance of the action and the resources at issue, taking into account any risks of harm to affected resources. In some cases, agencies may need to balance competing privacy or confidentiality concerns (e.g., protecting confidential business information or the location of sacred sites) with the benefits of public disclosure.

III. REMEDYING INEFFECTIVE OR NON-IMPLEMENTED MITIGATION

Through careful monitoring, agencies may discover that mitigation commitments have not been implemented, or have not had the environmental results predicted in the NEPA and decision documents. Agencies, having committed to mitigation, should work to remedy such inadequacies. It is an agency's underlying authority or other legal authority that provides the basis for the commitment to implement mitigation and monitor its effectiveness. As discussed in Section I, agencies should not commit to mitigation considered in an EIS or EA unless there are sufficient legal authorities and they expect the resources to be available to perform or ensure the performance of the mitigation. In some cases, as discussed in Section II, agencies may exercise their authority to make

[37] 42 U.S.C. § 4332(2)(G).

[38] Presidential Memorandum for Heads of Executive Departments and Agencies Concerning the Freedom of Information Act, 74 Fed. Reg. 4,683 (Jan. 21, 2009); *accord* DOJ, "Memorandum for Heads of Executive Departments and Agencies Concerning the Freedom of Information Act" (Mar. 19, 2009), *available at* www.usdoj.gov/ag/foia-memo-march2009.pdf.

[39] Office of Mgmt. & Budget, Executive Office of the President, "Open Government Directive" (Dec. 8, 2009), *available at* www.whitehouse.gov/open/documents/open-government-directive.

relevant funding, permitting, or other agency approvals and decisions conditional on the performance of mitigation commitments by third parties. It follows that an agency must rely on its underlying authority and available resources to take remedial steps. Agencies should consider taking remedial steps as long as there remains a pending Federal decision regarding the project or proposed action. Agencies may also exercise their legal authority to enforce conditions placed on funding, grants, permits, or other approvals.

If a mitigation commitment is simply not undertaken or fails to mitigate the environmental effects as predicted, the responsible agency should further consider whether it is necessary to prepare supplemental NEPA analysis and documentation.[40] The agency determination would be based upon its expertise and judgment regarding environmental consequences. Much will depend upon the agency's determination as to what, if any, portions of the Federal action remain and what opportunities remain to address the effects of the mitigation failure. In cases where an EIS or a supplementary EA or EIS is required, the agency must avoid actions that would have adverse environmental impacts and limit its choice of reasonable alternatives during the preparation of an EIS.[41]

In cases where there is no remaining agency action to be taken, and the mitigation has not been fully implemented or has not been as effective as predicted, it may not be appropriate to supplement the original NEPA analysis and documentation. However, it would be appropriate for future NEPA analyses of similar proposed actions and relevant programs to consider past experience and address the potential for environmental consequences as a result of mitigation failure. This would ensure that the assumed environmental baselines reflect true conditions, and that similar mitigation is not relied on in subsequent decisions, at least without more robust provisions for adaptive management or analysis of mitigation alternatives that can be applied in the event of mitigation failure.

IV. CONCLUSION

This guidance is intended to assist Federal agencies with the development of their NEPA procedures, guidance, and regulations; foster the appropriate use of Findings of No Significant Impact; and ensure that mitigation commitments are appropriately and effectively documented, implemented, and monitored. The guidance also provides Federal agencies with recommended actions in circumstances where mitigation is not

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[40] 40 CFR § 1502.9(c) (requiring an agency to prepare supplements to draft or final EISs if the agency makes substantial changes in the proposed action that are relevant to environmental concerns, or if there are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts).

[41] *Id.* § 1506.1(a) (providing that until an agency issues a Record of Decision, no action concerning the proposal may be taken that would have an adverse environmental impact or limit the choice of reasonable alternatives).

implemented or fails to have the predicted effect. Questions regarding this guidance should be directed to the CEQ Associate Director for NEPA Oversight.

APPENDIX

Case Study: Existing Agency Mitigation Regulations & Guidance

A number of agencies have already taken actions to improve their use of mitigation and their monitoring of mitigation commitments undertaken as part of their NEPA processes. For example, the Department of the Army has promulgated regulations implementing NEPA for military installations and programs that include a monitoring and implementation component.[42] These NEPA implementing procedures are notable for their comprehensive approach to ensuring that mitigation proposed in the NEPA review process is completed and monitored for effectiveness. These procedures are described in detail below to illustrate one approach agencies can use to meet the goals of this Guidance.

a. *Mitigation Planning*

Consistent with existing CEQ guidelines, the Army's NEPA implementing regulations place significant emphasis on the planning and implementation of mitigation throughout the environmental analysis process. The first step of mitigation planning is to seek to avoid or minimize harm.[43] When the analysis proceeds to an EA or EIS, however, the Army regulation requires that any mitigation measures be "clearly assessed and those selected for implementation will be identified in the [FONSI] or the ROD," and that "[t]he proponent must implement those identified mitigations, because they are commitments made as part of the Army decision."[44] This is notable as this mitigation is a binding commitment documented in the agency NEPA decision. In addition, the adoption of mitigation that reduces environmental impacts below the NEPA significance threshold is similarly binding upon the agency.[45] When the mitigation results in a FONSI in a NEPA analysis, the mitigation is considered legally binding.[46] Because these regulations create a clear obligation for the agency to ensure any proposed mitigation adopted in the environmental review process is performed, there is assurance that mitigation will lead to a reduction of environmental impacts in the implementation stage and include binding mechanisms for enforcement.

Another important mechanism in the Army's regulations to assure effective mitigation results is the requirement to fully fund and implement adopted mitigation. It is acknowledged in the regulations that "unless money is actually budgeted and manpower

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[42] The Department of the Army promulgated its NEPA implementing procedures as a regulation.

[43] *See* 40 CFR § 1508.2.

[44] 32 CFR § 651.15(b).

[45] *Id.* § 651.35(g)

[46] *Id.* § 651.15(c).

assigned, the mitigation does not exist."[47] As a result, a proposed action cannot proceed until all adopted mitigation is fully resourced or until the lack of funding is addressed in the NEPA analysis.[48] This is an important step in the planning process, as mitigation benefits are unlikely to be realized unless financial and planning resources are committed through the NEPA planning process.

b. *Mitigation Monitoring*

The Army regulations recognize that monitoring is an integral part of any mitigation system.[49] The Army regulations require monitoring plans and implementation programs to be summarized in NEPA documentation, and should consider several important factors. These factors include anticipated changes in environmental conditions or project activities, unexpected outcomes from mitigation, controversy over the selected alternative, potential impacts or adverse effects on federally or state protected resources, and statutory permitting requirements.[50] Consideration of these factors can help prioritize monitoring efforts and anticipate possible challenges.

The Army regulations distinguish between implementation monitoring and effectiveness monitoring. Implementation monitoring ensures that mitigation commitments made in NEPA documentation are implemented. To further this objective, the Army regulations specify that these conditions must be written into any contracts furthering the proposed action. In addition, the agency or unit proposing the action is ultimately responsible for the performance of the mitigation activities.[51] In a helpful appendix to its regulations, the Army outlines guidelines for the creation of an implementation monitoring program to address contract performance, the role of cooperating agencies, and the responsibilities of the lead agency.[52]

The Army's effectiveness monitoring addresses changing conditions inherent in evolving natural systems and the potential for unexpected environmental mitigation outcomes. For this monitoring effort, the Army utilizes its Environmental Management System (EMS) based on the standardized ISO 14001 protocols.[53] The core of this

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47 *Id.* § 651.15(d).

48 *Id.* § 651.15(d).

49 *Id.* § 651.15(i).

50 *Id.* §§ 651.15(h)(1)-(4) Appendix C to 32 CFR § 651, 67 Fed. Reg. 15,290, 15,326-28 (Mar. 29, 2002).

51 *Id.* § 651.15(i)(1).

52 *See* Appendix C to 32 CFR § 651, 67 Fed. Reg. 15,290, 15,326-28 (Mar. 29, 2002).

53 *See also* CEQ, "Aligning NEPA Processes with Environmental Management Systems" (2007), *available at*

program is the creation of a clear and accountable system for tracking and reporting both quantitative and qualitative measures of the mitigation efforts. An action-forcing response to mitigation failure is essential to the success of any mitigation program. In the context of a mitigated FONSI, the Army regulations provide that if any "identified mitigation measures do not occur, so that significant adverse environmental effects could be reasonably expected to result, the [agency actor] must publish a [Notice of Intent] and prepare an EIS."[54] This is an essential response measure to changed conditions in the proposed agency action. In addition, the Army regulations address potential failures in the mitigation systems indentified through monitoring. If mitigation is ineffective, the agency entity responsible should re-examine the mitigation and consider a different approach to mitigation. However, if mitigation is required to reduce environmental impacts below significance levels are found to be ineffective, the regulations contemplate the issuance of a Notice of Intent and preparation of an EIS.[55]

The Army regulations also provide guidance for the challenging task of defining parameters for effectiveness monitoring. Guidelines include identifying a source of expertise, using measurable and replicable technical parameters, conducting a baseline study before mitigation is commenced, using a control to isolate mitigation effects, and, importantly, providing timely results to allow the decision-maker to take corrective action if necessary.[56] In addition, the regulations call for the preparation of an environmental monitoring report to determine the accuracy of the mitigation impact predictions made in the NEPA planning process.[57] The report is essential for agency planning and documentation and promotes public engagement in the mitigation process.

c. *Public Engagement*

The Army regulations seek to integrate robust engagement of the interested public in the mitigation monitoring program. The regulations place responsibility on the entity proposing the action to respond to inquiries from the public and other agencies regarding the status of mitigation adopted in the NEPA process.[58] In addition, the regulations find that "concerned citizens are essential to the credibility of [the] review" of mitigation

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ceq.hss.doe.gov/nepa/nepapubs/Aligning_NEPA_Processes_with_Environmental_Management_Systems_2007.pdf.

[54] 32 CFR § 651.15(c).

[55] *See id.* § 651.35(g) (describing the implementation steps, including public availability and implementation tracking, that must be taken when a FONSI requires mitigation); *id.* § 651.15(k).

[56] *See* subsections (g)(1)-(5) of Appendix C to 32 CFR § 651, 67 Fed. Reg. at 15,327.

[57] 32 CFR § 651.15(l).

[58] *Id.* § 651.15(b).

effectiveness.[59] The Army specifies that outreach with the interested public regarding mitigation efforts is to be coordinated by the installation's Environmental Office.[60] These regulations bring the public a step closer to the process by designating an agency source responsible for enabling public participation, and by acknowledging the important role the public can play to ensure the integrity and tracking of the mitigation process. The success of agency mitigation efforts will be bolstered by public access to timely information on NEPA mitigation monitoring.

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[59] *Id.* § 651.15(k).

[60] 32 CFR § 651.15(j).

Attachment C

Cervero, Robert and Hansen, Mark
Induced Travel Demand and Induced Road Investment
A Simultaneous Equation Analysis
Journal of Transport Economics and Policy, Volume 36, Part 3
September 2002

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Journal of Transport Economics and Policy, Volume 36, Part 3, September 2002, pp. 469–490

Induced Travel Demand and Induced Road Investment

A Simultaneous Equation Analysis

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Abstract

This paper presents simultaneous models that predict induced travel demand and induced road investment using an array of instrument variables reflecting political, environmental, and demographic influences. From a panel data set consisting of 22 years of observations for 34 California urban counties, short-run elasticities are estimated. Both the Vehicle–Miles-Travelled model and the Lane–Miles model feature good statistical fits and highly significant parameter estimates. While the research found strong reciprocal relationships between road investment and travel demand, the elasticity estimates generated from simultaneous equation modelling were generally of a comparable magnitude to those of past single-equation studies.

Date of receipt of final manuscript: October 2001

Introduction

The subject of "induced travel" continues to spark interest within the transport research and practitioner communities. Although certain segments of these communities have long maintained that adding road capacity spurs additional traffic, in recent years a spate of papers has sought to quantify the effect and obtained results suggesting that induced effects are stronger than previously believed. Many of these papers employ regional (county or metropolitan level) pooled time-series data on vehicle-miles travelled (VMT), lane-miles of road, population, income, and other relevant variables to infer elasticities of VMT with respect to lane-miles. While a wide range of estimates has been obtained, the majority is in excess of 0.5, suggesting that the most added road capacity is "absorbed" by increases in traffic (Hansen and Huang, 1997; Fulton *et al.* 2000; Noland and Coward, 2000; Marshall, 2000). Other works, based on disparate research methods and drawn from international experiences, suggest an average value for the elasticity of traffic volume with respect to travel time of about −0.5 in the short term, and up to −1.0 in the long term (Goodwin, 1996; Bar, 2000). Such findings contrast with earlier work, summarised in Reuter *et al.* (1979), in which estimated lane-mile elasticities were of a much smaller magnitude: 0.01 to 0.15.

The more recent results are broadly consistent with the assertions, made several decades ago, of two noted transport policy analysts, Anthony Downs and Wilfred Owen. Downs (1962, 1992), argued that expanding congested freeways triggers a phenomenon he termed "triple convergence" in which drivers shift their routes, times of travel, and modes in order to exploit the new capacity, thereby generating similar levels of congestion (at least during peak periods) as before. Downs' interpretation led Owen to conclude (1985: 366): "Meeting the ever-growing needs for transport capacity has often proved to be a fruitless task, as the persistence in urban traffic jams attest." In the United States, the contention that "you can't build your way out of traffic congestion" has become the rallying cry of the Surface Transportation Policy Project (STPP). In a recent report based on 15 years of data across 70 US metropolitan areas, STPP (1999) concluded that regions that invested heavily in expanding road capacity fared no better in easing congestion than areas that did not.

Past empirical research has not always been clear on distinguishing "induced travel" from "induced demand" (United Kingdom Department of Transport, 1993; Lee *et al.*, 1999). Induced travel is the more inclusive term, reflecting all changes in trip-making that are unleashed by a road improvement: (1) newly generated trips (that is, latent demand); (2) longer journeys; (3) changes in modal splits; (4) route diversions; and (5) time-of-day shifts. Induced demand is more restrictive, encompassing only the first three of these components, thereby representing only newly added VMT within a region. Past studies have focused on gauging changes in all five components of travel change (that is, "induced travel"), even though this is not always explicitly stated. This is partly because, short of placing an electronic tag on each traveller affected by a new road and monitoring his or her travel, disentangling the many contributors to increased travel — at least to a high degree of precision — can be a futile exercise (Bonsall, 1996). One way to gauge newly generated traffic, or induced demand, is to focus on changes in VMT at a county or metropolitan level *versus* along a specific project corridor; this is because the bigger the geographic area of study, the more likely it is that any route diversions are internal to the unit of analysis.

In addition to these definitional concerns, past research has been criticised on a number of other grounds. Most studies have considered VMT and lane-miles on higher-level facilities; for example, state or provincial highways. This raises the question of whether increases in VMT found in these studies represent shifts from lower-level facilities, either as the result of improvements to the main roads or, more trivially, the redesignation of roads from one category to the other, or altogether "new" traffic (Cohen, 1995; DeCorla-Souza and Cohen, 1999). A second line of criticism questions the normative significance of research findings. Even if the elasticities obtained are essentially correct, some contend, lane-mile growth accounts for only a small fraction of VMT growth (DeCorla-Souza, 1998). Moreover, it is argued, induced travel may increase the benefits from road improvements since the extra VMT is presumably generating some additional surplus that may or may not offset congestion impacts (Small, 1992; Hansen, 1998; Lee *et al.*, 1999).

A third claim, and potentially the most far-reaching one, is that induced traffic models confuse, or conflate, cause and effect (Sen, 1999). The statistical relationship between road supply and traffic is not the result of a simple, one-way, causal link between the former and the latter, but rather a simultaneous relationship in which more traffic also spawns more roads. The transport planning and programming process is designed to anticipate and respond to changes in traffic. Thus, the correlation between road supply and traffic could reveal nothing more than that this process is working successfully. Likewise, the STPP findings that road expansion fails to relieve congestion could simply indicate that regions are failing to keep pace with the burgeoning demand for additional road capacity. Irrespective of a traffic inducement effect, road supply will generally correlate with road use. Sceptics can easily claim that all or most of the observed relationships between traffic and road investment derive from good planning rather than traffic inducement.

The implications of this last argument are clearly profound. If most or all of the correlation between traffic and road supply derives from the effect of the former on the latter, then questions of interpretation or normative implication become mute. And if the same set of facts can equally support either causal interpretation, then policy debates are reduced to ideological conflicts no more resolvable than the question of when human life begins. It is therefore important to see whether the causal linkages between road supply and traffic can be disentangled.

This paper attempts to accomplish this by estimating a simultaneous set of equations from a dataset containing 22 years of observations from California urban counties. In the next section, we review and critique past efforts to determine the direction of causality between road supply and traffic. This is followed by a presentation of our methodology, research results, and conclusions.

Previous Work

As noted, recent work on induced travel demand has featured single-equation models in which VMT is the dependent variable and lane-miles is included among a vector of independent variables. The models are generally in log-linear form so that coefficients represent elasticities. Various single-equation regression techniques are employed to allow both short-run and long-run elasticities of VMT with respect to lane-miles to be estimated. Some representative studies of this kind, based on US experiences, include: Hansen and Huang (1997), who obtained a short-run elasticity of 0.3 and a long-run elasticity of 0.9 for California metropolitan areas; Noland and Cowart (2000), who, using state-level data, found short-run elasticities in the 0.3 to 0.5 range and long-run elasticities of 0.7 to 1.0; and Fulton *et al.* (2000), who, based on county-level data drawn from the mid-Atlantic states, calculated short- and long-run elasticities of 0.1 to 0.4 and 0.5 to 0.8 respectively. Despite some agreement across these studies that elasticities are not inconsequential and generally increase over time, all estimates are based on single-equation regression models, raising the concern that the estimates are "consistently inconsistent" as a result of simultaneity bias.

Efforts to disentangle the simultaneous relationship between lane-miles and traffic have to date been limited. One approach has been to examine sequences and patterns of changes. Sen (1999) used this approach to show that in the Chicago metropolitan area, "major population gains occurred in proximity to the expressways over a decade before the construction of the respective expressways." Another approach, used by Fulton *et al.* (2000), has been to include both forward and backward lags to predict changes in VMT as a function of changes in lane-miles. The authors found that the backward lags were significant while the forward lags were not, implying that changes in lane-miles generally precede changes in VMT. However, as Fulton *et al.* (2000, p.16) acknowledge, "this is not quite evidence of causality, i.e. that increases in lane miles *cause* increases in VMT, since the results can be explained by 'efficient' planning that correctly anticipates future growth in VMT by building new capacity in advance." (Italics in original.)

A more rigorous approach is to estimate a simultaneous system of equations in which lane-miles and VMT are both treated as endogenous variables. To do this successfully, it is necessary to find exogenous variables that directly influence one endogenous variable but not the other. For example, if the costs of road construction varied significantly over time and across regions, we would expect this to affect road supply but not (directly) the demand for roads. In this case, the effect of road supply on traffic could be inferred from the statistical relationships between road supply and construction cost (termed an "instrument variable" in this context) and VMT and construction cost.

Accounting for endogeneity effects can be difficult due to a lack of suitable instrument variables. Even though construction cost is a logical candidate, the only readily available highway construction cost index in the US is a national one. While a number of other variables influence lane-miles, most that are easy to obtain are likely to directly affect VMT as well. As part of a single-equation regression analysis of induced demand across the US, Noland and Cowart (2000) use metropolitan land area and population density as instrument variables for lane-miles, but it is highly likely that both of these also have a direct impact on VMT since travel generally increases with the geographic size and use-intensity of land. The search for more appropriate instrument variables was a major focus of our study.

Research Methodology

A pooled time-series/cross-section of data on road supplies, demand, and various control variables was compiled for the state of California. California was chosen for empirically studying these endogeneity questions not only because the state department of transport (CalTrans) maintains rich and reliable time-series data, but also because the state provides a fairly good portrait of urban, suburban, and exurban settings for studying induced travel demand impacts.

The time period chosen for the analysis was 1976 to 1997, a period of rapid growth and change. The population of the state increased by 50 per cent over this 22-year period, from 22 to 33 million. Annual state highway lane-mile and VMT data for the state's 34 urbanised counties with central-city populations of 50,000 or more (as of 1990) were available from CalTrans. In total, then, 22 years of 34 cross-sectional observations, or 748 data points, were available for the analysis.

We turned to county-level data to carry out the analysis for several reasons. Compared to a project-level grain of analysis, county data better capture network effects of road expansions, such as the additional access and egress traffic on unimproved roads that connect to newly improved ones. Capturing area-wide effects is important since road improvements have spillover impacts that reverberate throughout a network. While metropolitan-level data offer an even larger geographic context for capturing spillover effects, it was felt that studying impacts at the regional level would overly dilute the analysis since many key metropolitan areas (such as greater Los Angeles or the San Francisco Bay Area) encompass large geographies. Thus, as a balance between municipal/corridor level data and metropolitan-wide data, counties provide a meso-scale, "middle ground" for capturing induced travel demand impacts. Also, by using county-level data, this and similar analyses are thought to capture "induced demand" (for example, newly generated traffic, longer trips, and modal shifts) since route diversions largely occur within the unit of analysis. Thus, the term "induced demand" is used to reflect the study's focus on newly added traffic, as reflected by increases in countywide VMT over time.

An econometric modelling framework was used to probe roadway supply-demand relationships in California. A two-way system of equations was simultaneously estimated, taking the form:

$$\textit{Demand Model: } D_{it} = f\,(S, P, A, I, L, F)_{it}$$
$$\textit{Supply Model: } S_{it} = g(D, A, L, G, F)_{it}$$

where: $D =$ Travel demand vector (vehicle miles travelled); $S =$ Roadway supply vector (lane miles of major road facilities); $P =$ Price vector (fuel price per gallon); $A =$ Population Attribute vector (population size; demographics); $I =$ Income-effects vector (per capita income levels); $L =$ Localised-effects vector (land-use densities; meteorological characteristics); $G =$ Governance and policy factors vector (state political party affiliations; air quality levels); $F =$ Fixed-effects vector (county-specific dummy variables to account for unique and idiosyncratic characteristics, such as the effects of an earthquake on travel demand and road building in a particular county at a particular time point); $i =$ County cross-section observation; and $t =$ Year time point.

In this formulation, travel demand (D) and road supply (S) are jointly related, and must be predicted as a function of pre-determined (exogenous and lagged-endogenous) variables using reduced-form instrumental-variable estimation to avoid simultaneous equation biases. Two-stage least squares (2SLS) estimation was used accordingly. This approach allowed both *induced demand* and *induced investment* effects to be simultaneously accounted for. To obtain more efficient estimates, a third stage of estimation was introduced that explicitly accounted for the cross-equation correlation of error terms as well as, unlike 2SLS, the presence of a right-hand side endogenous variable. Three-stage least square (3SLS) results are presented in this paper.

Because of institutional delays, various lagged structures were attempted in estimating the system of equations. Notably, roadway investments for any time point are thought to be largely determined by traffic volumes in prior years and future forecasts of traffic that are derived from those volumes. Because of the necessary time commitments to propose, evaluate, design, programme, and build new facilities, lags of up to five years were empirically investigated. This more or less corresponds to the typical time frames of Transport Improvements Programmes (TIPs). Similarly, theory holds that travel demand adjusts to changes in road capacity over a number of years. Accordingly, past research has used lagged model structures of five or so years to estimate intermediate to long-term induced-demand elasticities (see, for example, Hansen and Huang, 1997).

Some of the right-hand side policy variables in the system of equations probably influence road programmes in a lagged fashion. For example, because state budgetary cycles work one or more years in advance, the influences of state party affiliation on road investments probably follow a lagged structure. Similarly, the effects of air-quality levels on road development are also probably lagged in nature. Because California has a number of non-attainment areas, in violation of both state and national clean air standards, this policy variable is thought to be a particularly important predictor. While such lagged structures are compelling from a theoretical point of view, this should be tempered by the reality that introducing lags can significantly cut into degrees of freedom. Our preferred model specifications are therefore compromises between what is theoretically called for and what is practical given a limited dataset.

The core variables used as candidate predictors in this research and their sources are summarised in Tables 1 and 2. Table 1 presents the primary predictor variables, whereas Table 2 lists variables that were candidates for predicting and instrumenting road supply. The metric we used to represent travel demand was vehicle miles travelled (VMT) on state-owned facilities, which consisted principally of freeways, arterials, and other major thoroughfares. Supply was represented by lane-miles of the same facilities used in measuring travel demand. Care was taken to ensure that "apples and apples" were being compared, including making adjustments to account for newly designated state facilities and the re-assignment of existing facilities to state jurisdiction. Limiting the analysis to state owned and maintained facilities meant that other, sometimes significant, roadways (for example, county collectors) were omitted from the analysis; however, the advantages of using consistent and reliable data more than offset the disadvantage of an incomplete universe of road facilities, in our judgement.

Table 1 shows a host of variables related to vehicle operating cost, population size and composition, income levels, and fuel economy were culled from various sources as candidate predictors. Unavoidably, problems of multi-collinearity were encountered in simultaneously using all as predictors; hence variables chosen as predictors were selected based on contributions to fit and consistency with theory.

Table 1
Key Predictor Variables and Sources

Dimension	*Variable*	*Sources*
Demand	VM, state facilities	Caltrans files, Department of Finance
Supply	Lane–Mile, state facilities	Caltrans files, Department of Finance
Price	Operating Cost/Mile	AAA, *Your Driving Costs*, 1997
	Retail Gas Price, local cents/gallon	U.S. Department of Energy, Energy Information Administration
	Gas, Tax, state, cents/gallon	U.S. Department of Commerce, *The Book of States*, various years
Population	County Population	CA Dept. of Finance, files
	Population by race	CA Dept. of Finance, files
	Density, Person per acre	CA Dept. of Finance, files
	Density, Workers per acre	CA Dept. of Finance, files
Income	Personal Income, median ($000)	U.S. Department of Commerce, Bureau of Economic Analysis
Fuel economy	Pass. Car, average miles per gallon	U.S. Department of Transportation, FHWA, *Highway Statistics*, various years

Key: Caltrans: California Department of Transportation; AAA: Automobile Association of America; CA = California; VMT = vehicle miles travelled.

Table 2
Candidate Predictor and Instrument Variables for Predicting Road Supply

Dimension	*Variable*	*Source*
Geography/Weather	Precipitation, inches	CA Dept. of Finance, *California Almanac*
	Heating Degree Days	CA Dept. of Finance, *California Almanac*
	Cooling Degree Days	CA Dept. of Finance, *California Almanac*
	Low daily temp., avg.	CA Dept. of Finance, *California Almanac*
	High daily temp., avg.	CA Dept. of Finance, *California Almanac*
	Lowest Elevation, feet	CA Dept. of Finance, *California Almanac*
	Highest Elevation, feet	CA Dept. of Finance, *California Almanac*
Air Quality	No. Days >NAAQS	California Air Resources Board, data files
	Max. hr., CO, ppm	California Air Resources Board, data files
	Max. 8 hr, CO, ppm	California Air Resources Board, data files
	Max. hr, Ozone, ppm	California Air Resources Board, data files
Politics	Governor's Party (0–1)	U.S. Department of Commerce, *The Book of States*
	Gov. in 2nd Term (0–1)	U.S. Department of Commerce, *The Book of States*
	House Majority, party affiliation (0–1)	U.S. Department of Commerce, *The Book of States*, various years
	Senate Majority, party affiliation (0–1)	U.S. Department of Commerce, *The Book of States*, various years
	Local Assembly Rep. On Transp. Committee (0–1)	California Assembly, *CA Roster*, various years
	Local Assembly Rep. Chair Transp. Com. (0–1)	California Assembly, *CA Roster*, various years
	Local Senate Rep. On Transp. Committee (0–1)	California Assembly, *CA Roster*, various years
	Local Senate Rep., Chair Transp. Com (0–1)	California Assembly, *CA Roster*, various years

Key: NAAQS = National Ambient Air Quality Standard; CA = California; CO = Carbon Monoxide; ppm = parts per million.

Table 2 summarises variables that served as both potential predictors and instruments of the supply-side endogenous variable, roadway lane miles. The set of topographic and meteorological variables sought to gauge how extremes in weather and terrain might account for variation in road development, other things being equal. More mountainous areas with greater temperature extremes and high levels of precipitation, for example, might receive capacity additions as part of road reconstruction and rehabilitation programmes. Air quality is thought to shape road investment programmes for legal and policy reasons. What is unclear, however, is whether worsening air quality, on balance, encourages or discourages road expansion. On the one hand, new roads promise to relieve congestion and increase average travel speeds, which generally contributes to improved air quality; on the other hand, proposed road improvements are often opposed on the grounds that they exacerbate air quality over the long run by inducing sprawl and car-oriented development. Several road projects in the San Francisco Bay Area were legally challenged on the very grounds that road expansions induce sprawl; however, the courts generally sided with the argument that roads, by increasing travel speeds, on balance have a positive air-quality impact (Garret and Wachs, 1996). Lastly, a series of variables on executive and legislative party affiliations and committee assignments were compiled to gauge the influences of politics on road development in the state. Representation from a local (that is, municipal or county) elected official on a state transport committee, or better still, having a local politician as chairperson of such a committee, might be expected to result in relatively high levels of local road investments. In the US, conventional wisdom also holds that Republication administrations are friendlier to road programmes than their Democratic counterparts, who tend to focus more on social programmes. Thus, the analyses that follow examine how politics and parochialism have shaped road development in California over the last quarter of the twentieth century.

Empirical Findings

The 3SLS estimation results are presented in Tables 3 and 4. Both models, simultaneously estimated, represent best-fitting equations that are free of serious collinearity problems and violations of underlying estimation assumptions. In the three-stage technique, all exogenous variables in the system of equations (that is, the variables other than VMT and lane-miles) were used as instruments in estimating the two endogenous variables, VMT and roadway lane-miles. Because there were no serial auto-correlation problems in the calibration of models, there was no need to first-difference equations.

These model results are consistent with theory and much of the empirical literature to date. Notably, a strong short-term travel *induced-demand effect* was uncovered from the 22 years of county-level California data: from the elasticity estimate, every 10 per cent increase in lane-mile capacity was associated with a 5.9 per cent increase in VMT, controlling for other factors including the simultaneous influences of road supply and demand. However, the results also reveal a significant *induced-investment effect*, with lane-mile additions significantly explained by VMT: a 10 per cent increase in VMT was associated with a 3.3 per cent increase in lane-

Table 3

Induced Demand Model: Natural Logarithm of Annual Countywide Vehicle Miles Travelled (VMT), 34 California Counties, 1976 to 1997; 3SLS Estimation

	Coefficient	*Std. Error*	*t-Statistic*	*Prob.*
Natural Log of:				
Lane–Miles	0.588	0.028	21.17	0.000
Population	0.690	0.030	21.02	0.000
Employment density	−0.079	0.013	−6.30	0.000
Income, $ per capita	0.294	0.012	27.51	0.000
Gas Price, local, cts.	−0.179	0.016	−11.02	0.000
County Fixed Effects:				
Los Angeles	−0.563	0.035	−15.79	0.000
Orange	−0.122	0.021	−5.64	0.000
San Bernadino	−0.843	0.030	−28.24	0.000
Riverside	−0.694	0.021	−28.57	0.000
Ventura	−0.469	0.021	−22.52	0.000
San Diego	−0.533	0.027	−19.41	0.000
Santa Barbara	−0.547	0.018	−30.22	0.000
Contra Costa	−0.087	0.023	−3.73	0.000
Santa Clara	−0.306	0.021	−14.29	0.000
Sonoma	−0.475	0.020	−24.22	0.000
Napa	−0.367	0.021	−17.09	0.000
Sacramento	−0.405	0.018	−21.86	0.000
Yolo	−0.306	0.022	−13.96	0.000
Monterey	−0.579	0.020	−29.41	0.000
Santa Cruz	−0.261	0.018	−21.86	0.000
San Luis Obispo	−0.502	0.023	−25.17	0.000
Fresno	−1.051	0.023	−44.78	0.000
El Dorado	−0.344	0.021	−15.64	0.000
Placer	−0.111	0.019	−5.78	0.000
Kern	−0.847	0.022	−37.75	0.000
Madera	−0.069	0.025	−2.79	0.006
Sutter	−0.298	0.023	−12.75	0.000
Merced	−0.348	0.020	−17.57	0.000
Tulare	−0.835	0.022	−37.02	0.000
San Joaquin	−0.417	0.017	−23.85	0.000
Stanislaus	−0.603	0.022	−27.02	0.000
Butte	−0.855	0.022	−38.25	0.000
Shasta	−0.549	0.022	−25.49	0.000
Yuba	−0.296	0.028	−10.53	0.000
Constant	0.102	0.175	0.86	0.582

Summary Statistics:
No. of Cases: 713
F Statistic = 6037, prob. = 0.000
R-Square = 0.996.

Table 4
Induced Investment Model: Natural Log of Annual Countywide Lane Miles of Freeway–Highway Capacity, 34 California Counties, 1976 to 1997; 3SLS Estimation

	Coefficient	*Std. Error*	*t-Statistic*	*Prob.*
Natural Log of:				
VMT	0.329	0.021	15.47	0.000
Population	0.516	0.020	26.05	0.000
Employment density	−0.321	0.006	−57.69	0.000
White Pop., prop.	0.411	0.069	5.99	0.000
Gov. Party, 1 = Dem., lag	0.097	0.008	12.09	0.000
CO Max 1 Hour, ppm, lag	0.060	0.006	9.85	0.000
Temperature Diff., low-hi	0.501	0.027	18.61	0.000
County Fixed Effects:				
Los Angeles	0.497	0.027	18.58	0.000
Orange	0.183	0.027	6.77	0.000
San Diego	0.398	0.025	15.97	0.000
Santa Barbara	0.102	0.016	6.44	0.000
Alameda	0.434	0.027	16.13	0.000
Contra Costa	−0.218	0.018	−12.10	0.000
San Francisco	0.261	0.028	9.02	0.000
San Mateo	0.282	0.020	13.88	0.000
Marin	−0.269	0.018	−14.61	0.000
Solano	−0.123	0.018	−6.88	0.000
Sonoma	−0.305	0.021	−14.84	0.000
Napa	−0.281	0.019	−14.26	0.000
Yolo	0.183	0.018	10.16	0.000
Monterey	0.125	0.020	6.34	0.000
Santa Cruz	0.296	0.029	10.05	0.000
San Luis Obispo	0.151	0.016	9.33	0.000
Kern	0.448	0.016	26.97	0.000
Madera	−0.433	0.019	−22.23	0.000
Stanislaus	−0.300	0.019	−15.65	0.000
Butte	−0.271	0.025	−10.83	0.000
Sutter	−0.317	0.021	−14.63	0.000
Yuba	−0.473	0.023	20.61	0.000
Constant	−3.827	0.150	25.40	0.000

Summary Statistics:
No. of Cases: 713
F Statistic = 3645, prob. = 0.000
R-Square = 0.994.

mile additions, all else being equal and simultaneous influences accounted for. Thus, "induced demand" effects were found to be stronger than "induced investment" effects, although not overwhelmingly so. Regarding the polarised debate that swirls around induced travel demand, as often is the case with ideological differences, there is some truth in both sides of the argument. That is, California experiences suggest that road investments induce travel demand and traffic growth induces road investments. The former dynamic appears to be stronger than the latter; however, both sets of relationships are statistically significant.

In terms of model estimation, failure to account for simultaneous influences invariably leads to biased parameter estimates. Because the two endogenous variables are positively correlated with each other, the direction of bias in many past studies has probably been an overstatement of induced travel demand effects. Despite this, we uncovered a respectable elasticity of 0.588 for induced travel demand from our database, in line with estimates of Hansen and Huang (1997) who used single-equation (non-simultaneously estimated) models in estimating elasticities for California counties. This is partly explained by the fact that the models presented in this paper have different specifications, are estimated on a different set of years, and are thus not completely comparable with the earlier work. Consequently, our models could very well be yielding elasticity results that are fairly consistent with less well-specified models that contain biases due to single-equation estimation. And in relation to elasticity estimates from our models and those of other researchers who have built single-equation models using data from other states, the comparability of results could very well be due to stronger induced demand effects in California, America's most populous state and, in aggregate terms, the fastest growing one.

It is worth noting that including county fixed effects enhanced the simultaneous equations. Statistically, their chief role was to improve model specification, similar to the induced demand work carried out by Noland and Cowart (2000) and Fulton *et al.* (2000). Still, both the induced demand and induced investment models were highly significant even when county fixed effects were excluded in model runs (with R-Squares of 0.94 or more). Adding fixed effects helped to specify more fully the system of equations (revealed by marginal increases in R-Squares to over 0.99), thus refining elasticity estimates of induced travel demand and induced roadway investments.

Induced demand model

Besides the strong influence of lane-mile additions on VMT, other explanatory relationships revealed in Table 3 are also of policy interest. Population growth most strongly accounted for VMT increases. Because of the steady pattern of year-to-year population increases among California counties, the population variable also served as a secular-trend proxy, obviating the need for any temporal fixed-effect variable.

Table 3 shows that, as expected, VMT was market-sensitive—it rose with personal income levels and fell as local fuel prices increased, both expressed in constant 1990 currency. Areas with relatively dense employment averaged less VMT, controlling for other factors (notably population), suggesting that commuting alternatives (for example, better public transport in denser settings) and other influences (for example, higher parking charges in denser settings) worked to suppress VMT. Cross-sectional fixed effects were significant for 29 of the counties, indicating lower levels of travel consumption relative to the five suppressed Bay Area counties — San Francisco, Alameda, San Mateo, Marin, and Solano counties.

Overall, the VMT model had superb predictive abilities, explaining virtually all of the variation in travel consumption across the 34 California counties over the 22-year time period. This near-perfect fit was attributable largely to core variables that closely tracked VMT secularly, notably population and income.

Induced investment model

Table 4 reveals that, in addition to VMT, California's roadway capacity responded to population trends (that is, demographic characteristics), localised effects (that is, density and temperature differentials), and policy-related influences (that is, governor party affiliation and air-quality levels). Consistent with expectations, road investments increased with population size and temperature differentials and decreased with employment density. Settings with wide swings in yearly temperatures have been recipients of more road improvements, most probably because higher investments in maintenance and road reconstruction afford opportunities for piggybacking road expansions onto these programmes. High employment densities probably act as a deterrent to road investments since right-of-way acquisitions tend to be costlier and Not-In-My-Backyard (NIMBY) resistance to potential disruptive effects tends to be stronger in more urbanised settings.

Signs on the other predictor variables are less grounded *a priori* and thus warrant explanation. Unexpectedly, our analysis revealed some sensitivity in state road investments with respect to county racial composition. Controlling for population size, VMT, and other factors, counties with higher shares of white residents averaged more road-capacity expansion. While one might argue this reflects the tendency of whites to live in suburban areas where roads tend to be more plentiful, this was so even when controlling for county fixed effects, including the unique influences of counties that are quintessentially suburban, such as Orange County in Southern California and Solano County in the San Francisco Bay Area.

The positive coefficient on the air-pollution variable, represented by maximum levels of carbon monoxide (CO) emissions recorded in one hour (expressed in parts per million) the previous year, was not totally expected. As discussed earlier, road improvements are variously viewed as an asset and a liability in relation to air pollution. To the degree they reduce stop-and-go traffic, they generally improve air quality (CO in particular); to the degree they spawn VMT increases, as revealed in this model, they worsen air quality. On balance, it appears that the former argument has succeeded over the latter in California public policy circles. That is, worsening of air quality in prior years appears to be a catalyst to road expansion, all else being equal. Because of the time commitments involved in proposing and programming road improvements, one might contend that a longer lag period than one year should be used to represent the influences of prior air quality levels on contemporaneous road investments. Longer lagged structures were indeed attempted in the exploratory phases of model construction; however, these consistently provided poorer model fits — and not to be overlooked, at the loss of considerable degrees of freedom. Accordingly, one-year lags were used. It might very well be that prior-year slippages in air quality add momentum to road investment initiatives and perhaps, during periods of budget constraints, make a difference in which projects are built and which ones are delayed. Or, as argued above, planners may have anticipated the congested conditions giving rise to high CO levels in planning and programming decisions that were made years earlier.

Most surprising was the influence of party affiliation the prior year on contemporary state road investments. In California, road supply is higher, other things being equal, when a Democrat is governor. This reflects the historical evolution of the California highway program. The 1974–82 period when Jerry Brown was California's governor coincided with a rapid deceleration in the state's highway construction programme because of a variety of factors, including increased costs, declining fuel tax revenues, heightened environmental concerns, and Brown's own multi-modal transport policy (Taylor 1992). Subsequent Republican governors were unable to resurrect this programme. Thus, while the California population and economy have grown rapidly in the past two decades, road supply has not kept pace, and, controlling for these variables, road expansions have been more tentative under the later, Republican, administrations.

Table 4 also reveals distinct county-by-county variations in road investments even when controlling for other variables such as VMT and population. Based on the positive coefficients, many urbanised counties, particularly those in Southern California, were recipients of relatively high levels of road improvements over the 1976 to 1997 period. This could reflect the need for major road improvements following the widespread damage caused by major earthquakes during this period (such as, the 1994 Northridge incident). The high positive signs on the fixed-effects variables representing San Francisco, Alameda, San Mateo, Santa Cruz, and Monterrey Counties similarly may reflect the massive road rebuilding that followed the catastrophic 1989 Loma Prieta earthquake.

Overall, the model shown in Table 4 was a very good predictor, explaining over 99 per cent of the variation in lane-mile additions. While much of the explained variation was attributable to secular population growth, VMT was not an inconsequential factor in explaining road development in California. One should expect nothing less, for any competent highway planning and development programme should fully anticipate and respond well in advance to unfolding trends in travel demand.

Intermediate-term relationships

As measures of short-term elasticities, our estimates of induced traffic demand effects from Table 3 are in line with those of earlier studies (see, Goodwin 1996; Hansen and Huang 1997; Fulton *et al.*, 2000). For purposes of measuring induced-demand and induced-investment effects over longer time horizons, we re-estimated the models using polynomial distributed lagged structures. For both the supply and demand equations, models were fitted assuming second-degree polynomial lags with five-year lag periods (and no endpoint restrictions). Exponential distributions were also attempted, similar to those reported by Noland and Cowart (2000); however, our data suggested that induced-demand and induced-investment effects did not diminish exponentially over time lags but rather followed more of a convex-shaped delayed-response pattern.

Table 5 presents the results of the distributed-lagged model for predicting induced-demand effects. Because coefficients on the fixed-effect variables were similar to those of the 3SLS model (Table 3), only coefficients for the primary predictor variables are shown. Slightly significant auto-correlation (revealed by Durban–Watson statistics) prompted us to estimate the second-degree polynomial distributed lag model using first-order autoregressive estimation (Yule Walker estimates). The convex nature of the lagged response effects is revealed by the coefficient weights, with VMT adjustments appearing to be the strongest one year after road expansion, and influences tapering thereafter. A sum of lag coefficients provides an additive estimate of the intermediate induced demand elasticity: +0.79. This estimate aligns with those of other recent studies that have computed longer-term lane-mile elasticities using distributed lag models (Noland and Cowart, 2000; Fulton *et al.*, 2000). Whereas other studies have imputed longer-term

Table 5
Intermediate-Term Induced Demand Model: Polynomial Distributed Lag Structure; Constant and Fixed-effect Controls not Shown

	Coefficient	*Std. Error*	*t-Statistic*	*Prob.*
Natural Log of:				
Lane Miles (*t*-0)	0.197	0.007	28.19	0.000
Lane Miles (*t*-1)	0.223	0.009	24.69	0.000
Lane Miles (*t*-2)	0.173	0.011	15.70	0.000
Lane Miles (*t*-3)	0.120	0.010	11.93	0.000
Lane Miles (*t*-4)	0.056	0.009	6.24	0.000
Lane Miles (*t*-5)	0.022	0.005	4.56	0.000
Population	0.699	0.033	21.06	0.000
Employment density	−0.107	0.009	−11.77	0.000
Income, $ per capita	0.227	0.010	22.84	0.000
Gas Price, local, cts.	−0.223	0.016	13.92	0.000
Fixed Effects/Constant	***	***	***	***

Summary Statistics:
No. of Cases: 625
F Statistic = 3554, prob. = 0.000
R-Square = 0.986.

induced demand using a single-period lag on both lane-miles and VMT (that is, as a lagged-endogenous term), we were able to estimate directly the longer-term elasticity from the additive coefficients on the distributed lag model (Johnston, 1984; Pindyck and Rubinfeld, 1991).

Results of the distributed lagged model for estimating induced-investment effects, also estimated using auto-regressive techniques, are shown in Table 6. (Again, coefficients on the many fixed effect variables are not shown.) An even stronger convex quadratic structure is revealed by the coefficients on the lagged terms of this model. As both theory and common sense hold, road investments appear to be strongly influenced by traffic loads in previous periods. From the sum of distributed lag coefficients, the estimate five-year (intermediate-term) elasticity is +0.66. This is a far bigger jump from the near-term elasticity than in the case of the induced-demand model, suggesting that induced-investment effects build more strongly over time than do induced-demand effects.

Triangulation: Granger Causality Testing

For purposes of cross-checking the simultaneous estimations findings and triangulating the research design, a Granger (1969) causality test was

Table 6
Intermediate-Term Induced Investment Model: Polynomial Distributed Lag Structure; Constant and Fixed-effect Controls not Shown

	Coefficient	*Std. Error*	*t-Statistic*	*Prob.*
Natural Log of:				
VMT (*t*-0)	0.154	0.011	12.89	0.000
VMT (*t*-1)	0.209	0.016	13.07	0.000
VMT (*t*-2)	0.191	0.015	12.65	0.000
VMT (*t*-3)	0.126	0.011	11.32	0.000
VMT (*t*-4)	0.067	0.006	11.16	0.000
VMT (*t*-5)	−0.021	0.005	−4.14	0.000
Population	0.605	0.034	17.79	0.000
Employment density	−0.366	0.014	−26.19	0.000
Gov. Party, 1 = Dem., lag	0.045	0.009	4.99	0.000
CO max 1 hr, ppm, lag	0.042	0.007	5.86	0.000
Temperature Diff., low-hi	0.714	0.069	10.42	0.000
Fixed Effects/Constant	***	***	***	***

Summary Statistics:
No. of Cases: 622
F Statistic = 2279, prob. = 0.000
R-Square = 0.997.

conducted using the same dataset. The Granger test infers the direction of causality based on establishing a clear time ordering in the predictability of two correlated variables. If a variable X is a causal factor for a variable Y, then a model for Y that includes past values for X as well as past values for Y should perform better than a model that includes only past values of Y. Thus one can test the null hypothesis that X does not cause Y by estimating a model relating Y to past values of X and Y and testing the restriction that coefficients on the X variables are all zero. An analogous test can be performed to determine whether Y is a causal factor in explaining X. Thus, given two correlated variables, one can use the Granger test to infer whether X causes Y, Y causes X, or both, or neither.

Results of the Granger test are summarised in Table 7. The length of lagged structure in any Granger test is guided partly by theory but mostly by what provides the best statistical fits. With our database, a two-year lagged structure yielded the best statistical results. For purposes of testing whether lane-mile capacity adds significant incremental explanatory power in explaining variation in VMT, the reduced model took the lagged form of: $VMT_t = f(VMT_{t-1}, VMT_{t-2})$. The full model was expressed as: $VMT_t = f(VMT_{t-1}, VMT_{t-2}, LANEMILE_{t-1}, LANEMILE_{t-2})$. The null hypothesis of no value-added was easily rejected. Thus, consistent with the earlier results, road capacity passed the Granger test as a significant

Table 7
Granger Causality Test Results for Two-Year Time Lagged Structure (N = 680)

	Sum of Square Errors		Explanatory Improvement F-Statistic	
	Reduced Model	*Full Model*	*(probability)*	*H_o Action*
VMT Model: H_o: "Lane Miles" do not add significant incremental explanatory power	3.83E+13	3.68E+13	13.774 (.000)	Reject
Lane Miles Model: H_o: VMT does not add significant incremental explanatory power	1,291,139	1,165,647	36.330 (.000)	Reject

incremental predictor in explaining variation in VMT. When the analytical process was reversed, with two-year lags of VMT added to a lane-mile model with one- and two-year lags of the endogenous variable, it was found previous-year VMT levels significantly affected lane miles. Overall, then, the Granger results were wholly consistent and reinforced the econometric results — during the past quarter-century in California, at least, road supply and demand have jointly influenced one other.

Conclusions

Our research found, unequivocally, a strong two-way empirical relationship between road supply and demand, as theory holds. Over the past several decades in California, road supply has been both a cause and an effect in relation to VMT. That is, our analysis showed significant *induced-demand* and *induced-investment* effects. Presumably, past state highway investments were based on levels of travel demand that were anticipated — suggesting, in California at least, that road investments not only stimulated travel demand but responded to it as well. While the effects of lane–mile additions on VMT appear to be stronger than vice-versa, both relationships are significant and should be acknowledged when addressing policy questions related to congestion relief and highway development. Like most policy debates full of ideology, the truth often lies somewhere in between the extreme positions of the debaters. The findings of this research occupy this middle ground.

Consistent with other studies, our research shows induced-demand effects build over time, revealed by an increase of the short-term elasticity estimate of +0.59 to +0.79 over the intermediate term. Our research also suggests that induced-investment effects build even more rapidly, with the estimated short-term elasticity of +0.33 doubling to +0.66 within a five-year time horizon. While the simultaneous structure used in this study is appealing theoretically, and performs well statistically, we were somewhat surprised that lane-miles respond to contemporaneous or near-contemporaneous exogenous influences even though project implementation can take many years. These results can be partly explained by the "look-ahead" nature of transport planning. However, they are also revealed by the strong correlations of contemporaneous values of the endogenous variables, VMT and lane miles, to lagged values; when polynomial distributed lag structures were used to estimate relationships, insights into the delayed-response of road investments to VMT increases were revealed.

Besides shedding light on the core research question of how road supply and demand jointly influence each other, this research yielded several other useful policy insights. Overall, state road projects in California appear to have been fairly de-politicised, with investments governed mainly by need (for example, growth in VMT and population). Still, governor party affiliation appeared to have some bearing on statewide road development, with Democratic administrations presiding over periods of more abundant road supply, partly a result of historical happenstance. Our research also uncovered possible race-based inequities in road development. While we do not believe that racial discrimination has overtly influenced transport investment decisions, nevertheless California's past allocation of roads has gone disproportionately to counties with predominantly white populations. In addition, our analysis disclosed that deterioration in air quality has generally worked in favour of road expansion, ostensibly as a means of improving traffic flows, at least at the margin. While the desire to expedite traffic movements has never been a centrepiece of air-quality policies in California over the years, the fact that most transport and air-quality forecasting models assign benefits to higher average speeds has no doubt played some role in promoting road development in the state.

Despite the advance over single-equation estimates of induced travel demand, our "bottom-line" elasticity estimates fall well within the range of earlier studies. Single-equation methodologies are no doubt subject to simultaneity bias; however, this does not seem to have greatly distorted their results. While some sceptics continue to castigate the elasticities from induced demand studies as nothing more than "random numbers", they cannot deny that these numbers have a central tendency.

Although simultaneous equations improve internal validity, we acknowledge that the use of aggregate data can increase the chance of drawing spurious inferences. We used county-level data, as have other researchers, since the spillover effects of road improvements on connecting facilities can be more readily captured. Several recent studies (see, Strathman *et al*, 2000; Barr, 2000) have sought to examine the travel-demand impacts of road improvements using household travel-diary data. These disaggregate studies derived lower elasticities than those of most aggregate-scale analyses. However, as cross-sectional studies with fairly poor statistical fits, and which ignore impacts of road improvements on commercial travel, studies based on household travel diaries have limitations as well. While our understanding of induced travel demand remains incomplete, as empirical evidence accumulates and model specifications improve, a balance of aggregate and disaggregate research should help close some of the existing knowledge gaps regarding how urban roadways and travel jointly influence each other.

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Attachment D

Environmental Council of Sacramento v. California
Department of Transportation
Case No. 07CS00967
July 15, 2008

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Transportation

FILED / ENDORSED
AUG 1 2 2008
By L. Young, Deputy Clerk

IN THE SUPERIOR COURT OF THE STATE OF CALIFORNIA

FOR THE COUNTY OF SACRAMENTO

ENVIRONMENTAL COUNCIL OF SACRAMENTO; and NEIGHBORS ADVOCATING SUSTAINABLE TRANSPORTATION Petitioners v. CALIFORNIA DEPARTMENT OF TRANSPORTATION, WILL KEMPTON, Director; and, DOES 1 through 20; Respondents	Case No. 07CS00967 **~~[PROPOSED]~~ JUDGMENT GRANTING PETITION FOR WRIT OF MANDATE**

This matter came on for a hearing on the Petition for Writ of Mandate on March 21, 2008, and was heard, argued, and submitted for decision in Department 29 of the above-entitled Court, the Honorable Timothy Frawley presiding. Donald B. Mooney appeared on behalf of Petitioners Environmental Council of Sacramento and Neighbors Advocating Sustainable Transportation. Martin Keck appeared on behalf of Respondents California Department of Transportation ("Caltrans") and Will Kempton, Director of Caltrans.

The Court having reviewed the record of Respondents' proceedings in this matter, the briefs submitted by counsel and the arguments of counsel, the matter having been submitted for decision, and the Court having directed that a peremptory writ of mandate issue in this proceeding,

IT IS SO ORDERED that:

1. Judgment granting a writ of mandate be entered in favor of all the above-referenced Petitioners' in this proceeding. Judgment is so entered because the Court finds that Respondents committed a prejudicial abuse of discretion by failing to prepare a legally adequate Environmental Impact Report and did not comply with the California Environmental Quality Act ("CEQA"), Public Resources Code, section 21000 *et seq*. The basis for the Judgment is set forth in the attached Minute Order ("Ruling After Hearing"), which is incorporated by reference.

2. A peremptory of writ of mandate directed to Respondents California Department of Transportation and Director Will Kempton shall issue under seal of this Court, ordering Respondents to do all of the following:

a. Within 30 days from service of this writ of mandate, Respondents shall vacate and set aside the June 21, 2007, certification of the Final Environmental Impact Report for the Sacramento 50 Bus/Carpool Lanes and Community Enhancement Project, and the June 21, 2007, approval of the Sacramento 50 Bus/Carpool Lanes and Community Enhancement Project ("Project").

b. Respondents shall not reapprove the Project unless and until Respondents have certified an environmental impact report that complies with CEQA and the CEQA Guidelines, and otherwise complied with CEQA.

c. Respondents and their agents shall suspend any and all activities to approve and implement the Project that could result in adverse change or alteration to the physical environment, until this Court determines that Respondents have taken the actions specified herein to bring their approval of the Project into compliance with CEQA.

d. Respondents shall file an initial return to the peremptory writ of mandate within 30 days of service. Respondents shall file a supplemental return to the writ of mandate after they have certified an EIR for the Project, or after they have determined not to reapprove the Project. The Court shall retain jurisdiction over Respondents' proceedings by way of the return to the peremptory writ of mandate until the Court has determined that Respondents have complied with CEQA.

3. Petitioners are awarded their costs of suit upon appropriate application.

4. The Court shall retain jurisdiction for any motion for an award of attorney's fees.

DATED: ~~July __, 2008~~ August 12, 2008

The Honorable Timothy Frawley
Judge of the Superior Court

SUPERIOR COURT OF CALIFORNIA COUNTY OF SACRAMENTO

Approved as to Form:

DATED: July 24, 2008

CALIFORNIA DEPARTMENT OF TRANSPORTATION

By M Keck
Martin Keck
Attorney for Respondents
California Department of Transportation and Director Will Kempton

SUPERIOR COURT OF CALIFORNIA, COUNTY OF SACRAMENTO GORDON D SCHABER COURTHOUSE

MINUTE ORDER

Date: 07/15/2008 Time: 11:51:50 AM Dept: 29

Judicial Officer Presiding: Judge Timothy Frawley
Clerk: L. Young

Bailiff/Court Attendant: NONE
ERM:
Reporter: NONE,

Case Init. Date: 11/12/2007

Case No: 07CS00967 Case Title: ENVIR COUNCIL OF SAC. ET AL VS. CA DEPT OF TRANSPORT. ET AL

Case Category: Civil - Unlimited

Causal Document & Date Filed:

Appearances:

RULING AFTER HEARING

Petitioners Environmental Council of Sacramento and Neighbors Advocating Sustainable Transportation ("Petitioners") challenge Respondent California Department of Transportation's ("Caltrans") June 21, 2007, approval and certification of a Final Environmental Impact Report ("Final EIR") for the Sacramento 50 Bus/Carpool Lanes and Community Enhancement Project under the California Environmental Quality Act ("CEQA"). Petitioners seek a writ of mandate directing Caltrans to set aside its certification of the EIR and approval of the Project.

The Project, as approved, proposes to build approximately 13 miles of High Occupancy Vehicle ("HOV") lanes, in the east-bound and west-bound directions, within the existing median of U.S. Highway 50 from Sunrise Boulevard to Watt Avenue, plus various transportation-related "community enhancements" related to the highway improvements. Currently, within the Project boundaries, the number of lanes in each direction varies from three to six lanes.

The concept for the Project was conceived several years ago and has been incorporated into a number of regional transportation studies and reports since 1996-97. (14 AR 4640-4673; 23 AR 8638; 11 AR 3716-3724.)

In June 2005, a Notice of Preparation of a Draft EIR for the Project was filed with the California Office of Planning and Research (State Clearing House). (21 AR 8078-8086.)

On December 13, 2006, Caltrans released the Draft EIR for a 60-day public review and comment period. (2 AR 508-775.) The Draft EIR identified two "build" alternatives (Alternatives 10d-1 and 10d-3) and a "No Build" alternative. (2 AR 513-514.) Alternative 10d-1 provides for the construction of HOV lanes from Sunrise Boulevard to the Oak Park interchange in downtown Sacramento. Alternative 10d-3, which is the approved Project, provides for the construction of the HOV lanes from Sunrise Boulevard to Watt Avenue. The No Build Alternative provides no improvements to Highway 50. The Draft EIR also identifies and discusses various other alternatives that were initially considered but then eliminated for various reasons. (2 AR 526-535.) Petitioners and others provided comments on the Draft EIR. (1 AR 339 through 2 AR 472.)

In June 2007, Caltrans issued the Final EIR. The Final EIR includes Caltrans' responses to the comments on the Draft EIR. (2 AR 473-507.) The Final EIR concludes that the Project will not result in any significant environmental impacts after mitigation. (1 AR 9-13; 4 AR 1419.)

On June 21, 2007, Caltrans certified the Final EIR and approved the Project. Caltrans adopted findings that the Project will not have a significant effect on the environment. (4 AR 1419; 1 AR 1.)

Caltrans filed a Notice of Determination under Public Resources Code § 21152 with the State Clearing House on June 25, 2007, commencing CEQA's 30-day period of limitations. (1 AR 1.) On the final day of that period, Petitioners filed the instant petition for writ of mandate, alleging that Caltrans violated CEQA.

Discussion

In determining whether an administrative body failed to comply with CEQA, the Court considers whether there was a prejudicial abuse of discretion. (Western States Petroleum Assn. v. Superior Court (1995) 9 Cal.4th 559, 568; Pub. Res. Code § 21168.5.) Abuse of discretion is established if the agency has not proceeded in a manner required by law or if the determination or decision is not supported by substantial evidence. (Citizens of Goleta Valley v. Board of Supervisors (1990) 52 Cal.3d 553, 564.)

Under the substantial evidence test, the court does not decide whether the agency's determinations were correct, but only whether they are supported by substantial evidence in the record. (Id.; see also Association of Irritated Residents v. County of Madera (2004) 107 Cal.App.4th 1383, 1391.)

Substantial evidence is defined as "enough relevant information and reasonable inferences from this information that a fair argument can be made to support a conclusion, even though other conclusions might also be reached." (Cal. Code Regs., tit.14, § 15384.) Substantial evidence includes facts, reasonable assumptions predicated upon facts, and expert opinion supported by facts. (Id.) Substantial evidence does not include "[a]rgument, speculation, unsubstantiated opinion or narrative, evidence which is clearly erroneous or inaccurate, or evidence of social or economic impacts which do not contribute to or are not caused by physical impacts on the environment . . . ." (Id.)

In applying the substantial evidence standard, the reviewing court does not reconsider or reweigh the evidence before the agency. The court must indulge all reasonable inferences from the evidence that would support the agency's determinations and resolve all conflicts in the evidence in favor of the agency's decision. (Western States Petroleum, supra, at p.571 [finding the power of the court begins and ends with a determination as to whether there is any substantial evidence, contradicted or uncontradicted, which will support the finding]; Laurel Heights Improvement Ass'n v. Regents of University of California (1988) 47 Cal.3d 376, 393.) A court should not set aside an agency's conclusion merely because an opposite conclusion would be equally or more reasonable. (Laurel Heights, supra, at p.393.)

In addition to reviewing whether an agency's factual determinations are supported by substantial evidence, a court may rule that an agency has prejudicially abused its discretion by failing to proceed in the manner required by law. (Pub. Res. Code §§ 21005, 21168, 21168.5; see also Rural Landowners Assn. v. City Council (1983) 143 Cal.App.3d 1013, 1022.) While an agency's factual determinations are subject to deferential substantial evidence review, questions of interpretation or application of the requirements of CEQA are matters of law, and are reviewed de novo. (Save Our Peninsula Committee v. Monterey County Bd. of Supervisors (2001) 87 Cal.App.4th 99, 119.) Thus, a reviewing court must adjust its review to the nature of the alleged defect, depending on whether the claim is predominantly a dispute over proper procedure or a dispute over the facts. (Vineyard Area Citizens for Responsible Growth, Inc. v. City of Rancho Cordova (2007) 40 Cal.4th 412, 435.)

An agency fails to proceed in the manner required by law if its analysis is based on an erroneous interpretation of CEQA's requirements or if it has failed to comply with the standards in CEQA for an adequate EIR.

When reviewing the adequacy of an EIR, a court does not pass upon the correctness of the EIR's environmental conclusions, but upon its sufficiency as an informational document. (Laurel Heights

Improvement Ass'n v. Regents of University of California (1988) 47 Cal.3d 376, 392.) An EIR must include detail sufficient to enable those who did not participate in its preparation to understand and to consider meaningfully the issues raised by the proposed project. (Association of Irritated Residents v. County of Madera (2004) 107 Cal.App.4th 1383, 1390.) Failure to disclose relevant information in an environmental impact report (EIR) may constitute a prejudicial abuse of discretion regardless of whether a different outcome would have resulted if the agency had disclosed the information. (Laurel Heights, supra, at p.392; Kings County Farm Bureau v. City of Hanford (1990) 221 Cal.App.3d 692, 711-712; see also Association of Irritated Residents, supra, at p.1391 [existence of substantial evidence supporting agency's ultimate decision on a disputed issue is not relevant when assessing violation of the information disclosure provisions of CEQA].)

However, the absence of information in an EIR is not per se a prejudicial abuse of discretion. (Pub. Res. Code § 21005; Al Larson Boat Shop, Inc. v. Bd. of Harbor Commissioners (1993) 18 Cal.App.4th 729, 748; Association of Irritated Residents, supra, at pp.1391-92.) In reviewing the adequacy of an EIR, courts do not look for technical perfection, but for "adequacy, completeness, and a good faith effort at full disclosure." (Cal. Code Regs., tit.14, § 15151; Sequoyah Hills Homeowners Ass'n v. City of Oakland (1993) 23 Cal.App.4th 704, 712; Association of Irritated Residents, supra, at pp.1390-1391; see also Al Larson Boat Shop, supra, at p.748 [standard is "rule of reason"].) The sufficiency of an EIR is determined according to what is reasonably feasible. (Id.) The EIR need not be perfect so long as it provides agencies with sufficient information to enable them to make a decision that intelligently takes account of the environmental consequences of the proposed project. (San Francisco Ecology Center v. City and County of San Francisco (1975) 48 Cal.App.3d 584, 594.) A prejudicial abuse of discretion occurs only if the failure to include relevant information precludes informed decision making and informed public participation, thereby thwarting the statutory goals of the EIR process. (County of Amador v. El Dorado County Water Agency (1999) 76 Cal.App.4th 931, 946; Al Larson Boat Shop, supra, at p.748.)

Although the Legislature intended CEQA to be interpreted in such manner as to afford the fullest possible protection to the environment within the reasonable scope of the statutory language, an EIR is presumed adequate and the plaintiff in a CEQA action has the burden of proving otherwise. (See Al Larson Boat Shop, supra, at p.740.)

Petitioners in this case raise a number of procedural and substantive challenges to Caltrans' EIR. The Court separately addresses each of these challenges below.

The Project's Operational Impacts on Air Quality

The first issue presented relates to whether the EIR adequately discloses and analyzes the Project's operational impacts on air quality. Petitioners claim the EIR is insufficient as an informational document because the EIR fails to adequately analyze the Project's operational impacts on emissions of NOx, PM10, and PM2.5.

The law is settled that an EIR is intended to be an informational document. The purpose of an EIR is to provide public agencies and the public with detailed information about the effects a proposed project is likely to have on the environment, identify alternatives to the project, and indicate the manner in which those significant effects can be mitigated or avoided. (Pub. Res. Code § 21002.1; see also Pub. Res. Code §§ 21002, 21061, 21100.) In this manner, the EIR is intended to act as an "environmental 'alarm bell,' [alerting] the public and its responsible officials to environmental changes before they have reached ecological points of no return." (County of Inyo v. Yorty (1973) 32 Cal.App.3d 795, 810; see also Laurel Heights Improvement Assn. v. Regents of University of California (1988) 47 Cal.3d 376, 392 [EIR intended to demonstrate to an apprehensive citizenry that the agency has, in fact, analyzed and considered the ecological implications of its action].)

CEQA requires the agency to focus the discussion in the EIR on those potential effects on the environment which the agency has determined are or may be significant. Lead agencies may limit discussion on other effects to a brief explanation as to why those effects were determined not to be significant and therefore not discussed in detail in the EIR. (Pub. Res. Code §§ 21002.1, 21100(c); Cal. Code Regs., tit. 14, § 15128.) Determining whether a project may have a significant effect on the environment, therefore, plays a critical role in the CEQA process. (Cal. Code Regs., tit. 14, § 15064.)

CEQA defines significant effects to mean substantial, or potentially substantial, adverse changes in the environment, including the land, air, water, minerals, flora, fauna, noise, historic and cultural sites, and aesthetics. (Pub. Res. Code §§ 21060.5, 21068, 21100, 21151; Cal. Code Regs., tit. 14, §§ 15126.2, 15360, 15382.)

There is no "gold standard" for determining whether a given environmental impact is significant. (Protect the Historic Amador Waterways, supra, at p.1107.) A precise definition of significant effects is not possible because the significance of an activity varies according to a project's environmental setting. (Cal. Code Regs., tit. 14, § 15064.) The determination of whether a project may have a significant effect on the environment calls for judgment on the part of the public agency, based to the extent possible on scientific and factual data. (Id.)

In this case, Petitioners challenge the methodology and scope of analysis used by Caltrans to assess the Project's air quality impacts. Petitioners contend that Caltrans improperly relied exclusively on a federal Clean Air Act conformity analysis to evaluate whether there will be significant air quality impacts from the Project. Further, Petitioners contend there is no evidence or rationale supporting Caltrans' decision to limit the scope of its analysis in this manner. Petitioners claim that because Caltrans relied on federal Clean Air Act conformity as the sole threshold of significance, Caltrans failed to analyze and disclose critical information about the Project's impacts on emissions of PM10, PM2.5, and NOx, including what those impacts are and how much of the regional emissions budgets they constitute.

Caltrans admits that it relied exclusively on a federal Clean Air Act conformity approach to evaluate the Project's air quality impacts, but denies that its conformity-based approach violates CEQA. The initial question presented, therefore, is whether a federal Clean Air Act conformity approach is sufficient to meet the requirements of CEQA.

Before proceeding to address this issue, some background on the federal Clean Air Act is required.

The Clean Air Act establishes a joint state and federal program to control the nation's air pollution. The Act requires the EPA to establish national ambient air quality standards ("NAAQS"), which establish the maximum limits of pollutants allowed in the outside ambient air. (42 U.S.C. § 7409.) The EPA must designate areas that meet the standards ("attainment areas") and those that do not meet the standards ("non-attainment areas"). (42 U.S.C. § 7407.) The Sacramento region has been designated by the EPA as a "non-attainment" area for PM10 and O3, but as "attainment" for PM2.5.

Under the Clean Air Act, states implement, attain, and enforce the NAAQS through regional state implementation plans ("SIPs"). (42 U.S.C. §§ 7409, 7410.) Each SIP identifies the total allowable amount of emissions necessary to attain and maintain the NAAQS for each pollutant, and allocates the total allowable emissions between stationary, mobile, and other sources. (42 U.S.C. § 7410; 40 C.F.R. § 93.101.) Federally approved transportation projects located in non-attainment areas must conform to the SIP. (Id.)

The Clean Air Act also requires conformity findings for metropolitan transportation plans ("MTPs") and metropolitan transportation improvement programs ("MTIPs"). MTPs describe the policies and strategies for accommodating current and future travel demand in the region. An MTP typically includes all of the federally-sponsored and regionally-significant transportation projects planned for the region over a period of years, usually at least 20 years. An MTIP describes specific transportation projects that are consistent with the MTP. The regional planning organization – in this case, SACOG – is required to ensure that the MTPs and MTIPs conform to the mobile source emissions budgets established in the SIP. (42 U.S.C. § 7506.)

Here, Caltrans relied exclusively on the Project's conformity with federal Clean Air Act standards to evaluate whether the Project will have any significant air quality impacts. Petitioners argue that while a Clean Air Act conformity-based approach may be sufficient to analyze the Project's cumulative air quality impacts, it is not sufficient to discharge Caltrans' duty to analyze and disclose the Project's specific traffic-based emissions. The Court agrees.

While regulatory environmental standards can provide an appropriate benchmark for determining whether a particular impact is significant, compliance with environmental laws is not enough to support a finding of no significant impact under CEQA. (Californians for Alternatives to Toxics v. Department of

Food and Agriculture (2005) 136 Cal.App.4th 1, 17.)

In Californians for Alternatives to Toxics, the Court of Appeal addressed the question whether the Department of Food and Agriculture (DFA) could forgo environmental analysis of the statewide use of pesticides for a disease control program by relying on the Department of Pesticide Regulation's (DPR's) certified regulatory program. In its EIR, DFA did not independently evaluate the environmental impacts of the project's use of pesticides. Instead, DFA determined that compliance with DPR's existing regulatory scheme was adequate to ensure the project would not result in any significant adverse environmental impacts. Specifically, DFA reasoned that because all pesticide applications must be in compliance with DPR's existing regulatory program, and because the DPR pesticide program was approved as meeting the requirements of CEQA with respect to the use of pesticides, the use of pesticides by DFA according to approved label directions also must comply with CEQA. (Id. at p. 17.)

The Court of Appeal held that DFA's reliance on DPR's regulatory program was not sufficient to comply with CEQA. As the lead agency, DFA was responsible for presenting the facts, data, and analysis necessary to meaningfully assess the environmental impacts of its project. (Id. at p.13; see also Whitman v. Board of Supervisors (1979) 88 Cal.App.3d 397, 411 [requiring specificity and detail in EIRs since a conclusory statement affords no basis for a comparison of the problems involved with the proposed project and the difficulties involved in the alternatives]; Cal. Code Regs., tit. 14, § 15147.) The Court held that DFA fell short of its duty under CEQA by deferring to DPR's regulatory scheme as a substitute for performing its own evaluation of the environmental impacts of its program. (Californians for Alternatives to Toxics, supra, at pp.16-17.) According to the Court, DFA could not rely solely on compliance with an existing regulatory program to conclude that its proposed project would not result in significant adverse impacts. (Id. at p. 17.) "Compliance with the law is not enough to support a finding of no significant impact under the CEQA." (Id.)

The Court in Californians for Alternatives to Toxics acknowledged that DFA's duty to analyze the effects of pesticide use must take account of DPR's existing regulatory scheme, but the Court stated that this does not require DFA to duplicate the work of DPR. The Court suggested DFA could satisfy its duty under CEQA by *considering DPR's existing data in the context of the specific project proposed* by DFA. (Id. at pp. 16, 18.) DFA's EIR, however, contained only conclusory statements, unsupported by any data or environmental analysis. Thus, the Court ruled that DFA's EIR was inadequate. (Id. at pp. 13, 17.)

As a general rule, an EIR "must contain facts and analysis, not just the bare conclusions of a public agency." (Kings County Farm Bureau v. City of Hanford (1990) 221 Cal.App.3d 711, 736, quoting Santiago County Water Dist. v. County of Orange (1981) 118 Cal.App.3d 818, 831; Laurel Heights Improvement Assn. v. Regents of the Univ. of Cal. (1988) 47 Cal.3d 376, 404 [same].) While an agency's opinion concerning matters within its expertise may be of value, the public and decision-makers, for whom the EIR is prepared, should also have before them the basis for that opinion so as to enable them to make an independent, reasoned judgment. (Kings County Farm Bureau, supra, at p. 736; Californians for Alternatives to Toxics, supra, at p. 13 ["EIR should set forth specific data, as needed to meaningfully assess whether the proposed activities would result in significant impacts"]; Citizens to Preserve Ojai v. County of Ventura (1985) 176 Cal.App.3d 421, 429 [EIR should be prepared with a sufficient degree of analysis to make a decision which intelligently takes account of environmental consequences]; see also Citizens Assoc. for Sensible Dev. of Bishop Area v. County of Inyo (1985) 172 Cal.App.3d 151, 171 [initial study must disclose the data or evidence upon which the person conducting the study relied].)

Caltrans' EIR fell short of these standards. In its EIR, Caltrans determined that because the Project is included in the MTP and MTIP and will not violate any federal "hot spot" requirements, the Project is in conformity with the SIP. The EIR assumes that conformity with the SIP is sufficient to ensure the Project's emissions of PM10, PM2.5, and O3 will conform to regional air quality standards and, therefore, be less than significant. (1 AR 151-157.) The EIR does not, however, disclose or analyze the specific traffic-based emissions that would be generated by the Project. Nor does the EIR disclose or attach the MTP/MTIP, the SIP, or the air quality data and model used by SACOG to determine the MTP/MTIP's conformity with the SIP. Rather, similar to the DFA in Californians for Alternatives to Toxics, Caltrans relied on compliance with the federal Clean Air Act regulatory scheme in lieu of performing its own independent analysis of the specific environmental consequences of its Project. As discussed above, this is not sufficient under CEQA. Compliance with environmental laws alone is not adequate to support a finding of no significant impact under CEQA.

Further, the record does not contain any evidence or analysis showing that a comprehensive analysis of the Project's actual traffic-based emissions would be infeasible or speculative. (See, e.g., 2 AR 486, 489, 503.)

As a post hoc rationalization for its failure to analyze the specific traffic-based emissions generated by the Project, Caltrans argues that a project-specific analysis of the Project's air quality impacts is unnecessary because (1) a federal Clean Air Act conformity analysis is functionally equivalent to CEQA's air quality requirements; and (2) HOV lanes are a federally recognized transportation control measure. Aside from the fact that Caltrans did not rely on these arguments in limiting the scope of its EIR, both of these arguments miss the mark.

Caltrans has not cited any authority to show that compliance with the Clean Air Act conformity analysis excuses compliance with CEQA. CEQA, unlike NEPA, does not exempt "functional equivalent" environmental schemes from its requirements. Insofar as CEQA may provide an exemption for agencies with functionally equivalent environmental responsibilities, it is only under the express statutory provision for "certified regulatory programs" set forth in Public Resources Code § 21080.5. (Mountain Lion Foundation v. Fish & Game Com. (1997) 16 Cal.4th 105, 121; City of Coronado v. California Coastal Zone Conservation Com. (1977) 69 Cal.App.3d 570, 582; see also Pub. Res. Code § 21080.5.) Here, nothing in CEQA suggests that a federal Clean Air Act conformity determination may be submitted in lieu of an EIR pursuant to the exemption in Public Resources Code § 21080.5.

Caltrans' second argument is also flawed. In essence, Caltrans argues that because the intended purpose of HOV lanes is to encourage carpooling, it is reasonable to assume the Project will reduce congestion, increase travel speeds, and decrease overall emissions. However, even if there is substantial evidence to support a determination that carpool lanes encourage carpooling, Caltrans has not cited any substantial evidence to support its assertion that encouraging carpooling means overall vehicle miles traveled and/or vehicle emissions will decrease or remain the same. Indeed, Caltrans admits that its EIR did not attempt to analyze (quantitatively or qualitatively) the Project's impacts on overall VMT, and, as discussed above, Caltrans did not independently evaluate the Project's specific traffic-based emissions. In contrast, there is evidence in the record suggesting that building HOV lanes can increase vehicle miles traveled and related emissions. (See discussion, infra.) In any event, as Petitioners contend, the EIR's failure to consider this issue – the potential of the Project to induce additional vehicle travel (i.e., new trips or longer trips) – is one of the primary reasons that the EIR is inadequate as an informational document.

Thus, Caltrans abused its discretion by relying on the Project's (purported) conformity with the SIP as a substitute for performing and presenting its own evaluation of the Project's environmental impacts. To be sufficient, the EIR must disclose and analyze the Project's specific traffic-based emissions.

In addition to failing to analyze and disclose the Project's specific traffic-based emission impacts, Caltrans also abused its discretion by relying on conformity with federal regulatory standards to foreclose consideration of potentially significant environmental impacts.

California courts have held that an agency cannot rely on established regulatory standards to foreclose consideration of substantial evidence that the project might have a significant environmental effect. (Protect the Historic Amador Waterways v. Amador Water Agency (2004) 116 Cal.App.4th 1099, 1109.) In preparing an EIR, an agency may use established regulatory standards as a measure of whether a certain environmental effect normally will be considered significant, but the agency cannot use the fact a particular environmental effect meets a threshold of significance as an automatic determinant that the effect is not significant. The agency must consider and resolve any substantial evidence of a fair argument that a certain environmental effect may be significant notwithstanding that the effect complies with established regulatory standards. (Protect the Historic Amador Waterways, supra, at p.1109; see also Cal. Code Regs., tit. 14, § 15064(i)(3).)

The Court acknowledges the fair argument standard normally would be limited to the issue of whether an EIR must be prepared. But courts in California have held that the fair argument standard also is properly applied when an agency has assessed the significance of impacts by relying on established regulatory standards. (Protect the Historic Amador Waterways, supra, at p.1109; Communities for a Better Environment, supra, at pp.113-114.) Thus, if the record contains substantial evidence to support a fair argument that the Project may have significant impacts on emissions of PM10, PM2.5, or O3, notwithstanding the Project's compliance with the federal Clean Air Act standards for those pollutants, case law holds that CEQA requires Caltrans to consider and discuss whether those possible significant environmental impacts will, in fact, be significant.

It is a question of law whether substantial evidence of a fair argument exists. (Pocket Protectors v. City of Sacramento (2004) 124 Cal.App.4th 903, 928.)

Substantial evidence to support a fair argument means "enough relevant information and reasonable inferences from this information that a fair argument can be made to support a conclusion, even though other conclusions might also be reached." (Cal. Code Regs., tit.14, § 15384; Pocket Protectors, supra, at p.927.) To raise a fair argument, it is not necessary to bring forth credentialed experts to offer scientifically irrefutable, site-specific information foretelling certain environmental harm. (Friends of the Old Trees v. Dep't of Forestry & Fire Prot. (1997) 52 Cal.App.4th 1383, 1402.) The evidence supporting a fair argument need not be overwhelming, overpowering, or even uncontradicted. (Id.)

Furthermore, because CEQA places the burden of investigation on the government rather than the public, an agency cannot hide behind its own failure to gather relevant data to defeat a fair argument. (Sundstrom v. County of Mendocino (1988) 202 Cal.App.3d 296, 311; Gentry v. City of Murrieta (1995) 36 Cal.App.4th 1359, 1379; City of Redlands v. County of San Bernardino (2002) 96 Cal.App.4th 398, 408.) The lack of study enlarges the scope of the fair argument by lending plausibility to a wider range of inferences. (Gentry, supra, at p.1379.)

The administrative record in this case contains substantial evidence to support a fair argument that the Project may cause a significant increase in traffic-based emissions notwithstanding the Project's compliance with the federal Clean Air Act conformity standards. Specifically, the administrative record contains substantial evidence of a fair argument that increasing the capacity of the highway may generate additional vehicle travel by inducing additional demand for vehicle travel (e.g., shifts from other transport modes, longer trips, new vehicle trips). (See, e.g., 23 AR 8586 [unintended effects of adding HOV lane may include induced trips]; 24 AR 8960, 8963 [noting statistically significant relationship between adding lane miles and VMT]; 2 AR 426, 428-430 [citing research discussing induced demand from expansion of roadway capacity]; 11 AR 3609 [discussing findings of model showing HOV lanes increase travel and emissions]; 11 AR 3683, 3692 [study discussing high occupancy vehicle lanes in the Sacramento region and noting that HOV lanes may increase VMT and emissions compared to no-build scenario].)

There also is substantial evidence of a fair argument that additional traffic generated by the Project may have a significant environmental impact on emissions of NOx, PM10, and PM2.5. There is substantial evidence, for example, that the Project may exceed SMAQMD's threshold of significance for NOx and cause non-attainment of the state standards for PM2.5 and PM10. (See 2 AR 463 [commenting that project may exceed SMAQMD's thresholds of significance for ROG and NOx]; 2 AR 398-399 [commenting that levels of PM10 measured at Branch Center Road station annually violate state ambient air quality standards and that the PM2.5 monitoring station closest to the Project regularly measures pollutant concentrations in excess of state standards]; 9 AR 3180-3181 [traffic report showing increase in freeway vehicle throughput relative to no build scenario].)

However, Caltrans did not consider or discuss the potential environmental impacts of induced demand in the EIR. The EIR discusses the Project's potential growth-inducing impacts on population and economic growth and land use patterns, and discusses the Project's potential to generate additional highway travel during peak periods by inducing shifts in routes or time of travel, but the EIR does not consider the potential for additional highway travel as a result of "induced demand." (2 AR 89-92, 475-477, 485-486, 490, 494, 498; 9 AR 3170.) The EIR expressly assumes, without support, that any additional highway traffic will consist of time of day or route shifts and will not increase overall VMT. (Id.) It is noteworthy that the administrative record includes an emissions study that accounts for induced demand, but the study was not analyzed in the EIR, was limited to a 5-year period, and expressly states that a "more expanded analysis is needed" to adequately compare the long-term emissions benefits/disadvantages of HOV lanes relative to a no-build scenario. (24 AR 8960; see Calif. Oak Found. v. City of Santa Clarita (2005) 133 Cal.App.4th 1219, 1239 [information scattered in EIR or buried in appendix is not substitute for good faith reasoned analysis].)

Caltrans argues that increases in VMT do not necessarily result in higher overall emissions, since emissions are a function of speed as well as VMT. (Opposition Brief, pp.9, 10.) However, there is substantial evidence in the record that emissions vary with VMT, and Caltrans did not perform a specific analysis of the Project's impacts on overall emissions. Thus, at best, Caltrans can argue that even if the Project increases overall VMT, it nevertheless might reduce overall emissions. But it is the failure to disclose and analyze these potentially significant impacts that renders the EIR inadequate from an informational standpoint.

Thus, the Court concludes that Caltrans applied the federal Clean Air Act conformity standards in a way that foreclosed the consideration of substantial evidence tending to show the Project may have significant air quality impacts notwithstanding its compliance with the federal conformity standards. Caltrans was not compelled to find that the Project will have a significant impact on emissions of NOx, PM10, and PM2.5, but Caltrans should have analyzed and discussed whether the Project may have a significant impact on such emissions notwithstanding the Project's compliance with the federal Clean Air Act conformity standards.

For all of these reasons, the Court concludes that the EIR is inadequate and incomplete as an informational document in respect to the Project's operational impacts on emissions of NOx, PM10, and PM2.5.

The Determination that the Project Will Not Increase Vehicle Miles Traveled

Petitioners argue that Caltrans' analysis regarding the Project's potentially significant environmental impacts relies upon a determination that the Project will not result in an increase in VMT (vehicle miles traveled). Petitioners allege that this conclusion is not supported by substantial evidence in the record. Rather, Petitioners claim, the administrative record shows that construction of HOV lanes induces additional demand, which will result in an increase in overall VMT. (See Petitioners' Reply Brief, p.13 [citing 2 AR 428; 9 AR 3154, 3180; 10 AR 3589-3607; 11 AR 3609, 3683, 3685, 3689, 3692; 24 AR 8960, 9194].)

Caltrans denies that its EIR was based on any analysis, or any determination, of the Project's impact on VMT. (See Opposition Brief, pp.18, 20.) This is correct. The record shows that Caltrans made no effort to disclose or analyze the impact that the Project may have on overall VMT in the Highway 50 corridor.

Since Caltrans never determined the Project's impact on overall VMT, it is unnecessary for the Court to decide whether that determination is supported by substantial evidence. However, to the extent Caltrans assumed for purposes of its EIR that the Project would have no impact on overall VMT, the Court finds that assumption is not supported by substantial evidence, for the reasons discussed above.

The Project's Potentially Significant Impacts on Local Roads and Parking

Petitioners allege the EIR fails to adequately disclose and analyze the Project's impacts on the volume, distribution, and flow of traffic on local roadways, and on the demand for parking in downtown Sacramento.

The EIR states that parallel routes and local street connections at freeway off-ramps were analyzed up to the first intersection, but Caltrans concedes that the EIR does not quantify these impacts. (See Respondent's Supplemental Brief, p. 7; see also 2 AR 497, 500.) Caltrans contends that the EIR nevertheless adequately discussed the Project's impacts on local roadways and parking since there is no reason to believe that the Project would have a potentially significant adverse impact on local roads or parking.

Although the EIR's failure to disclose the analysis of the Project's impacts on local street connections renders the EIR less than perfect, the Court is not persuaded that it precluded informed decision making and informed public participation. Even if the Project will increase the number of vehicles exiting the highway and entering local roads, the Final EIR adequately discusses this issue. (See 2 AR 485 [parallel routes were analyzed as were all local street connections at off-ramp termini up to first intersection], 490 [traffic study does not suggest commuters would be likely to divert to local streets as result of project], 491 [not practical for Caltrans to model the entire local street system], 496 [project would not alter traffic patterns in central Sacramento, and traffic signal connections would control the flow rate of traffic onto city streets], 497 [induced parking demand is not anticipated], 502 [Caltrans lacks authority to impose or enforce parking requirements].)

The EIR's discussion of the Project's impacts on local roads and parking is adequate.

The Project's Growth Inducing Impacts

Petitioners allege the EIR fails to adequately analyze the Project's growth inducing impacts.

Under CEQA, a project has growth inducing impacts if it will (1) foster economic or population growth or additional housing; (2) remove obstacles to growth; or (3) facilitate other activities that cause significant environmental effects. (Cal. Code Regs., tit.14, § 15126.2(d); see also City of Antioch v. City Council (1986) 187 Cal.App.3d 1325, 1335-1338; Stanislaus Audobon Society, Inc. v. County of Stanislaus (1995) 33 Cal.App.4th 144, 152-160; Napa Citizens for Honest Gov't v. Board of Supervisors (2001) 91 Cal.App.4th 342, 367-371.)

In discussing the Project's growth inducing impacts, a distinction must be made between the concept of "induced demand" and Petitioners' use of the phrase "growth inducing impacts." "Induced demand" is the concept that the increase in the capacity of the highway may generate additional vehicle travel by inducing additional demand for vehicle travel (e.g., shifts from other transport modes, longer trips, new vehicle trips). In contrast, when Petitioners refer to the Project's "growth inducing impacts," Petitioners are referring to the ways in which the proposed Project could directly or indirectly foster economic, population, or housing growth in the surrounding environment, and the related effects this might have on traffic and the environment. (Cal. Code Regs., tit. 14, §§ 15126.2(d), 15358(a)(2).) "Induced demand" is broader than a project's "growth inducing impacts" in that a highway project's "growth inducing impacts" may contribute to "induced demand," but "induced demand" also may occur even if the project will not have any "growth inducing impacts." In this section, the Court is addressing only Petitioners' assertion that the EIR did not adequately disclose and analyze the Project's "growth inducing impacts."

In this context, Petitioners allege the EIR failed to adequately disclose and analyze the Project's growth inducing impacts because the EIR states that population and employment growth occurs independent of the Project and will accelerate in the future with or without the addition of HOV lanes on U.S. Highway 50. Petitioners contend that the EIR is trivializing the Project's growth inducing impacts. (See Kings County Farm Bureau v. City of Hanford (1990) 221 Cal.App.3d 711, 718 [project's impact may be significant even though project contributes only a small amount to an existing problem].) Petitioners allege there is substantial evidence in the record to show that increases to highway capacity facilitate and accommodate regional growth. Thus, Petitioners contend, the EIR's analysis must use separate growth projections for the build and no-build scenarios to adequately account for the growth-inducing impacts of the Project.

Petitioners claim lacks merit. The EIR did not, as Petitioners suggest, find that growth in the Sacramento region occurs independent of construction of new highway capacity. To the contrary, the EIR expressly finds that regional traffic projects may have an impact on regional growth or land use. However, given existing and projected development in the area, and given the data showing that the Project is not expected to eliminate peak period traffic congestion or significantly improve the highway's peak period level of service,
Caltrans determined that the proposed Project would not add sufficient additional highway capacity to significantly affect growth patterns in the U.S. 50 corridor. (1 AR 89-92, 201-202; 2 AR 475, 485, 492, 494, 498.) This determination is supported by substantial evidence in the record. (Id.; 9 AR 3167-3168.) Accordingly, the Court concludes that the EIR adequately analyzes the Project's growth inducing impacts.

The Project's Contribution to Global Warming

Petitioners argue that the EIR also violates CEQA because it fails to analyze the Project's contributions to global warming. In light of the Governor's Executive Order (S-3-05) on global warming, and the legislative requirement that greenhouse gas (GHG) emissions be reduced to 1990 levels by the year 2020, Petitioners contend CEQA requires agencies to analyze a project's impacts on global warming. In order to properly analyze a project's global warming impacts, Petitioners assert, an EIR should (i) provide a regulatory and scientific background on global warming; (ii) assess the project's contribution to

GHG emissions and the potential impact of those GHG emissions on global warming; (iii) assess the effect of climate change on the project and its impacts; and (iv) make a significance determination.

Caltrans argues that the field of global warming is still in its "infancy." Caltrans notes that the California Global Warming Solution Act of 2006, codified at Health & Safety Code § 38500 et seq., was the nation's first mandatory cap on GHG emissions. Caltrans also notes that evaluation of a project's impact on global warming traditionally has not been demanded under CEQA. Although the Legislature has directed the Office of Planning and Research to develop guidelines for addressing GHG emissions in CEQA, those guidelines do not yet exist and are not required to be finalized until January 1, 2010. Consequently, Caltrans argues there is no workable framework for presenting the GHG analysis that Petitioners demand. According to Caltrans, this means any analysis of the Project's impact on global warming is too speculative for evaluation under CEQA.

Caltrans also argues that this Project's failure to analyze the effects of GHG emissions is not subject to legal challenge pursuant to Public Resources Code § 21097.

The Court agrees with Petitioners that the exemption in Public Resources Code § 21097 does not apply to this Project.

Although § 21097 exempts certain transportation projects – including, potentially, this one – from claims based on a failure to adequately analyze the effects of GHG emissions, that statute applies retroactively only to EIRs that have not become "final." The dispute in this case centers on the meaning of the term "final."

Caltrans contends – not unreasonably – that if the term "retroactively" is to have any meaning, then § 21097 must apply to EIRs certified before adoption of the legislation. If the intent merely was to make § 21097 retroactive to uncertified EIRs, Caltrans argues, then subdivision (c) was superfluous because § 21097 already would have applied to conduct occurring after the effective date of the statute, including certification of an EIR. (See Fairbank v. City of Mill Valley (1999) 75 Cal.App.4th 1243, 1257 [propriety of agency action under CEQA is determined on the date on which the document is presented for public review].) Because the general purpose of the statute was to insulate certain state transportation projects from causes of action based on a failure to adequately analyze the effects of GHG emissions, Caltrans claims the intent of subdivision (c) was to make the protections of § 21097 retroactive to all EIRs, including previously certified EIRs, provided the cause of action itself had not become "final."

In response, Petitioners argue that the statute plainly and unambiguously provides it "shall apply retroactively to an environmental impact report . . . that has not become final." Thus, Petitioners claim, retroactivity depends on the finality of the EIR, not the finality of the cause of action. Petitioners contend that the Legislature used the term "retroactively" to clarify that § 21097 would apply to steps in the CEQA process already undertaken on the effective date of the legislation, provided the EIR or other document had not yet become "final." (See Cal. Code Regs., tit. 14, § 15007(b).)

Although both arguments have some appeal, the Court is persuaded that Petitioners have the better argument. It is the Court's opinion that the Legislature used the word "final" in the same sense it is used in Code of Civil Procedure § 1094.5. (See Civ. Proc. Code § 1094.5 [providing for inquiry into the validity of any final administrative order or decision].) The Legislature did not intend § 21097(a) to apply to a Final EIR certified before the effective date of the legislation.

Section 21097 was signed into law on August 24, 2007, and became effective on January 1, 2008. Caltrans certified its Final EIR on June 21, 2007, months before the effective date of the legislation. Thus, this project does not qualify for the exemption in Public Resources Code § 21097.

The Court next considers whether the EIR provided adequate information about the Project's contributions to global warming, and concludes it did not.

The EIR recognizes the concern that GHG emissions raise for climate change, but concludes that because there is no accepted federal, state, or regional methodology for GHG emission and climate change impact analysis, analyzing the impacts associated with an increase in GHG emissions at the project level is not currently possible. (1 AR 159.)

However, as Petitioners point out, nothing in the administrative record supports Caltrans' conclusion that it is not possible to quantify the Project's GHG emissions, at which point, Caltrans could make its own evaluation of their significance. While CEQA does not require an agency to foresee the unforeseeable, CEQA does require an agency to use its best efforts to find out and disclose all that it reasonably can. (Cal. Code Regs., tit. 14, § 15144.) Only after thorough investigation may an agency find that a particular impact is too speculative for evaluation and terminate its discussion of the impact. (Cal. Code Regs., tit. 14, § 15145 [emphasis added]; see Berkeley Keep Jets Over the Bay Committee v. Board of Commissioners (2001) 91 Cal.App.4th 1344, 1370-1371 [fact that a single methodology does not currently exist does not excuse evaluation].) Here, there is no evidence in the record that Caltrans performed any investigation whatsoever. This fell short of Caltrans' duty to make a good faith effort to investigate and disclose all that it reasonably can.

Caltrans must meaningfully attempt to quantify the Project's potential impacts on GHG emissions and determine their significance, or at the very least explain what steps it has taken that show such impacts are too speculative for evaluation.

The Project's Construction-Related Impacts on Air Quality

Petitioners also allege that the EIR violates CEQA because it fails to quantify and adequately analyze the Project's construction-related impacts on air quality.

Caltrans concedes that construction equipment will generate emissions while the Project is being built. Nevertheless, Caltrans argues that the EIR is adequate in terms of informing the public about these environmental impacts. According to Caltrans, the EIR adequately advises the public that the Project may result in the generation of short-term construction-related emissions, and that such emissions will be controlled and rendered less than significant by requiring compliance with best management practices, Caltrans' Standard Specifications, and all pertinent rules, regulations, and ordinances of the SMAQMD. (See 1 AR 12, 157, 199; 2 AR 505.)

As described above, the sufficiency of the information contained in an EIR is reviewed in light of what is reasonably feasible. (Cal. Code Regs., tit. 14, § 15151; Rio Vista Farm Bureau Ctr. v. County of Solano (1992) 5 Cal.App.4th 351, 374-375.) "Feasible" means "capable of being accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, legal, social, and technological factors." (Cal. Code Regs., tit. 14, §§ 15147, 15364; see also Citizens to Pres. the Ojai v. County of Ventura (1985)176 Cal.App.3d 421, 429-430 [noting courts favor specificity and use of detail in EIRs].)

In this case, an evaluation of the Project's short-term construction-related emissions reasonably was feasible using SMAQMD's established methodology and thresholds of significance. (See 2 AR 463; 13 AR 4536.) Yet Caltrans made no effort to quantify this Project's construction-related air quality impacts or to analyze whether and to what extent the Project is or is not consistent with SMAQMD's threshold of significance. Nor does the EIR explain why an analysis of the Project's construction-related air quality impacts would be infeasible. (See, e.g., 2 AR 505; see also Ojai, supra, at p.430 [EIR failed to explain reliance on earlier analysis]; Berkeley Keep Jets Over the Bay Committee v. Board of Commissioners (2001) 91 Cal.App.4th 1344, 1368-1370 [EIR failed to support decision not to evaluate health risks with any meaningful analysis].) Accordingly, Caltrans' EIR failed to adequately disclose and consider the Project's potentially significant construction-related emissions.

The Description and Analysis of the Project's Community Enhancements

Petitioners allege Caltrans' EIR is inadequate because it does not provide a stable and accurate project description.

An accurate, stable, and finite project description is the sine qua non of an informative and legally sufficient EIR. (County of Inyo v. City of Los Angeles (1977) 71 Cal.App.3d 185, 193.) An adequate project description is necessary to ensure that CEQA's goals of providing information about a project's environmental impacts will not be rendered useless. An overly narrow description of a project could result in an agency overlooking a project's cumulative impact by focusing on the isolated parts of the whole. (Rio Vista Farm Bureau Ctr. v. County of Solano (1992) 5 Cal.App.4th 351, 370.) Thus, to further the objectives of CEQA, the term "project" is defined broadly to include the "whole of an action, which has a potential for resulting in either a direct physical change in the environment, or a reasonably foreseeable indirect change in the environment." (Cal. Code Regs., tit. 14, § 15378(a).)

The description of a project in an EIR should be sufficient to provide public agencies and the public with detailed information about the effects the proposed project is likely to have on the environment. (Dry Creek Citizens Coalition v. County of Tulare (1999) 70 Cal.App.4th 20, 26.)

On the other hand, the project description in an EIR is not required to supply extensive detail beyond that needed for evaluation and review of the environmental impact of the project actually being proposed. (Cal. Code Regs., tit. 14, § 15124.) CEQA requires consideration only of the potential environmental effects of the proposed project, not some hypothetical project. (Rio Vista Farm Bureau Ctr. v. County of Solano (1992) 5 Cal.App.4th 351, 372.) No purpose would be served by requiring an EIR to speculate as to the environmental consequences of future activities that are unspecified or uncertain when the project is proposed. (Id. at pp.372-373.) Accordingly, the project description in an EIR should not include future activities if it is not possible to provide meaningful information about those activities at the time the project is proposed. (Id.)

Petitioners allege Caltrans' EIR does not provide a stable and accurate project description because it fails to adequately identify and describe the proposed "community enhancements."

The Draft EIR states that Caltrans is committed to provide funding for "community enhancements" proposed by the Citizens Advisory Committee and/or requested by affected local governments. (2 AR 513, 524, 535-536.) Although the CAC and local governments identified numerous potential community enhancements – both within and without Caltrans' right-of-way – the Draft EIR never identifies what enhancements will be included in the Project. Similarly, the Final EIR states that the community enhancements will include certain sound walls and landscaping, but it does not state that the community enhancements will be limited to soundwalls and landscaping. (1 AR 32-33.)

Caltrans concedes that the EIR does not identify and describe all the "community enhancements" that actually will be included in the Project. However, Caltrans contends this was reasonable and necessary because it was not possible to identify all of the community enhancements at the time the Project was proposed. According to Caltrans, the final list of community enhancements could not be determined until after the close of the environmental review process because each affected local jurisdiction has the discretion to decide how to spend its share of the community enhancement funds, and such decisions do not have to be made until funding is actually allocated to the local jurisdictions.

Notwithstanding the obvious uncertainty as to what community enhancements will be constructed as part of the Project, (1 AR 6), the Court agrees with Caltrans that the uncertainty does not arise from any attempt by Caltrans to improperly constrain its environmental review by improper segmenting. Rather, it arises from a good faith effort to be inclusive -- or perhaps over-inclusive -- in describing the "whole of the action" being approved. (See, e.g., Cal. Code Regs., tit. 14, § 15378(b)(4) [a project does not include creation of government funding mechanisms or fiscal activities which do not include any commitment to any specific project].)

Caltrans has made clear that if a local jurisdiction chooses to commit funding to a community enhancement that was not evaluated in the EIR, then that enhancement will be subject to full CEQA review. Caltrans maintains that no community enhancement will be constructed without full CEQA review. Thus, while the EIR's description of the project was not perfect, the description did not preclude informed decision making and informed public participation. (See, e.g., Dusek v. Redev. Agency of City of Anaheim (1985) 173 Cal.App.3rd 1029, 1040-1041 [discrepancy between project description and project approved does not violate CEQA where agency approves a narrower project than that described in EIR]; see also Laurel Heights Improvement Assn. v. Regents of the Univ. of Cal. (1988) 47 Cal.3d 376, 394 [upholding description that defined projects as "[moving] the School of Pharmacy basic science research units from the UCSF Parnassus campus to Laurel Heights"]; Nat'l Parks & Conservation Ass'n v. County of Riverside (1996) 42 Cal.App.4th 1505, 1520 [deferral of environmental assessment does not violate CEQA where an EIR cannot currently provide meaningful information about uncertain or unspecified future projects].)

In addition to challenging the description of the project, Petitioners allege that the EIR failed to adequately disclose and analyze the potential environmental impacts of the community enhancements.

For the reasons discussed above, the Court concludes that the EIR was not rendered inadequate for failing to discuss possible community enhancements that either were not reasonably foreseeable at the time the project was proposed or that will not have any significant effect on the project or its environmental impacts. (See Laurel Heights Improvement Assn., supra, at pp. 395-396.)

However, in respect to the prospective community enhancements that were identified by the CAC and affected local governments, the Court agrees with Petitioners. The Court could not locate any analysis or evaluation of the possible adverse environmental impacts of the identified community enhancements. (See Sacramento Old City Ass'n v. City Council (1991) 229 Cal.App.3d 1011, 1027 [if the inclusion of a mitigation measure would itself create new significant effects, these too, must be discussed].) This lack of analysis renders this portion of the EIR inadequate as an informational document.

The Geographic Scope of the EIR's Cumulative Impact Analysis

Petitioners allege the geographic scope of the EIR's cumulative impact analysis was unduly restricted to the Highway 50 corridor. Petitioners assert the geographic scope of the cumulative impact analysis should be regional (i.e., the area under the jurisdiction of the SMAQMD), rather than strictly limited to the Highway 50 corridor. (See Opening Brief, p. 19 [citing Citizens to Preserve the Ojai v. County of Ventura (1986) 176 Cal.App.3d 421, 431-432; Cal. Code Regs., tit.14, § 15130(b)(3)].)

When determining the geographic scope of the area affected by the cumulative impacts of a project, the court reviews whether the lead agency has provided a reasonable explanation for the geographic limitation used. (Cal. Code Regs. tit. 14, § 15130(b)(3).)

Caltrans maintains that the geographic scope of its cumulative impact analysis was reasonable under the circumstances. The Court agrees.

For analysis related to transportation impacts, the scope of Caltrans analysis encompassed the Highway 50 corridor, but also considered the impacts from development projects in a larger area encompassing Rancho Cordova, Folsom, downtown Sacramento, and the unincorporated areas of Sacramento County. (See 7 AR 2508-2532; 1AR 198; see also 1 AR 198-259.) For analysis related to air quality, the EIR's analysis was regional, encompassing the entire Sacramento Valley Air Basin. (1 AR 151, 199.) Caltrans has provided a reasonable explanation for the geographic scope of its cumulative impact analysis. Thus, the geographic scope of the EIR's cumulative impact analysis did not violate CEQA.

The EIR's Discussion of Project Alternatives

Petitioners allege that the EIR is inadequate because it fails to discuss a reasonable range of project alternatives.

CEQA does not require an EIR to consider every conceivable alternative to a project. CEQA only requires an EIR to describe a range of potentially feasible alternatives.

The range of alternatives required to be considered in an EIR is governed by a "rule of reason." (Cal. Code Regs., tit. 14, § 15126.6(f).) The EIR should include those alternatives that could feasibly accomplish most of the basic objectives of the project and could avoid or substantially lessen one or more significant effects. (Cal. Code Regs., tit. 14, § 15126.6(a), (c).)

There is no categorical legal imperative as to the scope of alternatives to be analyzed in an EIR; each case must be evaluated on its facts. However, the range of alternatives considered in an EIR must represent enough variation to allow informed decisionmaking and informed public participation. (Cal. Code Regs., tit. 14, § 15126.6(a); Preservation Action Council v. City of San Jose (2006) 141 Cal.App.4th 1336, 1351.)

An EIR is required to include an in-depth discussion of those alternatives identified as at least potentially feasible. (Preservation Action Council, supra, at pp.1350-1351; Citizens of Goleta Valley v. Bd. of Supervisors (1990) 52 Cal.3d 553, 569.) On the other hand, an EIR is not required to consider alternatives which are infeasible. (Id.) Thus, the lead agency must make an initial determination as to which alternatives are potentially feasible and merit in-depth consideration, and which do not. (Citizens of Goleta Valley, supra, at p.569.)

The Legislature has defined "feasible" for purposes of CEQA to mean "capable of being accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, social, and technological factors." (Pub. Res. Code § 21061.1; see also Cal. Code Regs., tit. 14, § 15364.) Among the factors that may be taken into account when assessing feasibility of alternatives are site suitability, economic viability, availability of infrastructure, general plan consistency, other plans or regulatory limitations, jurisdictional boundaries, and whether the proponent reasonably can acquire, control, or otherwise have access to the alternative site. (Cal. Code Regs., tit. 14, § 15126.6(f)(1); Citizens of Goleta Valley, supra, at pp.574-575.)

The EIR should briefly describe the rationale for selecting the potentially feasible alternatives considered in-depth in the EIR. (Cal. Code Regs., tit. 14, § 15126.6(c).) The EIR also should identify the alternatives that were rejected during the scoping process, and briefly explain the reasons underlying the agency's determination. (Id.) Evidence of infeasibility need not be found within the EIR itself. However, a finding of infeasibility must be supported by substantial evidence in the record. (Citizens of Goleta Valley, supra, at p. 569.)

Here, Petitioners acknowledge that Caltrans considered and rejected many alternatives during the scoping process. (See 1 AR 24-32.) Nevertheless, Petitioners allege that the EIR fails to discuss a reasonable range of alternatives because the EIR considered only two "build" alternatives – with little variation between them – and failed to consider a transit-only alternative. (1 AR 24-32.) The Court agrees.

The EIR did not include an in-depth discussion of the transit-only alternative because SACOG's HOV-US 50 Corridor Study suggested that both light rail extensions and HOV lanes were necessary to alleviate congestion in the corridor. (1 AR 30.) But even if this statement is accurate, it is not a proper basis to reject the transit-only alternative as infeasible. (Cal. Code Regs., tit.14, § 15126.6(b) ["the discussion of alternatives shall focus on alternatives . . . which are capable of avoiding or substantially lessening any significant effects of the project, even if these alternatives would impede to some degree the attainment of the project objectives, or would be more costly."])

The test is not whether the transit-only alternative is the best strategy to achieve the Project's objectives, but whether it is a reasonable alternative that could feasibly accomplish most of the basic objectives of the Project and avoid or substantially lessen one or more of the Project's significant effects. (Cal. Code Regs., tit.14, § 15126.6; Wildlife Alive v. Chickering (1976) 18 Cal.3d 190, 197 [one of EIR's major functions is to ensure that all reasonable alternatives are thoroughly assessed].)

In this case, the objectives of the Project are to improve mobility, provide an option for reliable peak period travel time, improve traffic operations by reducing congestion and travel time, use highway facilities as efficiently as possible, provide incentives for commuters to use carpools, vanpools, or buses during peak period travel, and identify projects and strategies to improve adjacent street system and thereby enhance neighborhood livability. (1 AR 20.) The transit-only alternative is a potentially feasible alternative that could accomplish most of the basic objectives of the Project, while potentially avoiding or substantially lessening one or more potentially significant effects. (2 AR 417, 432-433; 11 AR 3648.) Thus, the transit-only alternative is a reasonable alternative that merits discussion and comparison to the two build options discussed in the EIR.

Because the EIR included only two build alternatives, with little variation between them, Caltrans' failure to include an in-depth discussion of the transit-only alternative precluded informed decision-making and informed public participation and rendered the EIR's discussion of alternatives inadequate. (Laurel Heights Improvement Assn. v. Regents of University of California (1988) 47 Cal.3d 376, 403-404.)

Impermissible Segmentation of Environmental Review

Petitioners contend that Caltrans impermissibly segmented its environmental review because the EIR fails to analyze a foreseeable extension of HOV lanes on major highways throughout the Sacramento region.

Although Caltrans admits that SACOG has an HOV network in concept, Caltrans denies that this Project is part of a larger enterprise to construct a comprehensive network of HOV lanes throughout the Sacramento region.

As described above, an EIR must consider all future phases of a project as the "whole of the action" so that "environmental considerations [do] not become submerged by chopping a large project into many little ones . . . ." (Burbank-Glendale-Pasadena Airport Auth. v. Hensler (1991) 233 Cal. App. 3d 577, 592.) On the other hand, CEQA does not require a detailed environmental analysis of every future activity that conceivably may occur. Where future activities are unknown or uncertain, no purpose would be served by requiring an EIR to speculate about their environmental consequences. (Laurel Heights Improvement Ass'n v. Regents of University of California (1988) 47 Cal.3d 376, 395, 398-399.) Generally speaking, an EIR should be prepared as early as feasible to enable environmental considerations to influence project design yet late enough to provide meaningful and reliable information for environmental review. (Id. at p. 395.)

In Laurel Heights, the California Supreme Court considered the difficult question of when an EIR is required to analyze the environmental effects of future activities that may become part of the project. The Court held that an EIR must analyze the environmental effects of a future activity if (1) it is a reasonably foreseeable consequence of the initial project; and (2) the future expansion or action will be significant in that it will likely change the scope or nature of the initial project or its environmental effects. (Id. at p. 396; see also Cal. Code Regs., tit. 14, § 15165.) Future activities not currently proposed for approval, and not reasonably foreseeable, need not be analyzed in the EIR. (Nat'l Parks & Conservation Ass'n v. County of Riverside (1996) 42 Cal.App.4th 1505, 1520.)

In Del Mar Terrace Conservancy, Inc. v. City Council (1992) 10 Cal.App.4th 712, the Fourth Appellate District Court of Appeal upheld a trial court's use of a federal standard for evaluating the specific issue of whether a particular highway project is an impermissible segmentation of a larger roadway project. (Del Mar Terrace Conservancy, Inc. v. City Council (1992) 10 Cal.App.4th 712, 732-735, disapproved on other grounds by Western States Petroleum Assn. v. Superior Court (1995) 9 Cal.4th 559.) The federal standard uses the following criteria to evaluate whether a proposed highway segment may be reviewed separately: (1) is the highway segment located between logical terminal points; (2) is the segment of sufficient length to assure adequate consideration of alternatives; (3) does the segment have "independent utility;" (3) and (4) does the segment seem to serve important state and local needs, such as relieving particular traffic congestion? (Id. at pp. 732-733.) The Court also considered whether approval of the segment would irretrievably commit the agency to a definite course of action in regard to other highway segments. (Id. at p. 734.)

Applying the criteria in Laurel Heights and, more specifically, Del Mar Terrace, the Court concludes that Caltrans did not impermissibly segment its environmental review of this Project. The evidence in the record supports the determination that this Project is of substantial length, is located between logical terminal points, serves important state and local needs, and has independent utility. Further, approval of the project would not irretrievably commit Caltrans to construct any other HOV-related projects. The eventual possible construction of a comprehensive network of HOV lanes throughout the Sacramento region was not, at the time the EIR was prepared, a reasonably anticipated future project. (2 AR 480.)

The CEQA Guidelines provide that where a project is one of several similar projects of a public agency, but is not deemed part of a larger project, the agency may prepare one EIR for all projects, or one for each project, but shall in either case comment, in at least general terms, upon the cumulative effect. (Cal. Code Regs., tit. 14, § 15165; see also Del Mar Terrace, supra, at p. 735, 736-737.) The Court's review of the record shows that Caltrans' EIR met this standard. (See, e.g., 1 AR 79, 83, 198, 205.)

The CEQA Findings

Petitioners finally allege Caltrans' Findings violate CEQA because (i)
Caltrans failed to adopt a mitigation monitoring plan; (ii) the Findings fail to specify the location and custodian of the record of proceedings; and (iii) the Findings are not supported by substantial evidence.

Caltrans contends that nothing in CEQA requires an agency to adopt a mitigation monitoring program as part of its Findings.

However, even if CEQA does not state how a mitigation monitoring plan may be adopted, CEQA clearly states when a mitigation monitoring plan must be adopted. Specifically, CEQA states that the lead agency is required to adopt its mitigation monitoring program "[w]hen making the findings required [for approval of the project under] Section 21081 . . . ." (Pub. Res. Code § 21081.6(a)(1); Cal. Code Regs., tit. 14, § 15091(d) ["When making the findings required in subdivision (a)(1), the agency shall also adopt a program for reporting on or monitoring the changes which it has either required in the project or made a condition of approval to avoid or substantially lessen significant environmental effects."]; Cal. Code Regs., tit. 14, § 15094(b)(6) [notice of determination, which is required to be filed within 5 five working days after approval, must state whether a mitigation monitoring plan/program was adopted]; see also Cal. Code Regs., tit. 14, § 15097(a) [requiring mitigation monitoring or reporting program in order to ensure that mitigation measures and project revisions identified in EIR are implemented].) Thus, while the agency is not required to include the mitigation monitoring program as part of the EIR or (arguably) the Findings, the agency is required to adopt the mitigation monitoring program when the Findings are made, and before the agency files its notice of determination. (Cal. Code. Regs., tit. 14, §§ 15091(d), 15094(b)(6).)

Nothing in the record before this Court establishes that Caltrans adopted a mitigation monitoring plan when the Findings were made. (1 AR 1.) Although Caltrans refers to a list of "Environmental Commitments" purportedly "developed" in June 2007, (see Opposition Brief, p. 36 fn.33), there is no evidence that Caltrans adopted this document as its mitigation monitoring plan. Nor is there any mention of a mitigation monitoring plan in the Notice of Determination. (4 AR 1419-1420.) Consequently, Caltrans should correct (or clarify) its Findings and/or Notice of Determination.

Caltrans' Findings also appear to violate CEQA because they do not specify the location and custodian of the documents which constitute the record of proceedings upon which its decision was based. (Cal. Code Regs., tit. 14, § 15091(e).) The Court is not persuaded that the omission of this information was prejudicial, since the information was included in Caltrans' Notice of Determination. (1 AR 1.) Nevertheless, on remand, Caltrans should modify its Findings to conform to the requirements of CEQA.

The Findings also violate CEQA because substantial evidence does not support Caltrans' finding that the EIR was adequate. (See Cal. Code Regs., tit. 14, § 15090.)

Conclusion

In conclusion, the petition is granted in respect to Petitioners' claims the EIR is inadequate in the following respects:
a) the EIR fails to adequately disclose and analyze the Project's operational and construction-related air quality impacts;
b) the EIR fails to adequately disclose and analyze the Project's potential impacts on GHG emissions and climate change;
c) the EIR fails to adequately disclose and analyze the possible effects of the identified community enhancements;
d) the EIR fails to consider a reasonable range of potentially feasible alternatives; and
e) the Findings are inadequate and not supported by substantial evidence.

To be sufficient, the EIR must: (a) disclose and analyze the Project's specific traffic-based emissions; (b) meaningfully attempt to quantity the Project's potential impact on GHG emissions and determine their significance (or explain what steps Caltrans has taken that show such impacts are too speculative for evaluation); (c) disclose and analyze the Project's potentially significant construction-related impacts; (d) disclose and analyze the possible significant environmental impacts of the identified community enhancements; and (e) identify and evaluate the transit-only alternative as a potentially feasible alternative to the Project.

The petition is denied in all other respects.

A peremptory writ of mandate shall issue from this Court commanding Caltrans to (i) set aside its certification of the portions of the environmental impact report that analyze the significance of the Project's operational and construction-related air quality impacts and that consider potentially feasible alternatives to the Project; (ii) prepare, circulate, and consider a new EIR for the Project that is consistent with the views expressed in this opinion before proceeding with the Project; (iii) suspend all activity that could result in any change or alteration to the physical environment until Caltrans has taken such action as may be necessary to bring the Project into compliance with CEQA; and (iv) file a return in this Court within six months after the issuance of the writ specifying what Caltrans has done to comply with the writ.

Petitioners are directed to prepare a formal judgment incorporating this ruling by reference, and a peremptory writ of mandate; submit them to opposing counsel for approval as to form; and thereafter submit them to the Court for signature and entry of judgment in accordance with Rule of Court 3.1312. Petitioners shall be entitled to recover their costs upon appropriate application. The Court shall retain jurisdiction to determine compliance with the writ and any motion for an award of attorney fees.

Case No. 07CS00967
Name of Case: Environmental Council of Sacramento, et al. vs. CA Dept. of Transportation, et al.

CERTIFICATE OF SERVICE BY MAILING
(C.C.P. Sec. 1013a(4))

I, the undersigned deputy clerk of the Superior Court of California, County of Sacramento, do declare under penalty of perjury that I did this date place a copy of the above-entitled RULING AFTER HEARING a notice envelopes addressed to each of the parties or their counsel of record as stated below, with sufficient postage affixed thereto and deposited the same in the United States Post Office at Sacramento, California.

Donald B. Mooney
Attorney at Law
129 C Street. Suite 2
Davis, CA 95616

Martin Keck
Attorney for Department of Transportation
1120 N Street (MS-57)
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Sacramento, CA 95812-1438

I, the undersigned Deputy Clerk, declare under penalty of perjury that the foregoing is true and correct.

Dated: 7/15/08

SUPERIOR COURT OF CALIFORNIA
COUNTY OF SACRAMENTO

By: L. YOUNG
Deputy Clerk

PROOF OF SERVICE

I am employed in the County of Yolo; my business address is 129 C Street, Suite 2, Davis, California; I am over the age of 18 years and not a party to the foregoing action. On July 25, 2008, I served a true and correct copy of

[PROPOSED] JUDGMENT GRANTING PETITION FOR WRIT OF MANDATE

X (by mail) on all parties in said action listed below, in accordance with Code of Civil Procedure §1013a(3), by placing a true copy thereof enclosed in a sealed envelope in a United States mailbox in the City of Davis, California.

Martin Keck
Legal Division
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1120 N Street (MS-57)
P.O. Box 1438
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Representing Respondents California Department of Transportation

I declare under penalty of perjury that the foregoing is true and correct. Executed on July 25, 2008, at Davis, California.

Donald B. Mooney

Attachment E

Cervero, Robert
Beyond Travel Time Savings: An Expanded Framework or
Evaluating Urban Transport Projects
World Bank
2011

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Transport Research Support

BEYOND TRAVEL TIME SAVINGS

ROBERT CERVERO

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BEYOND TRAVEL TIME SAVINGS: AN EXPANDED FRAMEWORK FOR EVALUATING URBAN TRANSPORT PROJECTS

The Transport Research Support program is a joint World Bank/ DFID initiative focusing on emerging issues in the transport sector. Its goal is to generate knowledge in high priority areas of the transport sector and to disseminate to practitioners and decision-makers in developing countries.

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ACKNOWLEDGEMENTS

The “Going Beyond Travel-Time Savings: An Expanded Framework for Evaluating Urban Transport Projects” has been prepared for the World Bank Transport Anchor group (TWITR) in Washington which administers and manages the Transport Research Support Program, TRSP, a financing of **DFID**, the Department for International Development of the United Kingdom Government.

We would like to express our thanks to Robert Cervero, Department of City and Regional Planning, University of California, Berkeley, who was contracted to provide the framework and the technical content. Roger Gorham, Economist, AFTTR, provided guidance and advice throughout the preparation of the study.

ABSTRACT

This paper challenges the widespread and often indiscriminant use of travel-time savings as a principal metric of economic benefits for evaluating urban transport projects. Time-budget theory and empirical evidence reveals that the benefits of a widened road or extended rail line often get expressed by more and longer trips to larger numbers of destinations and not by less time spent traveling. Induced travel demand can also erode time-savings benefits over the long term. Other conceptual and measurement issues related to travel-time reductions as a welfare measure are raised as well. A case is then made for elevating accessibility improvements as an outcome measure, particularly in light of the long-term nature of urban transport investments. Examples of measuring and monetizing accessibility are provided, although applying these techniques in developing countries is never easy. Still, tractability of measurement is no reason for relying on measures like reduced travel time when doing so flies in the face of theory, logic, and empirical evidence. The paper concludes that the World Bank should adopt a more robust and inclusionary framework for evaluating urban transport projects, one that supplements mobility-based measures like travel-time savings with metrics tied to accessibility, sustainability, livability, safety, and affordability. A preliminary plan of action is proposed in this regard.

1 Introduction

Travel-time savings are the principal economic benefit assigned to urban transport projects. Other benefits, like reduced vehicle operating costs (e.g., less wear-and-tear on vehicles; improved fuel economy) and accidents, are sometimes monetized as well. Because they are difficult to measure, less tangible second-order impacts, like improved air quality, are often treated subjectively in economic evaluations. According to Mackie et al. (2001), travel-time savings capture 80% of the quantified benefits for transportation Cost-Benefit Analyses (CBA) in the United Kingdom. In a recent evaluation of proposed bus-way improvements in Lima, Peru, travel-time savings represented 75% of the project's total estimated benefits (World Bank, Latin American and the Caribbean Region, 2003). World Bank studies likewise use travel-time savings as the chief measure of economic benefits — e.g., as an overall indicator in Monitoring and Evaluation (M&E) frameworks and Bank-sponsored CBAs.

This paper questions the focus on travel-time savings as the core and sometimes even exclusive metric of user benefits. History shows that major improvements to roads and public transit do not reduce the amount of time per day urbanites devote to getting around a city. More often, they increase the number and length of trips.

Despite dramatic gains in the average speed of travel conferred by modern technology over the past century — faster cars, super-highways, limited-access/grade-separated freeways — the amount of time urbanites spend traveling has remained largely unchanged over many decades, if not centuries. As transport systems become speedier and cheaper, urban dwellers take advantage of these improvements by traveling more and over greater distances as opposed to saving time or money. If conditions allow, users prefer to broaden their range of options rather than reduce general costs of travel. Thus, the benefit of a new road or bus-way gets expressed more in terms of expansion of trade-sheds, labor-sheds, market-sheds, and social networks than spending less on physical movement. Stated another way, the chief benefit is increased "accessibility" — i.e., the ability to get to destinations and activities people want to reach — not less total time traveling. It follows that any assessment of prospective transport investment projects should give at least as much attention to estimated impacts on accessibility as to travel-time savings.

Accessibility is a function of two main elements: (1) mobility – speed between point A and point B; and (2) location – distance between points A and B. In the near term, faster speeds either save time or allow more interactions between a fixed set of origins/destinations, possibly over a larger geographic catchment. Over the longer term, they allow origins and destinations to be farther apart – which, when unplanned, equates to sprawl but when well-planned can increase opportunities for job searching, trading, and social interaction.

Metz (2008) has been particularly critical about the conventional practice of equating benefits to shrinking travel times. He asserts: "travel time savings has the quality of a myth — a traditional story accepted as factual" (Metz , 2008, p. 333). Travel time savings, Metz argues, are transient. In the short term, the prospect of travel time savings can influence when, along which corridor, and by which mode one travels. But once the new route becomes part of an established pattern of daily activity, the benefit should be viewed as an improvement in access rather than as a savings in travel time.

2 Time-Budget Theory

Arguments for focusing on enhanced accessibility vis-à-vis travel-time savings are rooted in time-budget theory (Zahavi and Talvitie, 1980, Tanner, 1981). Despite rapid increases in average travel speed, people continue to invest roughly the same amount of time to move about a city, on average an hour per day. This daily time budget has held remarkably constant over time, from ancient Rome to the walking cities of 15th century Europe to the streetcar suburbs of the early 20th century and freeway-laced cities of today. Time budgets are seemingly an anthropological constant, as if people are genetically pre-disposed to spend a fixed amount of time during their lives moving about cities and their surroundings. If a new road speeds up this movement, people simply move more often or farther. Traveling longer means the boundaries of cities have stretched outward as average speeds have increased.

Scholars have long cited transportation systems and technology as powerful forces that shape cityscapes and economic growth patterns (Warner, 1962; Wachs and Crawford, 1992; Garrison and Levinson, 2006). One can easily trace the outward expansion of cities to a succession of transportation advances that increased average travel speeds. The maximum size of walking cities was around 20 square kilometers, which supported settlements up to 50,000 or so inhabitants. When electric streetcars gained ascendency in the late 1800s, many cities quadrupled in size and with the advent of freeways the population and spatial extent of cities grew by several additional orders of magnitude (Schaeffer and Sclar, 1980; Muller, 2004).[1] Faster mobility has thus mainly changed the spatial organization of cities, not the amount of time devoted to travel.

Among the most persuasive evidence in support of time-budget theory is the following:

- In a study of world cities, Zahavi and Talvitie (1980) found a fairly constant amount of time and budget devoted to urban mobility — on average, around one hour per day moving about the city and around 11% of disposable income, with mean statistics three to four times larger than standard deviations.

- Zahavi (1979) also studied changes in travel patterns in the U.S. from 1958 to 1970, finding that Americans did not spend any less time traveling during a period when massive freeway construction let them travel considerably faster. A later study updated Zahavi's analysis

[1] A walking speed of 5 km/hour permits a 2.5 km return journey to be covered in one hour, producing a 20 km2 range (a circle with a 2.5 mile radius). With car travel ten times faster, the access area becomes one-hundred-fold larger — i.e., 2000 km2 (Lefevre, 2010).

using data through 1990, showing the earlier results still held (Barnes and Davis, 2001).

- Several other studies documented constancy in the amount of time, around 1.1 hours per day,that Americans invest in traveling (Ryan and Spear, 1978). McLynn and Spielberg (1978) found the one-hour-per-day figure held as early as 1840, a time when the first high-speed form of mechanized movement, steam-engine trains, spurred the industrial revolution and ushered in an era of decentralized growth in America.

- National surveys in the UK show that travel hours per person per year remained constant from 1970 to 2005 (around 350-380 hours), a period of massive motorway construction throughout the British Isles. According to Metz (2008), this implies "a long run value of travel time savings of zero". What is preferred is more and longer trips – average distance travelled shot up by 60% over the 1970-2005 period.

3 Induced Travel Demand

Time-budget theory holds that supply-side improvements increase speeds which alter cities and travel distances. A related theory, called induced travel demand, contends supply-side improvements alter cities and travel so as to erode speed benefits. The two are flip sides of the same coin.

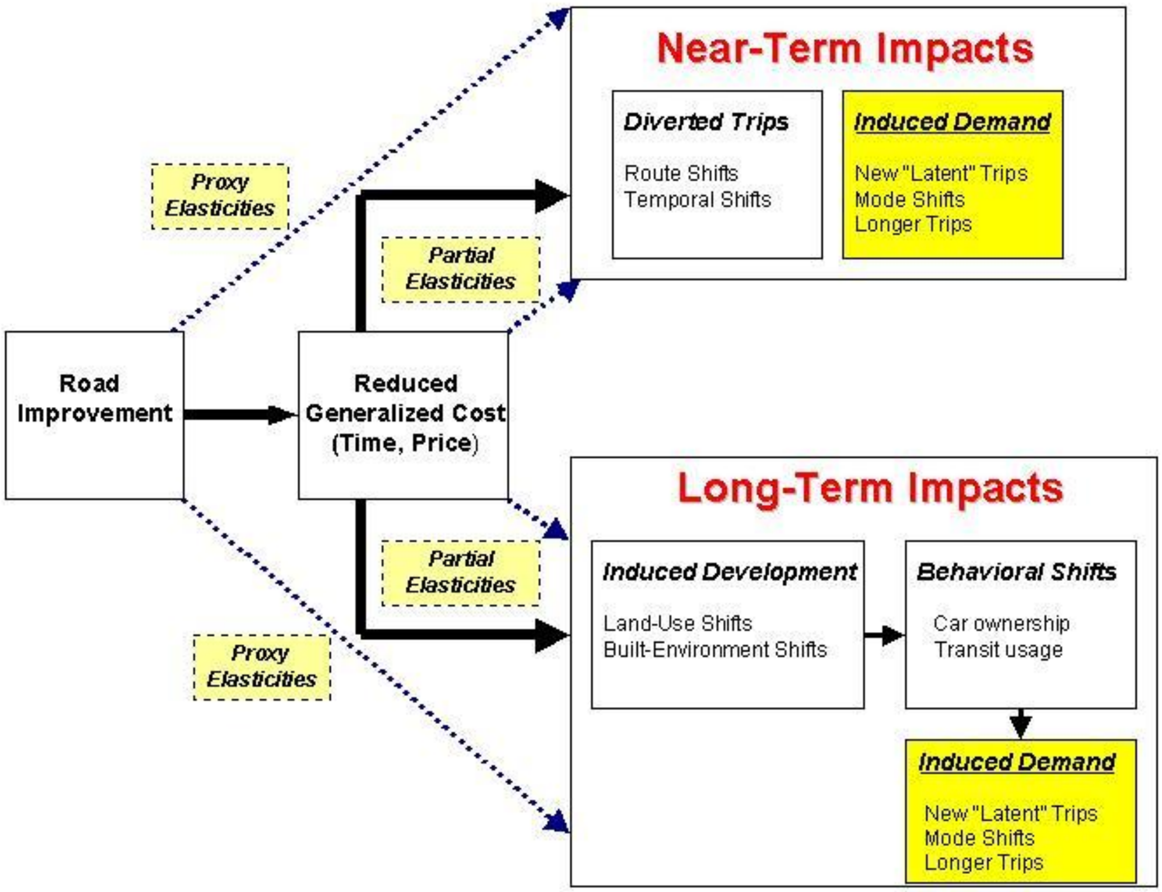
Critics of supply-side solutions to traffic congestion charge that the capacity-expanding benefits of most transport projects are short-lived. While all forms of transport investment influence travel, most complaints about the ephemeral benefits of added capacity are directed at the road sector. Figure 1 diagrams the flow of events attributed to the demand-inducing impacts of an expanded road. In the near term, increased capacity unleashes behavioral adjustments — e.g., trips previously suppressed are now made because of improved flows (i.e., latent demand); motorists switch routes, modes, or time-of-travel to take advantage of a new facility; motorists travel to destinations that are further away because of speedier flows (Downs, 1962, 1992; Cervero 2002; Noland and Lem, 2002). New trips, longer trips, and modal shifts contribute to increased Vehicle Kilometers Traveled (VKT), the strongest correlate to overall resource consumption and tailpipe emissions in the transport sector. Other adjustments, like route and temporal shifts, do not noticeably increase VKT and thus are largely redistributive in nature.

A meta-analysis found a mean short-term elasticity (between lane-km capacity and VKT) of several dozen roadway investments in the United States of 0.40 — i.e., all else equal, a doubling of road capacity was associated with a 40 percent increase in VKT within 1-3 years of the investment (Cervero, 2002). Over the long term, added road capacity led to more deeply rooted structural shifts, like increased car-ownership rates and more auto-oriented land-development patterns. Adding structural impacts to accumulated short-term ones markedly increases long-term elasticities — on average, 0.75 in the U.S. (Cervero, 2002). Other studies have estimated even higher long-term elasticities (Heanue, 1997; Fulton et al., 2000; Metz, 2008). Most empirical studies of induced travel demand have been conducted in the U.S. Metz (2008) has examined aggregate data to study nationwide trends in the UK. He found that average vehicle trip rates per household have changed little over the long run. This implies that induced traffic in the aggregate does not arise from increased journey frequency, retiming, or making entirely new additional journeys. Rather, Metz contends that induced traffic is generally the consequence of the choice of more distance destinations for the same journey purposes and is associated with changed land-use patterns. Metz also notes that induced traffic increases traffic accidents and vehicle emissions since they increase in lock-step with trip distances. Such factors should be adjusted in any long-range road project appraisal.

Overall, experiences reveal that travel adjusts to form a new equilibrium of traffic congestion following road improvements. This traffic-inducing and thus benefit-offsetting impact is incompletely accounted for by most economic appraisals of transport-facility investments (Downs, 1992; Saloman and Mokhtarian, 1997; Cervero, 2002; Cervero and Hansen, 2002; Ory et al., 2004).

This is true in developing and developed countries alike.[2] Ignoring induced-demand impacts further calls into question the validity of relying on reduced travel times as the standard bearer for gauging the benefits of capital investments in roads and transit facilities.

FIGURE 1: TRACING INDUCED TRAVEL DEMAND



The diagram shows near-term (i.e., first-order) and longer-term (i.e., second-order) impacts of expanded capacity. Initially, a road investment increases travel speeds and reduces travel times (and sometimes yields other benefits like less stressful driving conditions, on-time arrival, etc.); increased utility, or a lowering of "generalized cost", in turn stimulates travel, made up of multiple components, including new motorized trips (e.g., latent demand, previously suppressed), redistributions (modal, route, and time-of-day shifts), and over the longer term, more deeply rooted structural shifts like land-use adjustments

[2] There are rarely, if ever, adjustments for induced demand in travel forecasts of proposed urban transport projects in developing countries. Typically the subject matter is not even raised. Only a few World Bank appraisals of urban transport projects conducted over the past decade, such as in Hanoi and Lima, acknowledged that generated traffic or induced demand was not considered in estimating of travel-time savings.

and increased vehicle ownership rates (that in turn increase trip lengths and VKT). Some of the added trips are new, or induced, and some are diverted.

It is likely the case that the phenomenon of induced demand is more pronounced in the developing world than in most advanced first-world economies. Traffic gridlock creates a huge pent-up demand for mobility. Highly congested, poorly planned cities can thus expect to see the inducement of many newly generated trips following a roadway upgrade.[3] Over the long run, most new development in rapidly modernizing cities will gravitate to less-congested and newly expanded corridors, which are often on the urban fringes. In the Jakarta's, Nairobi's, and São Paulo's of the world — rapidly growing, bigger, denser, and poorer than their first-world counterparts — the transportation/land-use connection is robust, as are traveler responses to changes in road capacity and public-transport services.

[3] This is partly due to the archaic designs of central cities in many developing countries, often laid out to accommodate foot and bicycle traffic. The ability to retrofit urban cores with new transportation infrastructure is constrained in most instances and the costs of road construction thus tends to be quite high. Asian cities, for example, have 12% to 14% of land dedicated to roads compared to 25%-40% in US cities (Gwilliam, 2003).

4 Travel Time Savings

This section discusses both conceptual and measurement challenges in operationalizing travel-time savings as a metric of economic benefits.

4.1 Conceptual Challenges

Travel-time savings has been the centerpiece of transport economic analyses for approaching a half century (Small, 1992; Metz, 2008). Its popularity is as much due to the ease and convenience of measurement as to any theoretically grounded notion of why and how welfare — and particularly the welfare of the urban poor — would or should be improved by a transport investment.

There is a well-established literature on how to compare the benefits and costs of transportation proposals. Given the difficulty in determining how much consumers are willing to pay for, say, a new road, a common approach for imputing benefits is to multiply the predicted time savings to users by assumed values of time and sum the results (Mohring, 1961; Small, 1999; Banister and Berechman, 2000).[4] This has become conventional practice since total economic benefits are fairly easy to derive by comparing estimated total Vehicle Hours Traveled (VHT) "with" versus "without" a proposed improvement. Assumptions are needed, such as the estimated value of time, however even these often go unchallenged — e.g., 40% to 50% of a city's prevailing wage rate is what is typically assumed.[5] In developing countries, where current and reliable travel data are often in short supply and calibrated models are sometimes borrowed from elsewhere, potential errors from applying standardized and simplified approaches are likely magnified. In using computer-generated estimates of travel-time savings to gauge benefits, one must ask whether ease of measurement has usurped theory and logic?

Among the conceptual challenges faced in examining economic benefits and travel-time savings are the following:

- *Time Frame*. There can be a disconnect between the 40-50 year service life of most transport infrastructure and the near-term time horizon in which benefits are measured (given fixed land uses and thus fixed origin-destination patterns). CBA evaluates long-lived transport infrastructure based mainly on estimates of short-term

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[4] Travel-time impacts of a specific road project are typically gauged throughout an entire network using the traditional four-step travel-demand modeling approach. This reflects the fact that the impacts of improving any single link reverberate throughout a network, affecting speeds and performance on other links as well. Impacts are also registered across modes. Proposed transportation investments, by saving travel time, generally influence model outputs by changing mode choice and route assignments. In more advanced models, such as when there is a feedback loop between the traffic assignment and land-use allocation phases, they may also influence trip generation and distribution.

[5] This practice applies to developed and developing countries as well as road and non-road projects. The Mumbai rail capacity upgrade study, for instance, similarly set the value of passenger time at 40% of average wage rate for users of different models (World Bank, South Asia Region, 2002).

travel-time savings. These near-term estimates might then be straight-line extrapolated to 50 years in the future without any adjustments in assumed future land-use (and thus origin-destination) patterns.

Over time, land markets shift as changes in accessibility patterns and housing filtration occurs, newly formed households trade off housing and transport costs to maximize utility, and a host of other dynamic forces are unleashed that reshape cities and travel. By the time that market effects of a transport investment have played out, it is never clear whether the per-capita amount of time spent traveling actually declines, particularly for the urban poor. As noted earlier, empirical evidence suggests it does not.

- *Scale of Analysis.* Benefits can vary widely by the geographic scale of analysis. At the corridor level, significant time savings might accrue among those traveling along a newly expanded 10-kilometer highway. However at a larger geographical scale (i.e., sub-regional "meso-scale" or regional "macro-scale"), more traffic might be induced by the addition of new and longer trips on existing roads, thus slowing speeds. The net impacts might be no changes in travel time for the sub-region or metropolitan area as a whole. While temporal changes might be most dramatic at a small geographic scale like a corridor, within an entire travel-shed or at the regional level – the scale most appropriate for drawing welfare judgments on public-policy interventions – spatial changes are likely to be most dramatic, especially over the long run (which, of course, is the time frame most appropriate for evaluating projects).

- *Travel Trade-offs*. Urban economic theory suggests that travel time alone is not a sufficient indicator of welfare because it is "traded off" against housing values (i.e. site rents) (Alonso, 1964; Muth, 1969). Dictated by consumer preferences and often stage-of-lifecycle, some households willfully endure long commutes in return for lower-cost housing on a per-square meter basis. Stereotypically these are younger families seeking larger living spaces (and in the U.S., often better schools). Also stereotypically, once the kids have gone off to college, some "empty-nesters" downsize by moving closer to the city, effectively trading off less time spent traveling for higher priced housing per square meter. Measuring changes in travel time alone thus ignores the reality that transportation and housing are a bundled good in the minds of many households. Thus a new freeway or rail line might induce some households to move farther out and thereby increase total time spent traveling in return for cheaper housing — a utility-maximizing choice made within the limits of a fixed transportation/housing cost budget. In such instances, studying impacts on travel times alone becomes meaningless.

- *Path Dependence and Infrastructure.* Once a dominant technology, like the auto-highway combination, gains ascendency, other modes can be marginalized as functional carriers, to the long-term detriment of a region at large. Mogridge (1997) argues that investing exclusively in road transport at the expense of other alternatives may cause a lower net welfare and higher congestion than a modally diverse investment strategy. He contends that roadway capacity expansion and similar congestion-mitigation policies actually increase travel times in the long-term in many urban settings. Building on theories of induced travel, Mogridge asserts that the modal convergence of switching from transit to auto travel in response to congestion-mitigation policies ultimately leads to deteriorating transit service, auto dependence, gross increases in travel time, and even more congestion. Perhaps car-dependent U.S. metropolises like greater Los Angeles and Houston provide the strongest empirical backing of this viewpoint. Despite averaging high levels of freeway capacity per capita, Los Angeles and Houston have over the past two decades consistently ranked as among the most congested areas in the country in terms of annual hours of delays per traveler (Schrank et al., 2010).

The obverse of this path dependency argument can be seen when tracing the impacts of pursuing a more balanced, multi-modal transportation program. In the case of Seoul, South Korea, for example, road capacity has been reduced in the core area (e.g., the Chenggyecheon freeway-to-greenway conversion; replacement of a large traffic circle in front of City Hall by an oval civic green), replaced by expanded Bus Rapid Transit (BRT) and other transit service reforms. Commercial and residential land prices increased following these road-to-amenity conversions (Kang and Cervero, 2009; Cervero, 2010; Cervero and Kang, 2011). In Seoul's case, property markets placed a higher premium on neighborhood quality, livability, and public amenities than mobility or swiftness of movement. Seoul's experience also demonstrate that the withdrawal of road capacity matched by stepped-up public-transport services can yield net welfare benefits.

- *Time Loss = Reduced Productivity?* Arguments that congestion-induced travel delay results in lost productivity are questionable, at least as a *carte blanche* assumption (Stopher 2004). While current research on traffic congestion attributes substantial economic drags to time losses or scheduling delays, it does not offer any guidance on whether these delays constitute foregone productivity. Transportation infrastructure is not productive in and of itself; rather the service and accessibility premiums it provides enable agglomeration economies or transport savings that function as direct inputs into productivity (Boarnet 1997). Although congested conditions may appear to be less productive than higher speed, non-peak conditions, many users clearly derive benefits from traveling during specific times (such as peak commuting hours) and to specific locations, despite the lower travel speeds. If an employee finds that his or her commute is 15 minutes longer due to congestion, he or she may leave for work earlier or may depart from work later in order to make up the additional work time. Also, 15 minutes of congestion delay would not replace economically productive time for an individual traveling to a social event after shopping. While foregone recreational time would certainly be valuable from a cost-benefit analysis perspective, it is not economically productive (at least in the traditional sense of the word). Even for commuters, 15 minutes of delay might simply replace 15 minutes of idle time that would have been spent sometime during the workday or after work. Downs (1992; 2004) argues that time stuck in traffic is not necessarily stressful for some. Rather it might be the one time of the day when office workers enjoy solitude and quiet, comforted by the posh interior of a car playing relaxing music or having a novel recited on a high-end stereo unit. For some, sitting in an office bullpen separated by thin partitions from co-workers chatting on the phone might be just as stressful or unproductive.

4.2 Measurement Issues

Besides conceptual challenges, economic appraisals based on travel-time metrics face a number of practical measurement-related problems as well. These are discussed below.

- *Travel Surveys.* Data on travel times are usually obtained from self-reported travel diaries of a random sample of households in a region. This poses numerous problems, especially in cities of the developing world. One, informality and incomplete land registries make defining a population base from which to sample households virtually impossible. Since the poor most likely live in informal or itinerant settlements, they are most likely to be under-sampled. The same holds for any data-collection instrument using random-digit dialing of telephone numbers since the poor are least likely to have a landline or cell phone. Two, travel-diaries presume literacy and because they are self-reported, are easily subjected to biased or incorrect responses. Such issues are again most likely to surface for low-income individuals and households. However biases can also be introduced by failing to compile data from the wealthiest members of society. A travel-diary survey of households in Bogotá, Colombia, for instance, recorded low response rates from not only the two lowest income strata but also the highest (Cervero et al., 2009).[6] In a city once known as the "kidnap capital of the world" and where narco-terrorist attacks still occur, most wealthy households have armed guards whose sheer presence deter surveyors from approaching their properties. Lastly, household surveys fail to capture non-home-based or non-household travel, such as by commercial trucks, taxis, paratransit/informal-transport, or inter-city through traffic.

- *Derived estimates.* Sometimes travel-time impacts are not estimated directly but rather derived from estimated future travel speeds and invoking the questionable assumption that trip origins and destinations will be unaffected by changes in transport system

[6] Under-sampling of the lowest income stratum was due to households living in squatter settlements and either being unavailable or unable to comprehend the purpose of surveys. Illiteracy and cultural factors (e.g., uncomfortability of having someone of a higher income stratum enter a tattered shelter) accounted for low response rates among the next-to-lowest income stratum.

performance. This is common practice in the World Bank M&E framework. As already noted, smoother flowing traffic can unleash behavioral changes, such as the inducement of new trips or route shifts. Imputing travel times can also be problematic since trip durations often vary considerably from the statistical mean – e.g., by time-of-day, mode, section of corridor, etc. Imputing travel-time savings from average speeds is especially difficult in the developing world due to huge variations given the rather erratic and stochastic nature of traffic flows.

Computational errors are also possible when one invokes the simple assumption that changes in average speed and travel times are proportional. The current average speed is typically estimated by local traffic engineers using a floating car technique — i.e., a test car will pass as many vehicles that passes it over a defined distance, establishing a mean speed for a particular time-of-day. Say the recorded peak-period average speed for a hypothetical 10-km stretch of road is 40 kph. And assume a road improvement is expected to increase this figure to 50 kph. Ignoring issues of induced demand and induced growth effects, this is a 25 percent increase in mean speed. Does this mean average travel times similarly fell by 25 percent? Simple math shows this is incorrect (owing to different denominators used in measuring rates of change). It takes 15 minutes to cover the 10 km stretch at 40 kph and 12 minutes to do so at 50 kph. That's a 20 percent decline in mean travel time for a 25 percent increase in mean speed. Over a fixed distance, speed/travel-time trade-offs are not strictly proportional.

- *Absence of land-use adjustments*. The failure of the vast majority of travel-forecasting models to account for land-use adjustments poses a serious measurement problem in estimating travel-time benefits. The absence of any feedback loop from traffic assignment to land-use allocations implicitly assumes that trip origins and destinations do not change over time. As a result, Metz (2008) argues that the value of activities at trip ends "could be disregarded" since they are the same between the "do nothing" and "do something" alternatives. While travel demand might vary as a result of new infrastructure (as captured in trip distribution, modal split, and traffic assignment phases), the change in trip origins and destinations themselves (in the land-use allocation phase) is usually ignored. Thus, possible economic benefits of land-use adjustments — e.g., better matching of firms and labor; agglomeration economies from more efficient, clustered spatial arrangements; increased comparative shopping — get overlooked. Implicitly, this absence presumes no economic benefits are conferred by land-use adjustments. Assuming trip origins and destinations will not change following any transport-infrastructure enhancement flies in the face of theory, logic, and empirical evidence.

- Valuations. Time valuation stems from cost-benefit analysis (CBA) methods which compare the relative merits of two or more transportation alternatives. While researchers agree that the value of time is related to the regional wage rate (Small 1992, Miller 1989), they do not agree on how to determine its present value. Many cite half of the wage rate, however the range extends from virtually nothing to values greater than the wage rate (Rouwendal and Nijkamp 2004).7 Some analyses apply specific values of time to different socio-economic groups, trip purposes, or times of day, while others use average estimates.8 Some research indicates that different trip lengths and savings increments are valued differently. There is likely an indifference zone wherein small time savings are imperceptible. Few people will notice a minute or two savings on a half-hour trip however 10 minutes of savings on a 30-minute trip will be impressionable. Due to the induced-demand/induced-growth phenomenon, most supply-side expansions are likely to shave a few minutes of travel time versus big perceptible savings.

Measuring value-of-time is more complicated for non-highway infrastructure. This is partly due to the predominance of road infrastructure in cities. Rarely will an investment in pedestrian infrastructure increase speeds and thus save time. New bike lanes might divert riders from faster direct routes and thereby increase travel times. For transit users, service reliability, transfer-free direct connections, and perceived levels of safety may be more heavily valued than time (Train, 2009). For such reasons, reliance on travel-time savings as the core metric of economic benefits of urban transport projects engenders a road-based bias.

[7] Small (1992) estimates that the value of time for trips range between 20% and 100% of a region's prevailing wage rate and estimates that 50% is a good rule of thumb for peak-hour users. Parry et al. (2007) give a rough estimate of total transportation costs per automobile mile in the U.S. — $0.05 attribute to congestion.

[8] A project appraisal of rail capacity upgrading, for example, set the value of time of high-income railway users at 2 ½ times higher than low-income ones (US$2.40 versus US$0.99 per hour) and those with formal jobs were assumed to value time twice as much as those with informal ones (US$2.73 versus US$1.30 per hour) (World Bank, South Asia Region, 2002). An appraisal of a bus-way proposal in Lima used a value of time of US$0.80 per hour for those traveling by private vehicles and US$0.31 for public transport riders (World Bank, Latin America and the Caribbean Region, 2003).

5 Transportation Project Appraisals of the World Bank

Many of the issues discussed in the preceding sections apply to project appraisals conducted as part of loan packages for World Bank-funded projects. The economic appraisals of seven World Bank studies were examined in terms of their approach to measuring economic benefits.[9] Most rely on travel models to estimate differences (with versus without improvement) in network-wide VHT (reflecting total system-wide travel-time expenditures). Some address other impacts, like reductions in accidents and air pollution, as a consequence of changes in both VHT and VKT. Benefits from reduced VHT and VKT are compared to estimated costs to come up with net present value (NPV) and Benefit/Cost ratios.

Few appraisals dealt with induced demand or any generated-traffic impacts that could erode travel time benefits over time. Most appraisals did not even acknowledge the possibility of induced-demand/induced-growth impacts. To the degree they are even used, it is not clear that travel-demand forecasting models contain feedback loops between traffic assignment and earlier input stages (including initial land-use allocations). Models appear to gauge near-term travel-time savings and assume these will remain fixed and unchanged over the life of a project, annualizing these values and extrapolating them over a set number of years — and in so doing, failing to account for land-use and behavioral adjustments. Travel-demand models do not appear to have been estimated in some of the poorest cities of the world, thus how travel-time savings are derived in these settings is unclear.

[9] Report sections on "economic evaluations" were examined for project appraisals of proposed loans and grants for urban transport projects in Ghana, Hanoi, Lagos, Lima, Mumbai, Rio de Janeiro, and Urumqui.

6 Equity Considerations

Reliance on travel-time metrics also raise equity concerns. Travel-time savings accrue mainly to motorists, yet many poor in the developing world — where most World Bank urban transport projects are targeted — do not own a car or drive. Their values of time might also be substantially less than those of the middle and professional classes. For them, enhanced access opportunities might be a bigger benefit – and contribute to the World Bank's over-arching objective of poverty alleviation — than reduced travel-time expenditures. The ability to widen the territorial sphere for job searching, saving on food purchases, reaching medical clinics, and seeking educational opportunities is likely to benefit the poor more than saving a few minutes of time moving along an expanded roadway.

Experiences also show that the poor are willing to trade-off travel-time delays for lower transit fares, parking rates, or fuel prices — i.e., they tend to be more price-sensitive and less time-sensitive than the non-poor. More popular uprisings have been sparked by increases in fuel prices and bus fares than by delays in travel times. For such reasons, the use of travel-time savings as a singular metric of benefits is all the more questionable from an equity point-of-view.

7 Alternative Measures

The critiques of reliance on travel-time savings to gauge economic benefits does not mean they should be discarded. Rather they are just one of a number of measures that should be examined when weighing economic benefits of highway, public transport, and other transport infrastructure investments. A more complete palette of metrics for gauging benefits – one that includes changes in accessibility across a multitude of purposes – should be considered.

7.1 Accessibility Metrics

So far, this paper has made the argument that one of the major benefits of expanding roadway capacity and transport services is to enhance access to places where travelers want to go. Access is a theoretical construct as opposed to a manifest behavior, and for this reason can be difficult to grasp. Access is about opportunities versus revealed choices and outcomes.

Besides more directly capturing the benefits conferred by transport investments, the inclusion of accessibility measures promotes a more balanced approach to long-range urban planning. Notably, it gives attention to alternatives to capital investments strategies for reducing traffic congestion and mitigating environmental problems, such as promoting efficient, resource-conserving land-use arrangements. This is because accessibility is a product of *mobility* and *proximity*, enhanced by either increasing the speed of getting between point A and point B (mobility), or by bringing points A and B closer together (proximity), or some combination thereof. Since accessibility is a product of both travel time and the geographic location of urban activities, it captures not only the temporal but also spatial dimension of travel. Thus accessibility measures give legitimacy to land-use initiatives and urban management tools in addition to supply-side, mobility-enhancing measures. Focusing on accessibility improvements as a goal reflects the "derived" nature of travel demand and puts the focus on promoting interaction — e.g., trade, social contacts, engagement with nature – versus movement per se. Some would argue most people want to minimize the time traveling so that more time can be spent at the destination. Framing the objective as making cities more accessible versus more mobile prompts a paradigmatic shift in planning, elevating land-use management and information technologies as bona fide tools for managing traffic flows and mitigating traffic congestion.

Measuring Accessibility

While there is a conceptual elegance to gauging benefits in terms of changes in accessibility, operationalizing this is not easy. For this reason, accessibility is typically handled qualitatively. The appraisal of a proposed BRT investment in Lagos, for example, offered a simple qualitative statement in support of the project on social grounds, noting "the proposed project would benefit women, the elderly, and the physically challenged by responding to their needs and providing them with *better access* to basic social services (health, school, administration), jobs, and markets, at a lower cost than currently available" (World Bank, Africa Regional Office, 2009, p. 26).

There are quantitative ways to gauge changes in accessibility. Going from concept to measurement involves mathematics and, increasingly, the power of Geographic Information Systems (GIS) tools. Two approaches are commonly used: (1) gravity-like measures (based on the denominator, or balancing factor, of a singly-constrained trip distribution model); and (2) isochronic measures (indicating the cumulative count of opportunities reachable within a given travel time or distance).[10]
Accessibility is normally measured for specific purposes – such as accessibility to jobs, hospital facilities, retail outlets, etc. In the case of job access, the two approaches to capturing access can be expressed as:

Gravity-based Index:

$AI_i = \Sigma j \, [\, Jobs_j \; * \; F_{ij}]$ where: $F_{ij} = \exp(-\nu \, Time_{ij})]$ or $F_{ij} = Time_{ij}^{-\nu}$ (1)

AI	=	Accessibility Index
Jobs	=	# of jobs in tract
Time	=	network travel times
I	=	residential zone
J	=	employment zone
ν	=	estimated impedance coefficient

Isochronic-based Index:

$AI_i = \Sigma_j \, [\, Jobs_j \; (Time_{ij} \leq m)]$ where, in addition to above: (2)

M = time threshold (e.g., 30 minutes)

Gravity-like measures of accessibility consider all trip-end possibilities within a defined study area in weighing the drawing power of potential trip attractions, corrected for the friction of distance or time in reaching them. However the AI value of a gravity-based measure is often meaningless unless compared to another value — such as the AI of the poor and non-poor or of auto-highway versus public transit options. Regardless of how they are measured, the value of an accessibility index, like any performance indicator, lies in a comparative context. According to Handy and Niemeier (1997, p. 1181), "no one best approach to measuring accessibility exists; different situations and purposes demand different approaches.

Isochronic measures receive high marks for their transparency and intuitiveness (Koenig, 1980). Anyone can relate to a value such as the presence of 200 hospital and medical-clinic beds within a half-hour bus ride as

[10] Other measures, like random utility and prism-based approaches, can be found in the literature, though these tend to be applied less often in practice, partly because of data limitations (Niishi and Kondo, 1992; Kitamura et al., 1998; Handy and Clifton, 2001).

a gauge of how accessible one is to medical care via transit. GIS allows isochronic measures to be visualized. Perhaps the biggest drawback of isochronic measures is they require the analyst to draw a time or geographic boundary for gauging access, which is sometimes arrived at subjectively.

Cross-City and Longitudinal Comparisons

As noted, accessibility metrics find most advantage when used as a comparative indicator, either between places or in a longitudinal context. Casiroli (2009) did a cross-city comparison of access to central tourist destinations in São Paulo (Praça de Sé) and London (Trafalgar Square) by mapping out how far one can get within 45 minutes (in green) and 90 minutes (in yellow) by car versus public transport in the evening peak (Figure 2). Summing the number of inhabitants residing within these travelsheds produces an isochronic measure of relative accessibility to these major leisure destinations by mode. Modal ratios reveals that more than twice as many Paulistas can reach Praça de Sé by private car than public transport in the P.M. peak. If reducing the carbon footprint of the transport sector and promoting more balanced transportation are long-range goals of São Paulo's transportation planners, then shrinking this differential over time would signal progress. A smaller ratio would also better reflect benefits accrued from improving metrorail and metrobus services than would an estimate of transit travel-time savings.

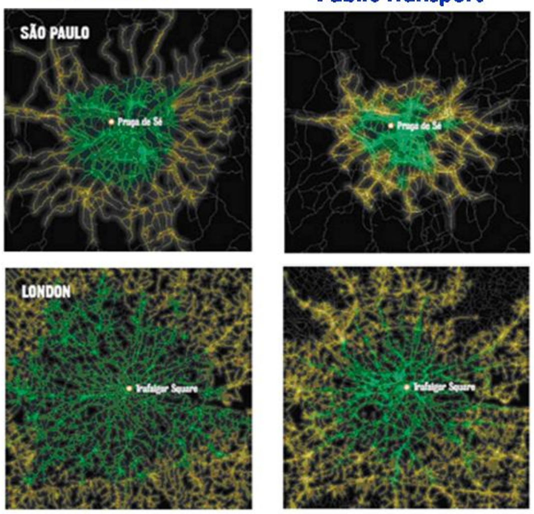
The accessibility profiles of competing transportation modes was recently studied over time in San Diego using isochronic metrics (Cervero, 2005). Figures 3 and 4 present comparative levels of job accessibility of those residing in the fast-growth Mission Valley area of San Diego via auto-highway and transit modes, respectively. Cumulative employment counts for 15-minute isochrones are also shown in each figure. The visual scan reveals that the near-ubiquitous road network in San Diego County covers a much larger geographic territory, and thus opens up greater access to jobs, than does the region's bus, light-rail, and commuter-rail systems. Not only are the isochrones in Figure 4 more geographically contained, they are also noncontiguous and spotty, indicating large gaps in transit service coverage.

FIGURE 2: COMPARISON OF HOW FAR ONE CAN TRAVEL BY CAR VERSUS PUBLIC TRANSPORT WITHIN 45 AND 90 MINUTES IN EVENING PEAK, LONDON AND SÃO PAULO. ISOCHRONIC MEASURES ARE IMPUTED

The Accessible City

How Far Can Travel in Evening Peak: São Paulo vs. London

Access by Car | **Access by Public Transport**



Green = 45 minutes
Yellow = 90 minutes

Differential Car vs. Public Transport	45 min.	90 min.
São Paulo	2.2	3.3
London	1.4	1.2

Source: Casiroli, *2009*

Figure 3: Isochronic Measure of Job Accessibility in San Diego County via the Auto-Highway Network for a Mission Valley Census Tract, 2000. Source: Cervero (2005)

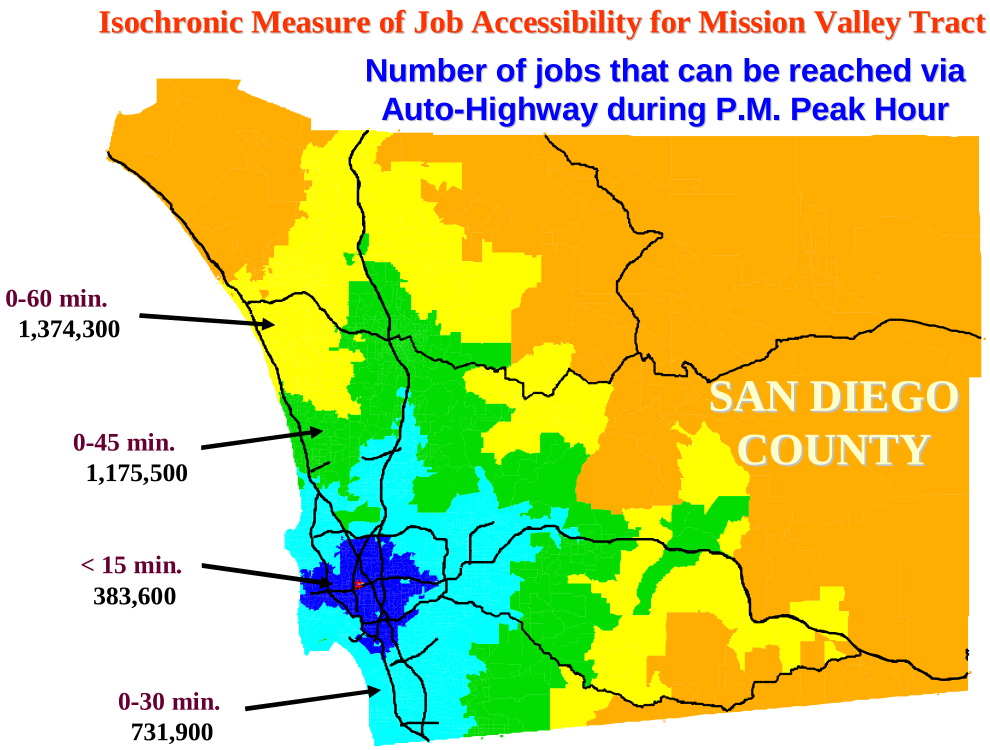


FIGURE 4: ISOCHRONIC MEASURE OF JOB ACCESSIBILITY IN SAN DIEGO COUNTY VIA THE PUBLIC TRANSIT ROUTES FOR A MISSION VALLEY CENSUS TRACT, 2000. SOURCE: CERVERO (2005)

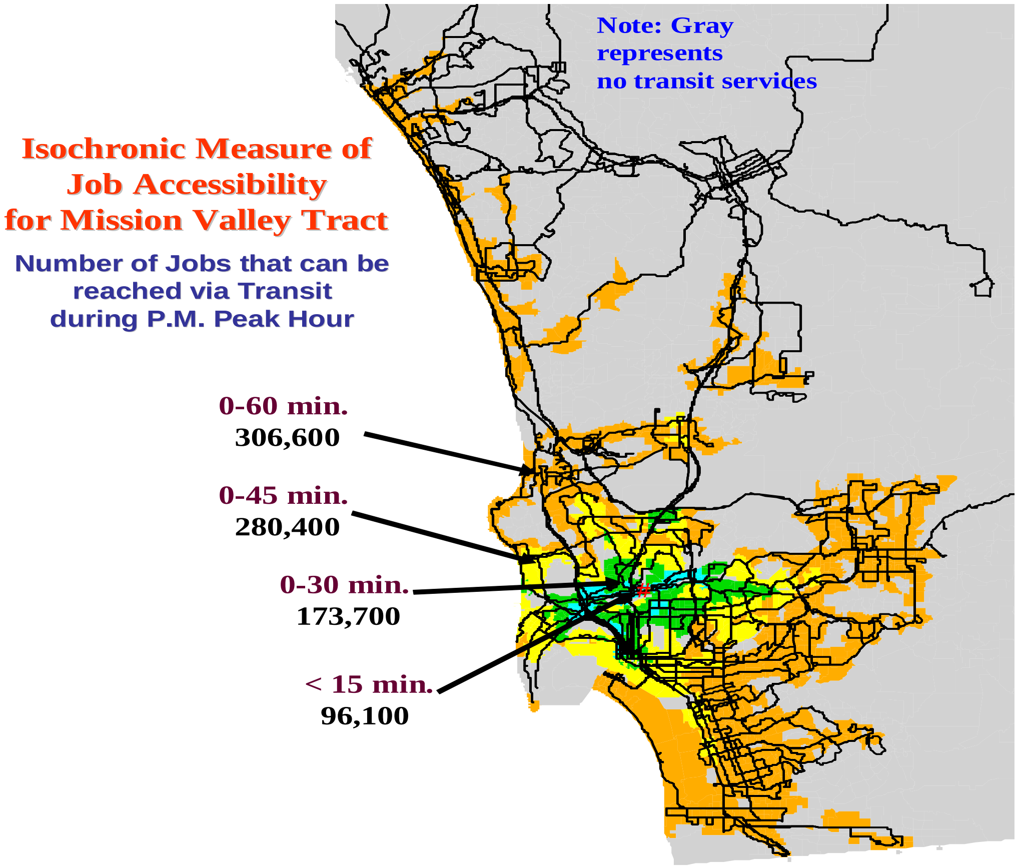


TABLE 1: COMPARATIVE JOB ACCESSIBILITY OF AUTO-HIGHWAY VERSUS TRANSIT FOR RESIDENTS OF SAN DIEGO'S MISSION VALLEY, 2000

Time Isochrone	A.I. Auto	A.I. Transit	Accessibility Advantage: Auto to Transit	MAG[1]
< 15 Min.	383,600	96,100	3.99	-.0559
15-30 Min.	731,900	173,700	4.21	-0.616
30-45 Min.	1,175,500	280,400	4.19	-0.614
45-60 Min.	1,374,300	306,600	4.48	-0.635

[1] MAG (Modal Accessibility Gap) = $(A^p - A^c)/(A^p + A^c)$, where A^p = AI of public transport and A^c = AI of private transport.

The comparative job accessibility advantages of auto-highway travel over public transit for residents of Mission Valley are shown in Table 1. Over all four travel-time rings, drivers enjoy a four-to-one accessibility advantage over transit riders. In general, the farther out one goes from the center, the job-accessibility advantage enjoyed by motorists over transit users increases.[11] The comparative AI values were computed for 99 neighborhoods in San Diego in addition to the Mission Valley and averaged to derive a countywide comparative measure of job accessibility by mode. Also, smart-growth and business-as-usual plans for 2020 were compared not only in terms of conventional performance measures (like VKT and VHT) but also in terms of how they narrowed the accessibility disadvantages experienced by transit users. Transit-oriented growth could reduce the automobile's job-accessibility advantage by 60 percent in year 2020 compared to a business-as-usual scenario (Cervero, 2005).

In transit-oriented cities, the accessibility advantage enjoyed by motorists, such as in San Diego, would flip in favor of transit users. A recent study revealed that Hong Kong residents were far more accessible to jobs via the city's highly integrated network of public and private bus, metro-rail, tramway, ferry, and even funicular than via private car (Kwok and Yeh, 2004).[12]

Increasing Accessibility or Sprawl?

As discussed earlier, studies show that capital investments in roadways and transit lines appear to increase the number and length of trips more than reduce total travel times. Findings that people travel more and farther does not necessarily mean they do so by choice or derive utility in such behavior. Higher accessibility could reflect the impacts of sprawl — i.e., trip origins and destinations being farther apart, producing longer journeys, albeit at faster average speeds. Expanded travel-sheds can equate with increased benefits (e.g., productivity gains from better matching of firms' labor-input needs and workers' job preferences) but also high environmental and energy costs.[13] Accordingly to Siegel (2010), the yearly distance the average American drives doubles every few decades — from 4,009 miles per capita in 1960 to 9761 in 2000. Does this mean that levels of access or even quality-of-life for Americans have similarly doubled? It is for reasons like this that accessibility metrics should to be supplemented by others — including changes in vehicle miles traveled (VMT) and travel durations – in evaluating transportation proposals.

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[11] Table 1 probably understates the accessibility advantages of automobile travel because out-of-vehicle times in accessing and waiting for transit are generally understated in the zone-to-zone travel time estimates of transit.

[12] The computed MAG level (defined in the footnote of Table 1) for Hong Kong was 0.856 in 1996, down from 0.937, meaning the big accessibility edge enjoyed by public transport eroded some during the 1990s. Zero MAG values indicate equal accessibility among modes while values close to one (in absolute terms) denote extreme disparities.

[13] Similar arguments can be made about expanded housing choices. Under the theory of choice, households search to find the right combination of public services and accessibility so as to maximize their utility. Those seeking to minimize commuting are likely to pay higher real-estate prices for job-accessible locations (Alonso, 1964; Muth, 1969). Thus expanded accessibility can mean expanded residential choice sets.

7.2 Monetizing Accessibility Benefits

While accessibility indicators are useful metrics for inter-modal comparisons and assessing likely impacts of transportation and land-use plans over time, they need to be expressed in monetary terms if they are to be of much use in economic appraisals. Consumers no doubt benefit from having more retail outlets to choose from. Employers similarly benefit from an enlarged laborshed from which to seek out new workers and fitness buffs benefit from having more recreational opportunities within a half hour of their residences. Assigning an economic value to such benefits, however, is challenging.

Willingness-to-Pay Approach

One approach to valuing access is to measure willingness-to-pay, applying stated preference techniques (Metz, 2008). Using various scenarios, residents might be asked how much they would be willing to pay for increased access to shopping choices. Or businesses might be asked about their willingness to pay for shaving an average of 5 minutes off the daily commute of their work forces. The willingness-to-pay approach, of course, relies on subjective responses to "what-if" scenarios. It presumes respondents have the capacities to carefully weigh and value options and to make informed choices, even if they have no first-hand experiences with those choices.

Land-Value Capitalization

The impacts of increased accessibility get expressed in land prices. There is a finite, limited supply of good, accessible locations in a city. In a reasonably well-functioning marketplace, those seeking accessible locations to open a shop or business will bid up the price for well-located, accessible properties. Land markets thus capitalize the benefits of accessibility.

To gauge capitalization benefits, hedonic price models are widely considered to be the best method available. Hedonic price theory holds that most consumer goods comprise a bundle of attributes and that the transaction price can be decomposed into the component (or 'hedonic') prices of each attribute (Rosen, 1974). Using estimation approaches like ordinary least-squares regression, hedonic price models apportion sales-transacted real-estate values among causal explainers, shedding light into the marginal contribution of factors like accessibility, land-use type, and neighborhood quality.14 For purposes of gauging land-value benefits, hedonic models generally take the form: $P_i = f(L, N, C)$, where P_i equals the estimated price (per square meter) of parcel i; L is a vector of location and regional accessibility attributes (e.g., accessibility to jobs); N is a vector of neighborhood characteristics (e.g., presence of mixed land uses; median housing income); and C is a vector of

[14] Many studies use data on rents as opposed to sales prices for real-estate transactions (that are open, arms-length transactions). Rental data can be problematic, however, in that contract rents do not always capture the full array of concessions received by tenants. Even if contract rents are fairly accurate, they need to be adjusted for occupancy levels to reveal effective contract rates. Data limitations often preclude this. Focusing on sales transaction data avoids such problems.

controls (e.g., fixed-effect variables).

Table 2 presents hedonic-price model findings on the impacts of accessibility on real-estate prices in San Diego (Cervero, 2004). This was part of a larger study on the capitalization effects of proximity to San Diego's light-rail transit line. Only the output pertaining to the impacts of Accessibility Indexes on single-family home prices are shown in the table. The model, which explained 60 percent of variation in housing prices, shows that single-family homes fetched more than $1,000 for every 1,000 additional jobs within 30-minutes peak travel time, all else being equal. Employment access via transit increased the value of single-family homes even more: for every 1,000 additional jobs within 15 minutes travel time by bus or rail, sales value rose by nearly $6,300, holding other factors constant. Clearly, home-buyers in San Diego placed a high premium on job access by public and private modes of commuting, consistent with residential location theory.

TABLE 2: SINGLE-FAMILY HOUSING: HEDONIC PRICE MODEL FOR

Variable	Coefficient	Standard Error	Prob. Value
Accessibility			
Regional Job Accessibility, Highway: Number of jobs (in 1,000s, 1995) within 30 minute peak-period auto travel time on highway network	1,042.0	160.4	.000
Regional Job Accessibility, Transit: Number of jobs (in 1,000s, 1995) within 15 minute peak-period transit travel time on transit network	6,286.5	710.2	.000

Control variables in model: attributes of property (e.g., size, location); attributes of buildings (e.g., size, number of bedrooms); attributes of neighborhood (e.g., median household incomes; school scores); municipal fixed effects.

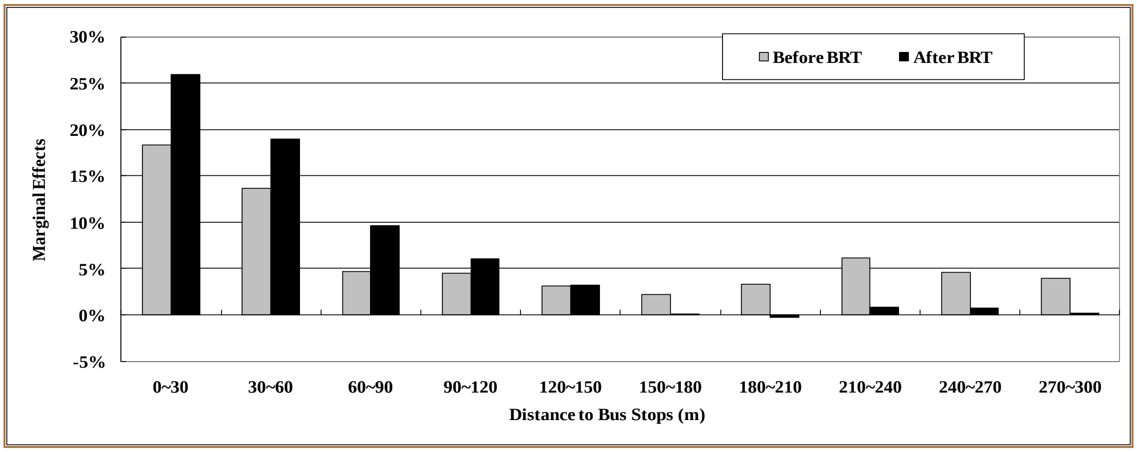
N = 14,576

R^2 = .605

Source: Cervero (2004)

A more recent study of upgraded Bus Rapid Transit (BRT) services in Seoul, South Korea similarly relied on hedonic price modeling to assess impacts on both residential and commercial real-estate market performance (Cervero and Kang, 2011). The study focused on how changing from a modest BRT curbside-lane configuration to a more substantial dedicated center-lane operation got capitalized into retail-commercial land prices. Data were compiled for more than 37,000 commercial real-estate properties within an estimated impact zone of the BRT-upgrade project for two time periods: 2001-2004 (curbside operations) and 2005-2007 (center-lane operations). Multi-level modeling was used to estimate benefits of proximity, or access, to the BRT corridor before and after the upgrade. The coefficients on dummy variables that measured the shortest walking distance of commercial parcels to the nearest BRT indicated whether proximity affected land prices differently before and after the BRT improvements. Figure 5 plots these coefficients, revealing the marginal effects of proximity on land prices, expressed in percentage terms and over 30 meter distance bands, relative to parcels more than 300 meters away (defined as the impact zone of the project). While access benefits accrued to those living near BRT corridors in both periods, the figure reveals the benefits were more prominently capitalized into land values in the post-period (2005-2007). Benefits were the greatest within 150 meters of the nearest BRT stop. A recent study of access to rail lines in Bangkok found similar results, with the premium of transit accessibility estimated to be $10 for every meter that a property lies closer to a station (Chalermpong, 2007).

FIGURE 5: MARGINAL EFFECTS OF WALKING ACCESS TO BRT BUS STOPS ON COMMERCIAL LAND VALUES IN SEOUL OVER DISTANCE INTERVALS. SOURCE: CERVERO AND KANG (2011)



Hedonic modeling results such as those reviewed above express a monetary premium conferred by accessibility improvements. For purposes of estimating a total economic benefit, the per square-meter premium needs to be multiplied by the number of square meters within the estimated impact zone of a project.[15] If, for example, the mean land-value premium of a transportation improvement is $10 per square meter and this benefit extends over 100 hectares (or one million square meters), then the project's economic benefit could be set at $10 million. Values might be adjusted to reflect changes in capitalization impacts over time (e.g., over the service-life of a capital project) or over space (e.g., reflecting the fact that premiums vary geographically, such as shown in Figure 5).

The presence of land-value premiums should not be added to the monetary value of travel-time savings. To do so would be to double-count since land values embody travel time savings. If consumer benefits are measured as a function of hours of travel saved multiplied by value of time per hour, changes in land values, which capitalize these benefits, should not be included as a benefit (Mohring, 1961; Small, 1999; Banister and Berechman, 2000). Thus,

[15] For more on this method of estimating total economic benefits using hedonic-price model results, see Cambridge Systematics et al. (1998).

accessibility benefits should be treated as a supplement to travel-time metrics or an alternative perspective for gauging impacts, not an un-related add-on.[16]

Applying land-value capitalizations to measure accessibility might be problematic in many developing countries. The absence of well-functioning land markets in some poor countries could distort estimates. Informality, complex patterns of land tenure, and incomplete land registries pose further hurdles (Törhönen, 2004). One approach might be to estimate shadow land prices however doing so for a multitude of informal parcels within the impact zone of a transport project might be impracticable.[17] Chalermpong (2007) states that very few hedonic studies have been published on the effect of transit accessibility on property values outside North America and Europe because data are often unreliable or non-existent. It could be that land markets in developing countries engender so many distortions and misallocations that reliably imputing accessibility benefits from land price data is nearly impossible. For these reasons, the use of accessibility indices as comparative and longitudinal measures — and as supplements to travel-time savings estimates — might be the best one can hope for in many developing country settings.

7.3 Economic Development Impacts

The benefits of increased accessibility can also be expressed in terms of second-order effects on net economic growth in a region. This might be done using an input-output model that enumerates inter-industry production and linkages that occur as a consequence of, among other things, improved access to factor inputs (e.g., labor, raw materials) and markets. Economic forecasting and simulation models, such as REMI, can use accessibility along with other input metrics to predict changes in business output, sales, gross regional product, employment, and population over a specified time horizon.

Economic development impacts are typically treated as a second-order "add on" benefit of transportation projects in urban settings. In rural areas, however, they can very well be the chief economic benefit. In most rural parts of developing countries, traffic levels are too low for there to be any measurable benefit of a roadway investment using conventional consumer surplus measures. However the prospect of stimulating trade and increasing agricultural production might be substantial. A recent evaluation of a proposed road upgrade between northeast Congo and the Central African Republic used a gravity model to estimate that goods traded via this route

[16] Also, as with estimated travel-time savings, estimates of capitalized land values likely provide a lower-end range of benefits conferred by an improved road or transit facility. This is not only because accessibility improvements fail to capture external benefits (e.g., improved air quality) but also because they ignore some of the non-derived, psychological benefits of movement (Metz, 2008).

[17] This might be done by using sales-transacted prices of formal, registered properties with similar levels of accessibility (based on regional location and proximity to transport infrastructure) as an informal property of interest, adjusting for differences in site (e.g., presence of piped versus non-piped water supply) and neighborhood (e.g., median income) characteristics. For more on shadow pricing of land market responses to transport-sector interventions, see Arnott and MacKinnon (1978).

would increase from a current value of US$16 million to US$142, nearly a 800 percent increase (Buysa et al., 2010). The study concluded that trade expansion promoted by the upgrading would exceed costs by about $220 billion over 15 years, while generating millions of construction and maintenance jobs in some of Africa's poorest regions. While trade volume expansion is not a direct measure of welfare improvement, estimates of the growth and income-inducing effects of increased trade can reflect generative (as opposed to redistributive) benefits and thus should be weighed in investment decisions (Frankel and Romer, 1999).

7.4 Cost-Effectiveness Measures

Rather than attaching a monetary value to transportation improvements, cost-effectiveness measures might be used instead. A cost-effectiveness metric might express the number of additional jobs that can be reached within one-half hour travel time per million dollar expenditure. Thus instead of attempting to assign a monetary value to benefits (e.g., increased access to jobs), only financial costs for project outlays are monetized. Combining data on financial expenditures with isochronic indices of accessibility can yield a reasonable performance measure that is free of such problems as valuing time or obtaining land valuation data.

Cost-effectiveness measures are likely better suited to many developing countries where reliable data are limited and outcomes are difficult to measure. Cost-benefit analysis is not used in evaluating public works projects — like a school building upgrade — when inputs cannot be easily translated to outcomes (e.g., higher student scores). Similar challenges in attributing transportation investments to accessibility outcomes argue for cost-effective measures as a second-best alternative in some instances.

8 Conclusion

The widespread and indiscriminant use of travel-time reductions as a stand-alone indicator of success in World Bank appraisals of urban transport projects is inconsistent with economic and spatial theories of how cities grow and function. In congested, fast-growing cities with a pent-up demand for mobility, unchecked sprawl, and correspondingly high induced-demand elasticities, travel-time savings is likely a poor measure of welfare benefits from transport interventions, policy changes, and capital investments.

The established practice of relying on time savings as the principal measure of economic benefit of urban transport projects needs to be questioned. Metz (2008, p. 324) echoes this view: "Data on average travel time offer no obvious support to the idea that travel time savings comprise the dominant element of the benefits from investments in the transport system". There is stronger evidence that people take advantage of transport system expansion in the form of additional access to desirable destinations, made possible by faster speeds within the fairly fixed budgets of time available for travel. Metz (2008, p. 325) adds that "given the long-term invariance of average travel time, travel time savings would necessarily be a transient phenomenon, in a context in which individuals tend to use improvements in the transport system to maximize access". Time savings is thus largely a short-term benefit. Over time, people tend to make longer journeys, not extra trips. Weighing impacts on accessibility thus brings a longer term perspective to the analysis, something that is needed given the fifty-plus year service life of most capital-intensive transport investments.

Concerns over induced travel, global warming, and auto-dependent cities call for a more balanced, holistic approach to evaluating future urban transport projects. Framing evaluations in terms of accessibility, not just mobility, allows a shift from a traditional engineering focus on speed and efficiency to a more balanced perspective that weighs environmental and social concerns as well. Additionally, assessing impacts on accessibility elevates the importance of land-use and demand-management strategies in the evaluation of alternatives. Besides accessibility and mobility (e.g., speeds), a more robust and inclusionary framework for measuring performance might also weigh factors like sustainability (e.g., VKT and emissions per capital), livability (e.g., community ratings or commute delays per capita), safety (e.g., road fatalities per 100,000 inhabitants), and affordability (e.g., percent wages spend on commuting) in judging proposals.

To date, accessibility has been treated qualitatively in most project appraisals of World Bank urban transport sector loans. It is not examined with the same rigor as projected travel-time savings. An evaluation of BRT proposals in Accra, Ghana, for example, used a qualitative scoring approach, subjectively giving "accessibility for low-income populations" a weight of 21.4% in judging competing corridors (World Bank, Africa Region, 2007). Many appraisals simply mention improved access in a list of "social benefits" as an adjunct to economic appraisals based mostly on savings in travel time and vehicle operating costs. Separating mostly quantified "economic benefits" from non-quantified "social benefits" gives the impression that accessibility impacts are secondary and non-pecuniary.

Elevating the importance of accessibility and other performance measures like sustainability in project appraisals need to be done with equity concerns in mind. If improved access to jobs, shops, and hospital services are limited to car-owning households, little progress will be made in alleviating urban poverty. It is thus important that all performance metrics stratify results in ways that allow the likely distributional equity impacts of a project to be assessed. Additionally, measures of affordability should be directly used as an indicator, in and of itself.

Our choices for evaluation are fortunately not "either/or" — travel time savings or accessibility. In fairly homogeneous small-town settings where growth rates are modest thus few land-use adjustments might be expected, travel-time savings might be an appropriate way to gauge benefits. In others, say in fast-growing cities where induced demand phenomenon is alive-and-well, as much focus might be placed on measuring accessibility impacts. In tandem, travel-time savings and accessibility shifts provide a rich perspective for exploring the economic benefits of proposed transport projects. When supplemented by other outcome measures, like impacts on the environment, safety, and vehicle operating costs, the two can provide a fairly complete portrait of future economic benefits

9 Next Steps

This paper argues for an enlarged, more inclusive set of indicators for evaluating transportation proposals in the developing world, most notably elevating the role and importance of accessibility improvements as a metric. How might this theory be put into practice? Given the reality that current appraisal methods are deeply entrenched and institutionalized, small, measured steps should be taken. Accordingly, a pilot demonstration is proposed. The aim should be to develop, refine, and apply a practical "tool-kit" of indicators for evaluating alternative urban transport proposals.

By way of illustration, this tool-kit might involve the following set of indicators:

First-Tier Indicators (with and without induced travel/induced growth adjustments):

- Total travel times
- Vehicle operating costs
- Collisions and accident injuries/fatalities

First-tier indicators could be measured using conventional methods, with the exception that adjustments would be made for estimated induced travel/induced growth impacts. Such adjustments might occur through feedback loops in 4-step models or through post-processing (i.e., applying induced travel/induced growth elasticities derived from comparable projects or provided as meta-analysis averages) [See: Cervero, 2006]. First-tier indicators might be further stratified by time-period (e.g., peak; all-day) and modes-of-travel.

Second-Tier Primary Indicators (with and without induced travel/induced growth adjustments):

- Environmental conditions (air pollution, noise pollution, visual impacts)
- Economic development impacts (employment, businesses, monetary value of private investments)

Second-order impacts generally reflect longer-term, delayed responses to changes in the urban transportation system. Conventional methods might be used, such as translating VKT and VHT impacts to air pollution levels using emissions-diffusion models. Economic development impacts might be estimated by applying techniques like shift-share forecasting, regional input-output modeling, or econometric/structural-equation modeling. Due to data and modeling limitations, more qualitative methods (e.g., expert-Delphi scoring) might be used in many developing country contexts to get at such hard-to-measure second-order impacts. In gauging impacts on economic development, care must be taken to distinguish those that are redistributive or pecuniary in nature versus those that are truly generative and income-producing.

<u>Second-Tier Supplemental Indicators (with and without induced travel/induced growth adjustments)</u>:

- Accessibility (jobs; medical facilities; education; retail-commercial)
- Sustainability (e.g., change in VKT per capita; change in VKT per motorist)
- Livability (e.g., percent change in trips by non-motorized transport by income strata; percent of peak-period traffic > 40 kph; percent green-space per capita; ratio of public green space to public impervious surfaces (i.e., parking and roads);
  lineal kms of bikeways/sidewalks per 10,000 inhabitants)
- Affordability (e.g., percent daily earns spent on transport; mean monthly transit fare payments to mean monthly income)

These supplemental second-tier indicators round out the evaluation framework by accounting for a wider array of impacts that go beyond those affecting direct users of transport facilities or services. Depending on the availability of suitable data, accessibility impacts could be gauged using a isochronic cost-effectiveness measure (e.g., change in mean number of hospital and clinic beds that can be reached within 30 minutes by public transit — an indicator of "medical access by transit" — per $1 million in investment costs). Or accessibility impacts could be monetized using hedonic-price methods. Alternatively, subjective scoring approaches might be used. In general, qualitative methods will need to be relied on to the extent that network-based travel-demand forecasting tools are unavailable for estimating impacts on VKT and VHT.

These multiple tiers of impacts are not additive. They represent overlapping Venn diagrams. Accordingly, trying to combine and force these metrics into a Cost-Benefit Analysis framework would be futile and yield erroneous results. Rather, consideration might be given to assigning relative weights to the indicators, based on local circumstances and expert opinions.

In closing, consideration should be giving to pilot-testing and operationalizing the expanded evaluation framework presented in this paper. This would involve choosing a case site and project, identifying appropriate indicators based on local conditions and data resources, and carrying out the evaluation. Field testing is the best way to move the theories and ideas expressed in this paper one step closer to implementation.

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Attachment F

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Air Qual Atmos Health (2010) 3:3–27
DOI 10.1007/s11869-009-0047-x

Cardiovascular health and particulate vehicular emissions: a critical evaluation of the evidence

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Received: 18 December 2008 / Accepted: 27 May 2009 / Published online: 30 June 2009

Abstract A major public health goal is to determine linkages between specific pollution sources and adverse health outcomes. This paper provides an integrative evaluation of the database examining effects of vehicular emissions, such as black carbon (BC), carbonaceous gasses, and ultrafine PM, on cardiovascular (CV) morbidity and mortality. Less than a decade ago, few epidemiological studies had examined effects of traffic emissions specifically on these health endpoints. In 2002, the first of many studies emerged finding significantly higher risks of CV morbidity and mortality for people living in close proximity to major roadways, vs. those living further away. Abundant epidemiological studies now link exposure to vehicular emissions, characterized in many different ways, with CV health endpoints such as cardiopulmonary and ischemic heart disease and circulatory-disease-associated mortality; incidence of coronary artery disease; acute myocardial infarction; survival after heart failure; emergency CV hospital admissions; and markers of atherosclerosis. We identify numerous in vitro, in vivo, and human panel studies elucidating mechanisms which could explain many of these cardiovascular morbidity and mortality associations. These include: oxidative stress, inflammation, lipoperoxidation and atherosclerosis, change in heart rate variability (HRV), arrhythmias, ST-segment depression, and changes in vascular function (such as brachial arterial caliber and blood pressure). Panel studies with accurate exposure information, examining effects of ambient components of vehicular emissions on susceptible human subjects, appear to confirm these mechanisms. Together, this body of evidence supports biological mechanisms which can explain the various CV epidemiological findings. Based upon these studies, the research base suggests that vehicular emissions are a major environmental cause of cardiovascular mortality and morbidity in the United States. As a means to reduce the public health consequences of such emissions, it may be desirable to promulgate a black carbon (BC) $PM_{2.5}$ standard under the National Ambient Air Quality Standards, which would apply to both on and off-road diesels. Two specific critical research needs are identified. One is to continue research on health effects of vehicular emissions, gaseous as well as particulate. The second is to utilize identical or nearly identical research designs in studies using accurate exposure metrics to determine whether other major PM pollutant sources and types may also underlie the specific health effects found in this evaluation for vehicular emissions.

Keywords Vehicular · Diesel · Cardiovascular · Exposure · Ambient · Epidemiology · Air pollution

Introduction

Method of assessing effects of vehicular emissions on cardiovascular endpoints

A considerable literature base is now available relating cardiovascular (CV) health effects from exposure to ambient particulate matter (PM) deriving from various sources. Specific components of PM from such sources—

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which are heterogeneous physically and chemically—will likely have differential health impacts.

Vehicular emissions consist of particulate and gaseous emissions, with biologically active carbonaceous products present in both phases. Black carbon, mainly from diesels, is found in ultrafine and fine size fractions, mainly less than 1 μm in size and predominantly below 0.18μm (Mauderly and Chow 2008). Such vehicular particulates are often coated with condensed organic and inorganic compounds (Mauderly 2001; Health Effects Institute 1995). Approximately 75% of diesel $PM_{2.5}$ emissions consist of such carbon (Health Effects Institute 2003). While particulate vehicular emissions per se, notably in the ultrafine fraction, have been specifically associated with endpoints such as oxidative stress and mitochondrial damage (Li et al. 2003), lipid peroxidation (Pereira et al. 2007), upregulation of genes relevant to vascular inflammation (Gong et al. 2007), and early atherosclerosis and oxidative stress (Araujo et al. 2008), non-particulate emissions have also been specifically linked to a variety of health endpoints (Mauderly and Chow 2008).

Our evaluation begins with the considerable amount of epidemiological evidence which has become available mainly since 2002 linking vehicular emissions with a range of CV outcomes. We then examine in vitro, in vivo, and human panel studies to understand if biological mechanisms have been identified in such studies which would explain the epidemiological findings for each CV outcome. Many of these studies use diesel emissions or diesel emission particulates, or evaluate effects from ambient air collected near highways in major cities with associations found with black carbon, mainly a diesel emission. Thus, our assessment assesses the coherence of results across different methodologies for CV endpoints, related to vehicular emissions.

Interpretation of studies related to accurate exposure assessment

Before reviewing epidemiological evidence linking vehicular emissions with CV endpoints, it is important to understand how differences among studies in accuracy of subject exposure to spatially variable emissions such as vehicular emissions can affect the strength and biological significance of associations.

Many epidemiological and panel studies use data from central monitors to characterize exposure to pollutants which may have considerable local variability and thus do not accurately characterize subjects' exposure to these emissions (Ito et al. 2004). Using central monitors or other less precise exposure estimation methods will result in underestimates of risks (Zeger et al. 2000), including those from vehicular emissions (Adar and Kaufman 2007). In multi-pollutant models, differential exposure error may cause risks to be transferred from variables having more exposure error to those having less (Goldberg and Burnett 2003; Hennekens and Buring 1987). Thus, it is essential to understand to what extent currently available studies include accurate assessment information for pollutants that might be particularly harmful, and to assess how these exposures relate to the magnitude and significance of risk estimates. This type of evaluation is necessary to determine whether emissions from specific sources rather than others may be more critical to regulate so as to preserve public health. Even with subject exposure misclassification, positive significant associations are not ruled out; however, in such a case, they are likely understated (Zeger et al. 2000).

This paper attempts to address these issues for vehicular emissions as they relate to CV health endpoints, with emphasis on epidemiological investigations incorporating reasonably accurate subject exposure information. We define "reasonably accurate exposure" as that exposure metric resulting from a methodology in which the measured exposure concentration varies with and, therefore, reflects reasonably closely the actual exposure for the population that is being assessed for adverse health outcomes. Methodologies which meet this criteria would include (1) personal monitors, (2) monitors which follow subjects closely as they go about their daily activities, (3) studies which use a combination of wind trajectories and pollution measurements to understand what sources were influencing exposure in the time period(s) of interest, and (4) studies in which the monitor was in close proximity to a roadway, and the subjects of the study also lived in close proximity to the same roadway not far distant from the monitor (Grahame 2009). On the other hand, an epidemiological study using a central monitored concentration and using this concentration as an exposure metric for subjects living over a wide area represents inaccurate exposure for traffic-related emissions, because such emissions have substantial variance across a city (Ito et al. 2004) and even within 100 m of a major highway vs. further away (Zhu et al. 2002a, b). A fuller discussion of these issues is found in Grahame (2009), which considers formally whether health effect associations vary consistently among studies which use reasonably accurate subject exposure information for spatially variable emissions such as BC, vs. studies using centrally monitored concentrations as a proxy for exposure to such local emissions.

The vehicle/traffic emissions category was selected since there is a large and growing evidence base suggesting that traffic-related pollution likely plays an important role in adverse health outcomes associated with ambient pollution such as urban PM, including black carbon (BC; White et al. 2005; Samet 2007; Adar and Kaufmann 2007;

Li and Nel 2006; Delfino et al. 2008), the latter derived primarily from diesel engines.

We first consider epidemiological studies which utilize information relating proximity of residence to major roads, to determine the extent to which such proximity may be associated with health outcomes such as all-cause or cardiovascular mortality and morbidity. Some of these studies examined associations of specific vehicular emissions, e.g., BC as a marker of diesel emissions, with such outcomes. Similar studies use modeled exposure to vehicular emissions (BC, or mainly outside the U.S., NO_2) at the residence, or use traffic density as a proxy for exposure to vehicular emissions (at county level or within 100 m of the residence).

We then consider studies which examine specific CV biological endpoints, e.g., oxidative stress, inflammation, change in EKG pattern (ST-segment depression), changes in heart rate variability (HRV), vasoconstriction and changes in blood pressure, arrhythmias, and lipoperoxidation/atherosclerosis. Such studies can vary considerably in accuracy of subject exposure; again, we emphasize findings from studies with more accurate exposure information. Toxicological evidence regarding specific biological mechanisms is also examined to understand if there might be common threads which extend from toxicological through panel studies to epidemiological evaluations.

Associations between vehicular emissions and lung cancer, and mutagenicity of vehicular emissions, have been reviewed elsewhere (Grahame and Schlesinger 2007) and will not be reviewed here. Similarly, the ample literature relating vehicular emissions and highway proximity to respiratory morbidity endpoints, such as asthma, will not be discussed.

Epidemiological evidence for association of vehicular emissions with adverse cardiovascular health outcomes

Investigating health effects specific to vehicular emissions in epidemiological studies has historically been problematic. Early studies did not monitor for pollutants most closely related to vehicular emissions (e.g., BC) and, thus, could not find associations with such emissions. Later reanalyses of the early studies were sometimes able to parse out such associations, despite the lack of vehicular pollution data (e.g., the Jerrett et al. 2005 reanalysis of the American Cancer Society cohort [Pope et al. 1995, 2002]). When studies began to monitor specifically for vehicular emissions such as BC, initial exposure assessment used central monitor data and associations were often not robust. NO_2 is also seen as a marker of vehicular emissions, particularly in European studies. Although NO_2 is emitted from sources other than vehicles, such as power plants and industry, vehicular NO_2 emissions usually dominate in busy urban centers lacking major industry. In some cases, where monitors were located in close proximity to major highways, even SO_2 and/or SO_4 from different sources, including diesels before the 2007 changeover to ultra-low sulfur diesel fuel, may be intermixed (Grahame and Hidy 2007a, b).

Studies using central monitoring for several different sources, including vehicles, did not always find daily mortality or morbidity associated with vehicular emissions. For example, Thurston et al. (2005) failed to find cardiovascular or non-accidental mortality associated with a traffic emissions factor in either Phoenix or Washington, DC, using different source apportionment models. However, the daily mortality study of Laden et al. (2000) found such associations, as did the Schwartz (2003) reanalysis of Laden et al. (2000), necessitated by problems in the original study with a statistical software package (which affected many other studies as well). Another multi-city study (Janssen et al. 2002) examined prevalence of air conditioning as an effect modifier, and found associations for daily morbidity (hospital admissions for CV disease) with diesel emissions, highway emissions, and vehicle miles traveled per square mile (traffic density). Two recent studies based in Atlanta (Sarnat et al. 2008; Tolbert et al. 2007) found significant associations between vehicular emissions and emergency department admissions for CV disease. However, Metzger et al. (2007), in a study also in the Atlanta area, failed to find associations between PM_{10}, $PM_{2.5}$, or vehicular emissions with daily morbidity (i.e., arrhythmias).

Four of these six multi-pollutant studies found CV health associations with vehicular emissions, but none of the studies utilized exposure measurements known to reflect subject exposure reasonably accurately, because all used pollution measurements from central monitors as a proxy for personal exposure. While these studies, taken as a whole, suggest the importance of vehicular emissions for the health endpoints examined, strength of effects may be underestimated (Ito et al. 2004), and results are not always consistent. Thus, the most credible studies linking spatially variable vehicular emissions to various health effect endpoints would be those which demonstrate that the ambient pollutant concentrations utilized relate reasonably well to actual exposure of populations examined for health effects.

Concentrations of vehicular emissions have been shown to drop by as much as an order of magnitude within 100 m of a major freeway. People living nearby major roadways will be exposed to greater amounts of vehicular emissions such as BC, ultrafine PM, and gaseous emissions, than will those living at a greater distance (Zhu et al. 2002a, b). As a result, the studies first to show large adverse cardiovascular effects clearly and consistently linked to vehicular emissions were “highway proximity studies.” These are studies designed to isolate the health risks of living near a major road from the traditional risk factors typically examined in cohort studies.

Conducted first in Western Europe and Canada, and later in the US, highway proximity studies found significantly elevated risks for cardiovascular death or morbidity outcomes and for all-cause mortality, for people living in close proximity (usually 100 m to major roadways or 50 m to a major urban road), compared to those living farther away. Several utilized data from existing cohort studies, adding only the highway proximity variables. In different ways and to different degrees, these studies accounted for socioeconomic and other variables which could confound pollution–health associations. These studies include the following (statistically significant associations are indicated):

- Finkelstein et al. (2004, 2005; all-cause mortality [relative risk, RR=1.18] and circulatory disease mortality [RR = 1.40], respectively);
- Hoek et al. (2002; cardiopulmonary mortality [RR= 1.95]);
- Gehring et al. (2006; cardiopulmonary mortality, RR= 1.70);
- Tonne et al. (2007; acute myocardial infarction [MI], RR=1.04 to 1.06);
- Hoffmann et al. (2007; increased coronary artery calcification: RRs=1.63 and 1.34 for distances of less than 50 m and 51 to 100 m from highways, vs. more than 200 m distant); and
- Hoffman et al. (2006; incidence of coronary heart disease, RR of 1.85).

These RRs can be compared to RRs for all-cause and cardiopulmonary mortality of 1.04 and 1.06 (per 10 $\mu g/m^3$ increase in $PM_{2.5}$) found in the American Cancer Society (ACS) study (Pope et al. 2002). Finkelstein et al. (2004) found a significant mortality rate advancement period of 2.5 years associated with residence near a major roadway.

Another method of associating mortality risks with proximity to traffic and highways utilizes different measures of traffic density (e.g., annual vehicle miles per square kilometer in a county, or daily vehicle kilometer within 100 m of a residence) as a proxy for exposure to vehicular emissions. Relevant studies finding significant health associations with traffic density measures include:

- Kan et al. 2008 (incidence of coronary heart disease [CHD]; significant increase in CHD incidence hazard ratio [HR] of 1.32 for those in highest quartile of traffic density vs. lowest quartile, HR of 1.38 for those in second highest quartile vs. lowest quartile);
- Janssen et al. 2002 (hospital admissions for CVD; one interquartile range [IQR] increase in vehicle miles traveled per square mile significantly associated with a 21.2% increase in CVD hospital admissions);
- Lipfert et al. 2006a, b (all-cause mortality; between these two studies, 30 of 33 tests of traffic density measures were significant, in single and multi-pollutant models, with two different ways of stating risks, with RRs centering around 1.16 in Lipfert et al. 2006a[1]); and
- Medina-Ramon et al. 2008 (survival after heart failure; an IQR increase in daily traffic within 100 m of home significantly associated with a mortality HR of 1.12 after adjustment for SES, and with a HR of 1.30 for those living within 50 m of a bus route).

The Medina-Ramon et al. (2008) study found that a measure of traffic density (vehicle km within 100 m of residence) was a stronger predictor of survival time after heart failure than were other measures, such as similar distance to a major roadway. This finding makes intuitive sense—ideally, exposure should be a product of both proximity and of the amount of pollution produced within that proximity. Just as proximity of a residence to a major highway is a better proxy for exposure to traffic emissions than is centrally monitored PM concentrations, traffic density within 100 m of a residence is likely a better proxy than distance of 100 m from a major road. Distance to a bus route was also an important predictor of survival in Medina-Ramon et al. (2008), suggesting the importance of diesel emissions.

Results of Kan et al. (2008) parallel findings of Hoffmann et al. (2006), in that both studies controlled for hypertension, a mechanism by which noise might cause stress and, thus, by which traffic might cause coronary heart disease via noise pollution rather than chemical pollution. As a result, findings associating mortality and morbidity risks to proximity to busy highways and traffic likely can be attributed primarily to chemical pollution rather than to noise.

Using geographic modeling systems to relate individual residences to either traffic emissions concentrations, distance to major roads, or traffic intensity, other studies also found elevated levels of vehicular pollutants to be associated with adverse cardiac-related health outcomes. Examples include:

- Rosenlund et al. (2006; NO_2 modeled to home significantly associated with out-of-hospital deaths, OR of 2.17 for a 5% to 95% increase in NO_2 [in Stockholm, Sweden]);

[1] The traffic density was insignificant only when EC was also included in a multi-pollutant model; in these cases, both variables came close to significance, but traffic density appeared to be the stronger of the two.

- Maynard et al. (2007; significant 2.3% increase in all-cause mortality per IQR increase in BC modeled to home);
- Beelen et al. (2008; significant RR of 1.05 for all-cause mortality for a 5% to 95% increase in black smoke); and,
- Nafstad et al. (2004; significant RR of 1.11 for ischemic heart disease mortality associated with a 10 µg/m^3 increase in NO_2 at home [in Oslo, Norway]).

Finally, Peters et al. (2004) found that a first MI was significantly associated with being in traffic 1 h prior to the event (odds ratio 2.92).

What all of these studies have in common is a demonstration that people exposed to the higher levels of traffic emissions found close to major urban roads or freeways, or modeled to their homes, have higher long-term risks for ischemic heart disease, acute MI morbidity and mortality, and all-cause mortality, or increased risks of a first-time MI with short-term exposure to traffic pollution. These studies, with reasonably accurate subject exposure information for traffic emissions, have results which often (but not always) contrast with studies using central monitors.

Several studies noted above also associated BC or its near equivalent, black smoke, with increased morbidity and mortality risks. Hoek et al. (2002) found risks of cardio-pulmonary mortality significantly associated with black smoke (local plus background, RR=1.71; background black smoke, RR=1.34), suggesting the greater effects of fresh, local roadway black smoke. Maynard et al. (2007) found that an increase of one IQR (interquartile range) in previous days BC exposure was associated with a significant increase of 2.3% in all-cause mortality in single-pollutant models, and of 2.2% in two pollutant models. Beelen et al. (2008) found significant increases in all-cause and respiratory mortality associated with black smoke and/or NO_2 but not with $PM_{2.5}$ or SO_2. Nafstad et al. (2004) found a 10 µg/m^3 increase in nitrogen oxides at the home to be associated with significant increases in all-cause and ischemic heart disease mortality of 1.08 and 1.11, respectively. Relative risks of cardiopulmonary mortality of 1.57 and of all-cause mortality of 1.17 were related to near-highway NO_2 exposure in Gehring et al. (2006). Rosenlund et al. (2006) found an odds ratio for out-of-hospital death of 2.17 related to NO_2 exposure.

Mechanistic bases for adverse cardiovascular health outcomes from vehicular emissions-derived PM

In order to provide mechanistic plausibility for the epidemiological findings noted above, it would be helpful to have information about specific conditions or biological responses which could lead to these reported health outcomes. Such information can be derived from in vitro and in vivo toxicology studies, as well as from human panel studies using vehicular emissions or ambient air.

Personal monitors would provide better exposure assessment than would a proxy for personal exposure, such as distance of residence from a major road, or modeled exposure at one's home. Although each of these proxies provides far better exposure differentiation than would a central monitor reading applied to all residents in a locality, there will still be differences in daily activity patterns and, thus, exposures, among similarly situated people. For obvious reasons, cohort studies of mortality and of many morbidity outcomes such as hospital admissions for CV disease could not utilize personal monitors. However, for certain short-term morbidity outcomes with fairly high frequencies, such as change in HRV, ST-segment depression, and arrhythmias, the use of personal pollution monitors or their equivalent may be possible.

Oxidative stress

Oxidative stress is a mechanism postulated to be involved in various PM-induced cardiovascular health effects, including chronic heart failure (McMurray et al. 1993), acute heart failure (especially when patients had atrial or ventricular arrhythmia [Charniot et al. 2008]), and atrial fibrillation (AF; Neuman et al. 2007). Kim et al. (2003) found in AF patients that gene expression profiles for reactive oxygen species were upregulated, while those for anti-oxidants were downregulated. Iravanian and Dudley (2006) suggest a unifying hypothesis that there are multiple triggers for oxidative stress and that oxidative stress, whatever the origin, causes AF. Furthermore, AF itself can result in further oxidative stress, creating a positive feedback loop.

Chahine et al. (2007) found that individuals lacking genes protective against oxidative stress (GSTM1 and the short repeat variant of HMOX-1), but not those with such genes, are vulnerable to HRV changes due to pollution exposure. Instillation of urban air particles and inhalation of concentrated ambient air particles caused oxidative stress in the heart in vivo, as well as reduction in HRV (Rhoden et al. 2005); increases in heart oxidant levels were demonstrated by increases in chemiluminescence or TBARS. Oxidant effects were abolished by the anti-oxidant, NAC. When oxidative stress was abolished, HRV returned to normal (Rhoden et al. 2005). Thus, findings of both Chahine et al. (2007) and Rhoden et al. (2005) suggest that reductions in HRV appear to be due to increased oxidative stress. If this is true, then lack of HRV changes may indicate lack of oxidative stress in some to many cases.

Given the evidence that oxidative stress can be mechanistically linked to cardiac pathophysiology, we next review studies which find that exposure to vehicular emissions generally, and to diesel emissions specifically, are linked to oxidative stress.

Pereira et al. (2007) found that in vivo exposure to ambient emissions taken adjacent to a busy road in Porto Alegre, Brazil caused oxidative stress and lipid peroxidation in rat lungs. Similarly, Huang et al. (2003) found that $PM_{1.0}$ was more likely to cause lipid peroxidation in human bronchial epithelial cells than either $PM_{1.0–2.5}$ or $PM_{2.5–10}$, and that the components of $PM_{1.0}$ associated with increased lipid peroxidation were organic carbon (OC) and elemental carbon (EC), but not various ions.

A number of studies suggest that diesel emissions, most specifically ultrafine PAH, appear to be associated with increased levels of cellular oxidative stress. As reviewed in Grahame and Schlesinger (2007), a series of studies demonstrated the ability of both diesel emissions and of ambient air in Los Angeles to cause oxidative stress in vitro in bronchial epithelial cells. These effects were highly correlated with organic carbon and PAH content. Briefly, Li et al. (2002a) found that organic diesel emission particles (DEP) caused oxidative stress in vitro (marked by increases in heme oxigenase-1, HO-1), and Li et al. (2002b) found that concentrated emissions from Los Angeles air, collected from near a major freeway, also caused increases in oxidative stress, e.g., in HO-1. Ultrafine (UF) fractions of Los Angeles air stimulated higher production of HO-1 than did larger PM fractions (Li et al. 2003). Production of HO-1 was correlated with the organic and PAH content of the ultrafine PM. Electron microscopy showed these UF particles penetrated into subcellular structures more easily than did larger particles, and damaged mitochondria. Taken together, these in vitro studies of Los Angeles air suggest that the ultrafine fraction of diesel emissions in Los Angeles air, likely including ultrafine BC coated with a mix of organic compounds, appear to be causally related to the increases in oxidative stress also found to be caused by organic DEP.

Findings of oxidative stress were confirmed in vivo, in a study where HO-1 levels in mice exposed to the exhaust of a normally running newer diesel increased significantly vs. filtered air control (McDonald et al. 2004). Furthermore, when a new catalytic trap was retrofitted on the diesel, most of the carbonaceous emissions were reduced by large percentages, BC was entirely oxidized, and the HO-1 levels were no longer elevated.

The panel study of Delfino et al. (2008) used indoor and outdoor monitors at the residences of 29 non-smoking elderly subjects with coronary artery disease living in Los Angeles. Decreased levels of an anti-oxidant enzyme were significantly associated with increased concentrations of BC, primary OC of outdoor origin, NO_2, and ultrafine PM.

Mills et al. (2005) exposed healthy human volunteers to diluted diesel exhaust (300 $\mu g/m^3$) or to filtered air for 1 h in a double-blind, randomized, crossover study. The authors found that inhalation of diesel exhaust impaired the regulation of vascular tone and endogenous fibrinolysis. Net release of "clotbusting" t-PA antigen was significantly reduced 6 h after exposure. The authors postulated that effects might be caused by reduced availability of nitric oxide (NO) in the vasculature due to oxidative stress induced by the ultrafine particle fraction of diesel exhaust, providing a mechanistic link for associations between PM and acute MIs. Consistent with this supposition, previous work has found that the ultrafine fraction of diesel emissions (likely with adsorbed carbonaceous species) causes greater levels of oxidative stress than larger fractions (Li et al. 2002a, b, 2003; Araujo et al. 2008). The results of Mills et al. (2005) suggest one possible explanation for the significant finding of an initial myocardial infarction in 1 h after being in traffic (as a driver or on public transit) noted by Peters et al. (2004), and for increases in cardiovascular mortality linked to traffic emissions on high pollution days (Schwartz 2003).

Because of its potential to be involved in various specific aspects of CV pathophysiology, further discussion of the role of oxidative stress in pollutant-related health outcomes is provided in discussions of individual CV endpoints below.

Alteration in heart rate variability

Many recent studies assess HRV, which refers to alterations in the beat to beat heart rate and is regulated by the autonomic nervous system. While normal sinus rhythm is characterized by regular R–R intervals in the EKG, the heart does normally show some variability from beat to beat, which can be measured by examination of these intervals. HRV changes appear to be predictive of MI for those who have had a previous MI (Tapanainen et al. 2002), or who have chronic congestive heart failure (Bilchick et al. 2002). Schwartz et al. (2005a) found that in those lacking the allele for glutathione-*S*-transferase M1 (*GSTM1*), a component of the cellular defense against oxidative stress, $PM_{2.5}$ effects on HRV (a decrease in high-frequency component, HF) is mediated by reactive oxidant species. Use of statins, which have anti-oxidant effects, eliminated the effects of $PM_{2.5}$ on HRV. Thus, while changes in HRV may be a cause of cardiac mortality, in particular for those who have had a previous MI, it also appears to be another possible sequela of oxidative stress in the heart (Rhoden et al. 2005; Schwartz et al. 2005a), which has broader health implications than change in HRV alone.

Several recent studies with accurate exposure information suggest that either vehicular emissions specifically, or urban emissions generally, are associated with changes in HRV. A literature search was performed to find studies of HRV which used ambient air and human subjects in the US, and which monitored for at least two of the three pollutants ($PM_{2.5}$, BC, sulfate).

Adar et al. (2007) used a mobile monitor, which followed 44 non-smoking elderly residents of a seniors' home who were going about daily activities, and found significant associations between increased BC exposure for the entire period and changes in six measures of HRV (see Table 1), for two different time periods, a total of 12 significant associations in 12 tests. When the subject boarded a bus and BC concentrations rose by about an order of magnitude, changes in most HRV measures were similar.

Schwartz et al. (2005b) examined HRV in 27 seniors living in close proximity to a busy urban road in Boston. The monitor, located about 0.5 km distant from the living quarters and also adjacent to the same road, recorded BC and PM concentrations which would mirror concentrations at the residences reasonably well (because of similar close proximity to the major urban road). The investigators found in six of eight tests (four HRV measures, two time frames), that increased BC was significantly associated with changes in different measures of HRV (a seventh test was borderline significant). $PM_{2.5}$ was significantly associated in two of eight tests. When an algorithm was used to remove BC from $PM_{2.5}$ on an hourly basis and thus obtain a measure of what the authors viewed as regional $PM_{2.5}$ without fresh BC and correlated emissions, no associations were found between $PM_{2.5}$ and HRV measures (Fig. 1). These findings appear to show that previous studies which did not monitor for BC and found associations with $PM_{2.5}$, may have been detecting unmeasured BC (i.e., vehicular) effects, and that $PM_{2.5}$ was associated with various changes in HRV only when $PM_{2.5}$ was highly correlated with BC, another finding of Schwartz et al. (2005b).

Creason et al. (2001), in a study of 56 non-smoking seniors with a mean age of 82, used wind trajectories to determine which air masses (containing different types of pollution) were associated with changes in HRV. The authors initially found a "U-shaped" association between increasing $PM_{2.5}$ levels and decreasing HRV—as PM concentrations increased from the lowest levels, HRV reductions occurred with increasing $PM_{2.5}$, but toward the highest $PM_{2.5}$ concentrations, HRV reductions reversed, and the HRV measure returned to where it was at the lowest $PM_{2.5}$ levels (null effect). Inclusion of a 2-day air mass with high $PM_{2.5}$ (highest and third highest of 24 days) had caused the reversion. On these 2 days, the investigators found, wind trajectories showed that the air masses had come from rural north-central Pennsylvania. When these 2 days were removed from the analysis, there was a monotonic decrease in HRV with increasing PM, similar to the monotonic decrease in PM found in Schwartz et al. (2005b) when the PM was highly correlated with urban BC. The authors noted that HRV reductions were found when the emissions reflected urban or industrial activity, but that there was no toxicity in the 2 days with high PM from rural areas.

Similar effects were noted by Park et al. (2007), a study of 487 male veterans. The authors found that trajectories reflecting urban emissions (either a stagnant local air mass in Boston or an air mass transported from the Washington, DC through New York City corridor) were associated with changes in several HRV measures. Two other trajectories reflecting mostly rural air masses were not so associated, even though monitored levels of sulfate, BC, and $PM_{2.5}$ were very similar among the air masses. Finally, Ebelt et al. (2005) used personal monitors in a panel study of 16 non-smoking COPD patients, and found that local urban particles, but not sulfates, were associated with HRV changes.

All these above-studies are characterized by reasonably accurate exposure information, whether for BC (Adar et al. 2007; Schwartz et al. 2005b), for PM in urban/industrial air masses vs. rural air masses (Creason et al. 2001; Park et al. 2007) or for urban emissions vs. sulfate (Ebelt et al. 2005). The two studies which monitored for BC (Adar et al. 2007; Schwartz et al. 2005b) showed consistently significant associations between changes in HRV measures and BC concentrations, with virtually no insignificant associations. Further, HRV changes were essentially monotonic with increasing BC levels in these studies.

Since the main contributor to "urban excess" $PM_{2.5}$ is vehicular emissions marked by carbonaceous species (Rao et al. 2002), the urban vs. rural air mass results are consistent with results of exposure to higher BC and vehicular emissions in an urban area. Furthermore, Anselme et al. (2007) exposed Wistar rats (ten healthy, ten with chronic ischemic heart failure, CHF) to diluted diesel emissions. Immediate decreases in a HRV measure (RMSSD) were observed in both healthy and CHF rats following exposure, a finding which parallels the reductions in HRV found in Schwartz et al. (2005b) and Adar et al. (2007) in association with increased BC exposure.

Other extant studies lacking accurate exposure information for locally variable emissions because they used central monitor readings for subjects living over a wide area, generally showed weak (Wheeler et al. 2006; Park et al. 2005) or non-existent (Luttmann-Gibson et al. 2006) associations for locally variable BC (Table 1), while some studies with central monitor readings still found associations with vehicular emissions (de Hartog et al. 2009). The exposure assessment for Luttmann-Gibson et al. in particular, uses a monitor several hundred feet in the air, adding

Table 1 Vehicular emissions and heart rate variability changes

Study	Subject exposure method	Characterization of HRV changes	BC levels
A. In vivo animal study			
1. Anselme et al. (2007)	Healthy and CHF rats exposed to diesel emissions	Immediate decrease in RMSSD in both CHF and healthy rats immediately after exposure, returning to baseline after 2.5 h	BC not measured
B. Human studies with accurate exposure			
1. Schwartz et al. (2005b)	Subjects lived adjacent to same urban road to which monitor was adjacent, less than 1 km distant	Monotonic decrease in SDNN with increase in BC exposure; significant BC associations in seven of eight tests (SDNN, RMSSD, PNN50, LF/HF, 1 and 24-h averages); no significant associations in eight tests for $PM_{2.5}$ without BC ("non-traffic secondary particles")	BC mean=1.2 $\mu g/m^3$
2. Adar et al. (2007)	Monitor followed subjects during activities, in residence at night	For change of one IQR, BC significantly associated with changes in all six measures of HRV, for both 5-min and 24-h means; sharply increased exposure to BC when subjects on buses associated with changes of similar magnitude in all six HRV measures (decreases in SDNN, PNN50+1, RMSSD, LF, and HF; increase in LF/HF), similar to Schwartz et al. (2005b)	BC mean not given; BC IQR for all periods was 330 ng/m^3; for bus periods, IQR was 2911 ng/m^3
3. Riediker et al. (2004b)	Presence of young patrol officers in vehicle for 9 h before tests	Significant increases in SDNN, PNN50 associated with "speed change" source factor, (braking and diesel emissions), but not "crustal," "steel wear" or gasoline factors	BC not measured
4. Ebelt et al. (2005)	Personal monitors in panel study in Vancouver	Estimated non-sulfate urban $PM_{2.5}$ associated with decreased RMMSD, sulfate not associated	BC not measured
C. Human studies using central monitors not far from street level (horizontal exposure misclassification)			
1. Wheeler et al. (2006)	Central monitor for greater Atlanta area subjects	EC associated with SDNN changes in only one of four tests, NO_2 in only 4 of 13 tests; authors discuss exposure error due to spatial variability of NO_2, note "this greater exposure error is consistent with the fact that traffic, which varies spatially over short distances, is a significant source of outdoor NO_2."	EC mean=1.6 $\mu g/m^3$
2. Park et al. (2005)	Central monitor for subjects living within 40 km of monitor	BC associated with one of four measures of HRV changes; exposure discussed in context of $PM_{2.5}$ (little exposure error) but not discussed for BC	BC mean=0.92 $\mu g/m^3$

Table 1 (continued)

Study	Subject exposure method	Characterization of HRV changes	BC levels
D. Studies using highly elevated central monitors (horizontal and vertical exposure misclassification)			
1. Luttmann-Gibson et al. (2006)	Central monitor elevated 400 feet above town where subjects lived, a mile from monitor	For IQR change in $PM_{2.5}$ or sulfate, significant reductions in SDNN, RMSSD, HF, and LF (sulfate borderline for LF), no associations for BC; exposure error not discussed	BC mean=1.0 μg/m^3

SDNN standard deviation of normal-to-normal intervals, *RMSSD* square root of mean squared difference between adjacent normal-to-normal intervals, *PNN50* percentage of adjacent normal-to-normal intervals differing by more than 50 ms, *HF* high-frequency power, *LF* low frequency power, *LF/HF* ratio LF to HF, *RR* risk ratio, *OR* odds ratio, *IQR* interquartile range increase, *SD* standard deviation

substantial vertical exposure misclassification (Restrepo et al. 2004) to the horizontal exposure misclassification (Ito et al. 2004) found in Wheeler et al. (2006) and Park et al. (2005). We are unaware of any study with reasonably accurate exposure information for BC or for urban emissions which fails to find associations between such emissions and HRV alteration when the latter was examined. A detailed review of US HRV studies utilizing ambient air and human subjects concludes that results of these studies appear to vary consistently with accuracy of exposure to vehicular emissions (Grahame 2009), with consistently strong BC associations with changes in various measures of HRV, almost always significant, only when BC exposure measures are reasonably accurate.

In a study of 643 healthy men and women aged 55 to 75 and with no prior history of heart disease or stroke,

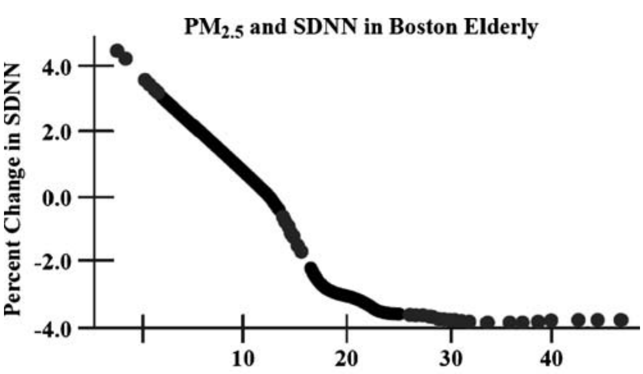

Fig. 1 SDNN monotonically decreases with increased $PM_{2.5}$ when $PM_{2.5}$ is highly correlated with BC, but is not affected by rising levels of $PM_{2.5}$ when $PM_{2.5}$ is higher and correlated with regional PM, but not BC [from Schwartz et al. (2005b), reproduced with permission]

Sajadieh et al. (2004) suggested the possibility of interactions between HRV changes (imbalance in sympathetic system) and subclinical inflammatory processes in promoting atherosclerosis. Thus, there are likely linkages between various aspects of cardiopulmonary pathophysiology related to pollutant exposure.

ST-segment changes

The ST interval in the EKG represents the period during which the ventricles depolarize. A depression in the ST-segment is associated with increased risk for future cardiac events; those with undetected ST-segment depression have significantly greater risk of death from cardiovascular disease and stroke (Kurl et al. 2003). Pekkanen et al. (2002) found elevated levels of $PM_{2.5}$ mass in urban areas to be associated with ST-segment depression, but could not determine which specific components of $PM_{2.5}$ resulted in such a response. On the other hand, Gold et al. (2005), in a study with the same reasonably accurate exposure protocol as its companion study (Schwartz et al. 2005b), found BC strongly associated with ST-segment depression. Total $PM_{2.5}$, which would include a mixture of both regional and local pollution, was not associated with ST-segment depression in this study.[2] Lanki et al. (2006) found that of several local and regional pollutants, only a traffic factor marked by absorbance coefficient (ABS, similar to black carbon) was associated with ST-segment depression. Subject exposure in Lanki et al. (2006), however, was based on central monitor readings.

[2] Another vehicular emission, CO, was also so associated, but in a two pollutant model with BC was no longer significant. In studies from the 1970s and 1980s, CO was found to be significantly associated with various health endpoints, but CO levels were more than an order of magnitude higher in the 1970s than they are today.

Although Lanki et al. (2006) did not have as accurate exposure characterization as did Gold et al. (2005), both of these studies came to the same conclusion, namely, that vehicular emissions marked by BC or ABS were associated with ST-segment depression. This endpoint, as well as HRV/oxidative stress in the heart and arrhythmias, is among the likely causes for a first-time MI 1 h after being in traffic (Peters et al. 2004).

In a double-blind, random crossover study (Mills et al. 2007), subjects with coronary heart disease were exposed for 1 h to diluted diesel exhaust or filtered air (alternating 15 min of mild exercise with 15 min of rest). ST-segment depression occurred in both sets of subjects, but the average change in ST-segment depression was twice as great in subjects exposed to diluted diesel exhaust. This result with diesel emissions parallels results of the two epidemiological studies of this endpoint reviewed above, which found associations with BC or its equivalent, ABS.

Yan et al. (2008) examined left ventricular function in healthy rats exposed to diesel exhaust particles (NIST standard) and in those subjected to isoproterenol-induced injury as a model for congestive heart failure. Diesel exhaust particles impaired left ventricular functioning, such as end diastolic diameter, in healthy mice, and this was further impaired in the myocardial injured animals. This suggests that acute exposure to these particles may result in exacerbation of congestive heart failure, which supports epidemiological findings of an association between PM components, fine PM, OC, and EC, and hospital admissions for congestive heart failure (e.g., Metzger et al. 2004).

Cardiac arrhythmia

Although some studies have associated measures of air pollution with arrhythmias monitored by implantable cardioverter-defibrillators (ICDs), none to date have utilized either personal pollution monitors or ambient monitors which follow residents of a seniors' home, or the specific exposure protocol of Schwartz et al. (2005b) and Gold et al. (2005). Thus, the available database having good spatial exposure information, and which would also allow evaluation of those pollutants that may be important for triggering arrhythmias, is limited.

Albert et al. (2007) examined risks of an ICD shock during and after driving, finding increased risk in the hour after driving (significant RR=2.24). The risks were specific for ventricular tachycardia or ventricular fibrillation (VT/VF), which occurred primarily in the half hour after driving (RR=4.46, CI=2.92 to 6.82). These risks are similar to but higher than the risks for a first MI found by Peters et al (2004) in the first hour after being in traffic (odds ratio 2.92; 95% CI=2.22 to 3.83). Charniot et al. (2008) found that oxidative stress in the heart was linked to acute heart failure when a subject had a ventricular arrhythmia. Thus, ventricular arrhythmias and oxidative stress, both of which are linked to exposure to vehicular emissions, together appear to contribute to acute heart failure. However, the role of oxidative stress as a specific cause of such arrhythmias is not yet fully understood. If oxidative stress were to be the cause of VT/VF, then the studies linking BC to HRV/oxidative stress (e.g., Schwartz et al. 2005b; Adar et al. 2007) would point to BC as a primary cause of arrhythmias as well. The actual cause of the oxidative stress could be BC itself, emissions adsorbed onto the BC, and/or emissions highly correlated with BC.

Riediker et al. (2004a, b) examined 11 different health endpoints, including changes in supraventricular ectopic (SVE) beats, an arrhythmia variable, in healthy young patrol officers. Measurements for this endpoint took place 10 h after a 9-h duty shift on roads and highways. Using the suite of emissions measured, the authors established three different factors of emissions, reflecting PM on road surfaces, gasoline emissions, and a "speed change" factor reflecting accelerating diesels and brake wear. Increases in SVE beats were associated only with the speed-change factor.

Ebelt et al. (2005) also found, in a study using personal monitors, increases in SVE beats associated with ambient urban PM and ambient non-sulfate PM, but not with sulfate, in a panel study in the Vancouver area. Table 2 shows results of studies of vehicular emissions and arrhythmias, stratified as in Table 1 by accuracy of exposure.

Peters et al. (2000) examined the incidence of arrhythmias among 100 patients in eastern Massachusetts in relation to various air pollutants (PM_{10}, $PM_{2.5}$, BC, NO_2, SO_2, CO, O_3) measured in South Boston. Associations were found with $PM_{2.5}$, BC, CO, and NO_2 with a 2-day lag. The strongest associations were found for BC and NO_2, which the authors took as evidence of effects of local traffic. However, because of exposure misclassification, BC and NO_2 effects were likely underestimated, a possibility suggested by others (Zeger et al. 2000; Ito et al. 2004) and discussed by authors of several studies with exposure error (Tables 1 and 2). As Peters et al. (2000) noted, "…we would expect any exposure misclassification [for a centrally monitored emission] to…bias the estimates toward the null."

Dockery et al. (2005) followed 203 cardiac patients with implanted ICDs living in metropolitan Boston for an average of 3.1 years each between 1993 and 2002. Pollution ($PM_{2.5}$, BC, SO_4, particle number, NO_2, CO, SO_2, O_3) was monitored at several sites in the metropolitan area. Average concentrations were derived for pollutants with multiple measurements. No significant associations for ventricular tachyarrhythmias were found for an interquartile range increase in any pollutant, for a 2-day pollution mean. However, when stratifying by a recent arrhythmia, significant associations were found for $PM_{2.5}$, BC, NO_2, CO and

Table 2 Vehicular emissions and arrhythmia risks

Study	Subject exposure method	Risks of arrhythmia
A. In vivo animal study		
1. Anselme et al. (2007)	CHF rats exposed to diesel emissions; no effect in healthy rats	200% to 500% increase in ventricular premature beats, persisting up to 5 h after exposure
B. Human studies with accurate exposure		
1. Albert et al. (2007)	Presence in vehicle before ICD events	RR of ICD shock in hour after driving =2.24; RR of ventricular tachycardia or ventricular fibrillation in half hour after driving =4.46
2. Riediker et al. (2004b)	Presence of young patrol officers in vehicle for 9 h before tests	~ 40% increase in SVE beats per change of one SD in "speed change" source factor (braking and diesel emissions), but not in "crustal," "steel wear" or "gasoline" factors
3. Ebelt et al. (2005)	Personal monitors in panel study in Vancouver area	Ambient and estimated $PM_{2.5}$, non-sulfate $PM_{2.5}$ each associated with ~ln 0.2 SVE effect estimate; sulfate not associated[a]
C. Human studies using central monitors not far from street level (horizontal exposure misclassification)		
1. Peters et al. (2000)	Central monitor for eastern Massachusetts area subjects	Risks highest for NO_2 and BC, then $PM_{2.5}$; results seen by authors as related predominantly to traffic emissions; OR of ICD shock 2 days later =1.8 for 26 ppb increase in NO_2; due to single monitor, authors' expectation would have been to bias estimates of gaseous emissions toward null
2. Dockery et al. (2005)	Central monitor for subjects living within 40 km of monitor in Boston	Ventricular tachyarrhythmias associated with BC, NO_2, CO, and $PM_{2.5}$, for those with an arrhythmia in previous 3 days, authors see these as indicative of vehicular emissions; for BC, OR=1.74 for increase of 0.74 $\mu g/m^3$ IQR exposure, for NO_2, OR=1.34 for 7.7 ppb IQR increase; exposure misclassification discussed, thought to weaken associations observed
3. Metzger et al. (2007)	Central monitor data for patients living in metro Atlanta area	No associations with ICD events with $PM_{2.5}$, NO_2, CO, EC, OC, SO_4; exposure misclassification discussed, study "does not contribute evidence regarding whether personal exposure may be a determinant of ventricular tachyarrhythmia"
4. Rich et al. (2006)	Central monitor for subjects living within 40 km of monitor in Boston	No risk associations for paroxysmal atrial fibrillation episodes with $PM_{2.5}$, NO_2, BC, CO, or SO_2; associations only with ozone; small number of episodes, thus reduced statistical power discussed, but exposure misclassification not discussed
D. Studies using highly elevated central monitors (horizontal and vertical exposure misclassification)		
1. Sarnat et al. (2006)	Central monitor elevated 400 feet above town where subjects lived, a mile from monitor	For 5-day moving average in pollution concentration, OR for having an SVE=1.42 for $PM_{2.5}$; 1.70 for sulfate; no associations for BC

RR risk ratio; *OR* odds ratio; *IQR* interquartile range increase; *ICD* implantable cardioverter-defibrillators; *SVE* supraventricular ectopy; *SD* standard deviation

[a] Association taken from Fig. 2 in Ebelt et al. (2005). Association in Ebelt et al. also reported [in Sarnat et al. (2006)] as a 22% increase in rate of SVE for subjects whose mean rate of SVE was 33 bph

SO_2, and a borderline significant association for SO_4, for an interquartile increase in the 2-day pollution mean; this finding suggests that the most at-risk patients in general may also be most at risk for a pollution-related ventricular tachyarrhythmia. The authors took the associations with $PM_{2.5}$, CO, NO_2, and BC as indicative of a link with motor vehicle emissions, and the sulfate association as evidence of a link with regional fossil fuel emissions. SO_2 was highly correlated with vehicular emissions and was seen as local in origin. In light of the findings of Albert et al. (2007), the lack of an association in this study with particle number, which is considerably higher in the 100 m nearest a major road (Zhu et al. 2002a, b), suggests that exposure misclassification may also have occurred in this study, perhaps understating effects of local vehicular emissions and transferring health associations to other emissions (Goldberg and Burnett 2003). The authors note that "… improved estimate of subject specific air pollution exposures would be expected to find stronger, more statistically significant associations."

Another study having exposure misclassification is that of Metzger et al. (2007), conducted in the Atlanta area and involving 518 patients with ICDs; there were found to be no associations with tachyarrhythmias for any of the emissions monitored (PM_{10}, ozone, NO_2, CO, and SO_2 for 10 years, $PM_{2.5}$ and oxygenated hydrocarbons for 4 years). Metzger et al. also discussed exposure misclassification, stating that the study "does not contribute evidence regarding whether personal exposure may be a determinant of ventricular tachyarrhythmia."

Sarnat et al. (2006) examined pollutant associations with supraventricular and ventricular arrhythmias. This was a companion study to that of Luttmann-Gibson et al. (2006), who examined pollution associations with reduced HRV in Steubenville, Ohio during summer and fall 2000. Both studies used a monitor several hundred feet higher than the living quarters of the subjects, and about a mile distant. Like Luttmann-Gibson et al., Sarnat et al. found associations with sulfate, but not with BC, although the companion study also found associations with $PM_{2.5}$. Exposure misclassification for locally variable emissions such as BC is particularly severe, as with the companion study, due to the monitor's height.

Anselme et al. (2007) found an immediate 200% to 500% increase in ventricular premature beats in CHF rats compared to healthy rats exposed to diluted diesel emissions. This finding is similar that of Dockery et al. (2005), in which the significant pollution associations for ventricular arrhythmias were only for those who had had a previous arrhythmia in the previous 3 days vs. more healthy people. The increase in arrhythmias following exposure to diesel exhaust in Anselme et al. (2007) appears to have its strongest parallels in the findings of Albert et al. (2007), e.g., increases in VT/VF in subjects half an hour after being in traffic, and of Riediker et al. (2004a, b), which found that the "speed change" factor, marked by diesel emissions and brake wear, was associated with significant increases of about 40% in SVE beats. Of the four epidemiological studies, none of which had good exposure information for spatially variable local vehicular emissions, two nevertheless suggest that traffic emissions are associated with arrhythmias, and three discussed exposure misclassification as a possible reason for results being smaller and weaker than had exposure information been more accurate.

The rapid initiation of arrhythmias after exposure to diesel emissions may suggest a direct effect on the myocardium. Anselme et al. (2007) state that such a quick response supports the idea that agents such as ultrafines, gasses, or soluble PM do cross the pulmonary epithelium into the circulation. However, rapid initiation might instead support the findings of Rhoden et al. (2005), who found that antagonists of both the sympathetic and parasympathetic nervous systems prevented oxidative stress in the heart caused by instillation of urban PM or inhalation of CAPs. In this second case, it might not be necessary for pollution to enter the bloodstream; oxidative stress in the heart due to exposure to PM (Rhoden et al.) or diesel emissions (Anselme et al.) might cause arrhythmias via direct modulation of the vagal nerve.

Inflammation

Initiation of an inflammatory response is another potential mechanism underlying PM-induced cardiovascular effects. Ridker et al. (2008) demonstrated that reducing systemic inflammation, initially marked by levels of high-sensitivity C-reactive protein (CRP), resulted in significant reduction of cardiovascular events (MI; revascularization or unstable angina; stroke; combined end point of MI, stroke, and death from any cardiovascular cause; and death from any cause) among those with low LDL cholesterol levels (<130 mg/dL) but initially high CRP (>2.0 mg/L). CRP itself is not the cause of progression of disease, however, but rather an indicator of inflammation (Schunkert and Samani 2008). Thus, elevated chronic systemic inflammation appears to be a cause of increased cardiovascular mortality and morbidity, even among apparently healthy people without hyperlipidemia. Systemic inflammation as marked by interleukin-6 (IL-6) is also associated with higher risks of mortality among older female CVD patients (Volpato et al. 2001) and with higher risks of a future MI among apparently healthy men (Ridker at al. 2000).

Bonvallot et al. (2001) exposed human bronchial epithelial cells to DEP and to DEP organic extracts, both of which induced activation of pro-inflammatory NF-κB, but the stripped carbonaceous core induced less intense responses. NF-κB is involved in inducement of inflammatory cytokines such as TNF-α, IL-6, and IL-8. Bonvallot et al. showed that DEP induced expression of a cytochrome P-450 specifically involved in PAH metabolism. This finding suggests the importance of PAH organic compounds in diesel emissions in causing inflammatory responses.

McDonald et al. (2004) found that diesel emissions from a relatively new diesel engine operating in steady state caused significant increases in several biological endpoints in mice, including inflammatory cytokines IL-6, TNF-α, and INF-γ (as well as oxidative stress, as marked by HO-1), with exposures of 200 μg/m^3 (6 h/day, 7 days). Use of a catalyzing trap eliminated virtually all the black carbon and a large percentage of many carbonaceous emissions, and also abolished the significant increases in cytokines and HO-1.

Tornquist et al. (2007) exposed 15 healthy men to diesel exhaust or filtered air for 1 h. In those exposed to diesel emissions, there were significant increases in TNF-α and IL-6, paralleling in vitro and in vivo findings just reviewed.

Seaton et al. (1999) estimated exposure to PM_{10} in 108 elderly subjects in Belfast and Edinburgh, modeling estimated personal exposures based upon activity diaries and multiple monitoring sites. Increased CRP was significantly associated with city center measurements of PM_{10}, but IL-6 was not. Another European multi-city study (Ruckerl et al. 2007) found in pooled results a significant increase in IL-6 per interquartile range increase (IQR) of particle number count 12–17 h before blood withdrawal, and per same day IQR increase in NO_2 (primarily a marker for vehicular emissions in European cities); no such association was found with CRP.

Riediker et al. (2004a), Riediker (2007), and Delfino et al. (2008) are examples of studies with excellent exposure assessments. Both of the Riediker et al. studies examined effects of 9 h of exposure to in-vehicle pollution on various cardiovascular parameters in healthy young male patrol officers. In Riediker et al. (2004a), elevated CRP was significantly associated with in-vehicle $PM_{2.5}$, but not with roadside $PM_{2.5}$. In Riediker (2007), IL-6 levels were significantly increased by about 20% for a one-standard-deviation increase in in-vehicle $PM_{2.5}$. Although IL-6 was not measured in the 2004 study, and CRP was not measured in the 2007 study, we can reasonably conclude that both CRP and IL-6 are elevated when healthy young men are exposed to several hours of vehicular emissions at levels found inside on-road vehicles.

Delfino et al. (2008) examined biomarkers of inflammation, anti-oxidant activity, and platelet activation in a panel study of 29 non-smoking elderly with CHD in retirement homes in Los Angeles. Using monitors just outside and inside the residences, the authors modeled concentrations of outdoor emissions inside the homes, where subjects spent most of their time. Delfino et al. (2008) found that several biomarkers of inflammation (CRP, IL-6, and soluble receptor-II for TNF-α) increased significantly with increasing exposure to various vehicular emissions (current day and multi-day averages). Reduced anti-oxidant activity was found for all but three subjects with several different traffic emissions. Among PM size fractions, only the smallest particles ("quasi-ultrafines," $PM_{0.25}$) were significantly associated with these biomarkers, paralleling findings regarding particles in Los Angeles taken close to freeways with regard to oxidative stress, as reviewed above. Particle number, BC, EC, CO, and primary OC were also associated with one or more of the biomarkers. Interestingly, secondary organic carbon showed no associations.

Thus, three studies of humans exposed to ambient air with accurate exposure monitoring found elevated levels of inflammatory indicators CRP and IL-6 associated with increased in-vehicle $PM_{2.5}$, or with several vehicular emissions. Of the other two studies (Seaton et al. 1999 and Ruckerl et al. 2007), one found elevated CRP in subjects in relation to modeled central city PM_{10}, while the other found IL-6 was elevated relative to centrally monitored particle number and NO_2 concentrations. Tornquist et al. (2007) found in healthy human volunteers significant increases in IL-6, TNF-*a*, and soluble P-selectin 24 h after inhalation (1 h) of 300 μg/m^3 diesel exhaust, suggesting the role of diesel emissions in the epidemiological findings noted above. Findings of these studies are in concert with the in vitro (Bonvallot et al. 2001) and in vivo (McDonald et al. 2004) studies reviewed above as well. Bonvallot et al. establishes a possible biological mechanism of inflammation involving PAHs.

Zeka et al. (2006) studied 710 members of the VA Normative Aging Study cohort living in the greater Boston area, with air pollution measured at a central monitor. Despite the potential exposure misclassification, the authors found an association for elevated CRP with an increase in one standard deviation in BC (for those with a BMI over 30, e.g., obese). Risks of elevated CRP were approximately four times higher for obese than for non-obese. Significant associations were not found for CRP with other types of PM. Those lacking a measure of genetic protection against oxidative stress, e.g., *GSTM1*-null subjects, were significantly more likely to have increased levels of CRP associated with increased BC concentrations. The authors discuss exposure misclassification, noting that a limitation of the study was the inability to measure personal exposure to different types of PM, and that they "would expect an underestimation of the effects of air pollution observed in the present study."

Atherosclerosis

Atherosclerosis refers to a thickening of the luminal wall of arteries that, depending upon the specific type of condition, may or may not result in reduction in blood flow. Atherosclerosis may be considered an inflammatory disease which progresses in concert with oxidation of LDL lipids (Steinberg 2002). Thus, initiation or exacerbation of inflammation, associated with pollutant exposure, may be a mechanism for some of the health outcomes noted herein.

Studies reviewed above show links between vehicular emissions and acute HRV reductions/oxidative stress reactions. A study of 1,133 non-smokers in a Swiss cohort (Probst-Hensch et al. 2008) found that those with glutathione-*S*-transferase polymorphism deletions (which reduce anti-oxidant defenses) have altered autonomic control, as marked by reduced HRV. The authors conclude that their results are consistent with an important pathological role for systemic, chronic oxidative stress among the general population. Although unexplored in this study, these findings may suggest as well that vehicular emissions which cause acute oxidative stress and thus change in HRV may be causally related to increases in arterial plaque formation via oxidation of LDL cholesterol. In this regard, Romieu et al. (2008) examined residents of a Mexico City nursing home for 6.5 months. Mexico City's elevated pollution levels contain high levels of vehicular emissions, likely resulting in increased oxidative stress. Subjects were treated with anti-oxidants (fish oil and soy oil supplements). Both supplements increased antioxidant activity, as measured by biomarkers of response to oxidative stimuli [glutathione (GSH) and Cu/Zn superoxide dismutase (SOD) activity]. Those treated with fish oil supplements, but not soy oil, also had 72% less lipoperoxidation. These results suggest that chronic oxidative stress caused by urban pollution is linked to increased lipoperoxidation, likely enhancing development of atherosclerotic plaques.

In the panel study of elderly non-smoking subjects reviewed above, Delfino et al. (2008) also examined associations of platelet activation, marked by soluble P-selectin, with various emissions. P-selectin is an adhesion molecule which plays an important role in atherosclerosis via leukocyte recruitment (Woollard and Chin-Dusting 2007). Delfino et al. (2008) found increased levels of soluble P-selectin significantly associated with increased levels of EC of outdoor origin and primary OC, suggesting that these emissions can produce platelet activation and, thus, advance atherosclerosis.

Araujo et al. (2008) showed that inhalation of concentrated ultrafine PM from close to a Los Angeles freeway, enriched in PAHs, caused significantly larger early atherosclerotic lesions in genetically susceptible (apolipoprotein E-deficient) mice inhaling concentrated $PM_{2.5}$ or filtered air. Exposure to ultrafine PM also resulted in inhibition of anti-inflammatory capacity of plasma HDL and greater systemic oxidative stress, in part as evidenced by upregulation of Nrf2-regulated anti-oxidant genes. The atherosclerotic lesions were likely caused by the combination of oxidative stress and inflammation, as both appear to be necessary for development of atherosclerosis (Steinberg 2002).

Studies reviewed noted above found ambient levels of traffic emissions PM to be associated with both oxidative stress and inflammation. Findings of Araujo et al. (2008), with a sensitive murine model, are in concert with both the findings of Delfino et al. (2008) and the epidemiological results of Kuenzli et al. (2005), i.e., that people exposed to higher annual levels of ambient air in Los Angeles had higher prevalence of atherosclerotic plaque or of important precursors of such plaque. The results of Araujo et al. (2008) are also consistent with the findings of Romieu et al. (2008), who found that lipoperoxidation in residents of a highly polluted city was reduced by use of a common anti-oxidant. Findings of these studies are also consistent with findings of studies in the sections on oxidative stress and inflammation, with regard to exposure to diesel emissions, urban pollution, and specific emissions such as BC.

Gong et al. (2007) examined exposure to ambient ultrafine particles that were highly enriched in redox cycling organic chemicals in terms of promotion of atherosclerosis in mice. The investigators found that an interaction between diesel exhaust particles and oxidized LDL lipids synergistically affected gene expression corresponding to pathways relevant to vascular inflammatory processes such as atherosclerosis. This study suggests how the lipid peroxidation found in the Huang et al. (2003) and Pereira et al. (2007) studies could lead to atherosclerosis such as found by Kuenzli et al. (2005) and lipoperoxidation as noted by Romieu et al. (2008). Similarly, Sharman et al. (2002) found that people regularly occupationally exposed to vehicular emissions (auto mechanics) had greater plasma susceptibility to oxidation, and, thus, a greater risk of developing atherosclerosis than did matched controls.

Kuenzli et al. (2005) and Jerrett et al. (2005) utilized a modeled $PM_{2.5}$ "surface" created for Los Angeles by interpolating data from 23 fixed-site monitors, creating within-city gradients for exposure to $PM_{2.5}$. Motor vehicles are the major source of emissions in Los Angeles, since other potentially major stationary sources of pollution (e.g., coal-fired power plants, steel mills, and coke industries) are absent. Thus, $PM_{2.5}$ in the Los Angeles basin as a whole is related primarily to vehicular emissions, although near ports shipping emissions may also be important.

Using the ACS data base for Los Angeles, Jerrett et al. (2005) found the relative risks for all-cause and cardiovascular mortality three to four times larger than in the original ACS study, which examined inter-city differences in $PM_{2.5}$, vs. intracity differences. Kuenzli et al. (2005) found higher levels of $PM_{2.5}$ within the Los Angeles airshed to be associated with higher levels of atherosclerotic plaques in the carotid artery (associations were strongest for women 60 years old or older.). These results, suggesting that mainly vehicular-derived $PM_{2.5}$ in Los Angeles may be causally related to the development of atherosclerosis, parallel those of Hoffmann et al. (2007), noted above, who found that people living close to major roads had significantly higher levels of coronary atherosclerosis as measured by coronary artery calcification.

Vascular function and blood pressure

Another potential mechanism by which vehicular-derived PM could cause cardiovascular injury involves changes in vascular tone. Urch et al. (2004, 2005) exposed healthy human volunteers to ozone plus CAPs (concentrated ambient particles) obtained in close proximity to a major Toronto freeway. The resultant increase in vasoconstriction of the brachial artery (2004 study) was associated with EC and OC, but not with any of the other 23 components of $PM_{2.5}$ examined, suggesting traffic emissions as a likely causal source. Diastolic blood pressure (2005 study), possibly related to the vasoconstriction findings of the first study, increased with increased levels of organic carbon and was attributed to traffic emissions.

Miller et al. (2009) exposed rat aortic rings in vitro to diesel exhaust particles (DEP) to explore mechanisms of effects on vascular function. The authors found that oxidative stress caused by DEP reduced the bioavailability of endothelium-derived nitric oxide "without prior interaction with the lung or vascular tissue."

Bartoli et al. (2009) examined the effects of CAPs collected adjacent to a major urban road on blood pressure of dogs. Increases in systolic blood pressure (SBP), diastolic BP (DBP), mean BP, heart rate, and rate times pressure were all associated with an IQR increase in $PM_{2.5}$, BC, and particle count, with the size of the effect increasing in that order (BC marginally significant for systolic pressure). As with the studies of Urch et al. the CAPs were taken from next to a major road, exposure was accurately known, and the BC, carbonaceous and/or ultrafine PM (emitted from traffic) were highly associated with the increases in BP.

Subjects in the multi-city study of Auchincloss et al. (2008) were aged 45–84 and clinically free of CVD. The authors found several associations between $PM_{2.5}$ and pulse pressure (PP), with only one model (which included traffic emissions) finding associations with SBP. Further analysis showed that when $PM_{2.5}$ exposure for subjects was stratified by either of three traffic variables (NO_2 levels above median; residence within 300 m of highway; or high density of roads nearby residence), a 10-$\mu g/m^3$ increase in $PM_{2.5}$ was associated with increased PP (all three cases) and SPB (two or three cases) when the traffic variable was "positive," but not when the traffic variable was "negative." Thus, $PM_{2.5}$ exposure was not associated with either endpoint unless exposure level to traffic emissions was stratified as "high." Using different methods of assessing exposure to vehicular emissions in a multi-city study, these investigators found similar SBP results to the studies above using CAPs taken from nearby major roads.

Findings have been inconsistent with regard to elevated blood pressure associations among studies lacking reasonably accurate information for exposure to locally variable emissions, such as those from vehicles. Ibald-Mulli et al. (2004) examined 131 subjects with coronary heart disease in three European cities, used centrally monitored $PM_{2.5}$, accumulation mode, and ultrafine particle mass concentrations. Results were controlled for temperature, barometric pressure, and relative humidity. Very small negative, but significant, associations were found for both SBP and DBP with particles of different sizes. However, the authors cautioned against inferring clinical relevance from these findings. Zanobetti et al. (2004), in a study of residents of greater Boston, found positive and significant $PM_{2.5}$ associations (mean level for 5 days before physician visits) with resting SBP, DBP, and mean arterial BP (MAP). In addition, for those with resting heart rate >70 bpm, mean $PM_{2.5}$ level for the 2 days preceding the visit were associated with increases in DBP and MAP during exercise. Temperature, dew-point temperature, and barometric pressure, as well as standard socioeconomic variables, were controlled for. Pollutants were measured at central sites. Associations were found with SO_2, O_3, BC, but not with NO_2 or CO in single-pollutant models, but only $PM_{2.5}$ remained associated with elevated DBP in multi-pollutant models.

Thus, it appears that when exposure to vehicular emissions are reasonably well characterized—as when ambient air is from near a major road, or when results are stratified by whether someone lives near major roads or has a high density of roads near their residence—increased blood pressure effects are consistently found associated with vehicular emissions. However, in the absence of reasonably well-characterized exposure information for vehicular emissions, associations become inconsistent, and vehicle-specific emissions are less likely to be associated with change in blood pressure.

Lai et al. (2005) found that toll workers exposed to traffic exhausts had significantly higher levels of plasma NO, an agent affecting vascular tone, than similar workers not so exposed, suggesting another pathway by which vehicular emissions could adversely influence vascular tone.

Peretz et al. (2008) exposed 27 adult volunteers (ten healthy, 17 with metabolic syndrome) to diluted diesel exhaust (100 or 200 $\mu g/m^3 PM_{2.5}$) or filtered air. The authors examined brachial arterial diameter change, and collected systemic blood samples for endothelin-1 (ET-1), a vasoconstrictor. Reduction in brachial artery diameter was linearly related to increasing exposure concentration of the exhaust, paralleling the findings of Urch et al. (2004), which used CAPs from nearby a Toronto freeway, and suggesting the importance of diesel emissions specifically for this endpoint. Plasma levels of ET-1 were increased only at the highest concentration of exposure.

Campen et al. (2005) found that fresh diesel emissions can cause vasoconstriction in the blood vessels of mice ex vivo, but that filtering diesel exhaust to remove particles did not change the vasoconstrictive properties of the emissions. Further analysis suggested that two specific gaseous emissions, aldehydes and alkanes, appeared to be responsible for these effects, suggesting a potential biological mechanism for the findings of Urch et al. (2004, 2005).

Changes in vascular homeostasis may be due to oxidative stress on endothelial cells or to systemic inflammation that affects the endothelium. Peretz et al. (2007) exposed healthy adults to diluted diesel exhaust and used microarray techniques to assess effects in peripheral blood leukocytes, since these cells are involved in inflammation and control of vascular homeostasis, including development of atherogenesis (Kristovich et al. 2004; Libby et al. 2002). They noted that the diesel exhaust exposure preferentially modulated genes involved in oxidative stress, inflammation, leukocyte activation, and vascular homeostasis, mechanisms by which adverse health effects may be modulated.

Research recommendations

Different types of particles have different biological effects, and some are likely to be more harmful than others; for example, some might cause more oxidative stress. Additional effort is needed to move closer to the goal of regulating those specific types of particles and emissions which may have the greatest health relevance. Research recommendations are made with this goal in mind.

First, although we suggest, based upon the data base discussed, that creation of a black carbon PM standard under the National Ambient Air Quality Standards may serve to protect public health, there is still much research to be done with regard to the different components of vehicular emissions. Non-PM carbonaceous components of vehicular emissions have adverse health effects (Mauderly and Chow 2008), but relatively little research has been done to date on them. Even if a black carbon standard were regulated under the NAAQS, and even if as a consequence of such a standard, many VOC and SVOC emissions would be controlled simultaneously, gasoline engines emit many of the same VOCs as diesels, and many different ones as well.

Several toxicology studies of gasoline emissions, using genetically engineered mice, have generated hypotheses about their effects. Lund et al. (2007), in a study using atherosclerosis-prone genetically modified ApoE$^{-/-}$ mice, showed that the gaseous fraction of gasoline emissions were associated with increased markers of vascular oxidative stress and transcriptional upregulation of factors associated with vascular remodeling important to the development of atherosclerosis. Campen et al. (2006), using the same mouse model, found that fresh gasoline emissions, but not paved road dust, altered cardiac repolarization. Should research establish that these emissions also cause serious harm to public health, technology solutions will have to be found for these as well.

More health endpoints appear to have been examined for diesel than for gasoline engine exhaust at this point, especially when using ambient air or human subjects or both; thus, further research is needed. To establish a comprehensive and consistent basis of comparison of gasoline with diesel emissions, ways should be found to test gasoline emissions in protocols using human subjects parallel to those of Mills et al. (2005, 2007), for example.

A second research recommendation is also quite important to determining which emissions need to be controlled to protect public health. It may be reasonable to think that today, there are two widespread types of air pollution of public health concern: those from vehicles and those from power plants, especially those using coal. Two to three decades ago, use of residual oil use was much more widespread than now, and the oil also contained higher amounts of metals (V, Ni) and sulfur (Thurston and Spengler 1985). With less than 3% of electric generation from residual oil today vs. 17% three decades ago, today's residual oil emissions are lower and more localized. Similarly, there were formerly more coking and non-electric arc steel plants, and these plants did not face the emission regulations they face today. Thus, epidemiological studies of the 1970s and 1980s would have had to be attentive to specific emissions from these sources in more locations and on a more regional scale than more recent studies.

Many early studies of PM did not recognize, as we now do, either the importance of monitoring specifically for emissions from vehicles, or the need to have reasonably accurate exposure information for such emissions. Now that methodologies rectifying these deficiencies are available, we recommend they be used to examine whether cardiovascular effects found to be associated with vehicular emissions, as in the studies above, are also found with emissions representing coal emissions (secondary sulfates and coal fly ash) as well as associated products of atmospheric chemistry involving such emissions.

Thus, one recommendation would be to perform tests utilizing ambient air masses, as with the work of Schwartz

Table 3 Summary of effects of vehicular emissions and black carbon on CVD health endpoints

Health endpoint	In vitro studies	In vivo studies	Human panel studies
1. Oxidative stress	Li et al. 2002a (increases in HO-1, diesel PM)	McDonald et al. 2004 (diesel emissions, increased HO-1 in normal mice; oxidative stress abolished with use of catalyzing trap which totally eliminated black carbon, largely eliminated most organics, including many PAHs)	Mills et al. 2005 (diesel emissions, healthy human volunteers; reduction in t-PA, impairment of vascular tone, postulated by authors to be related to oxidative stress; also see HRV Alteration [HRV changes often caused by oxidative stress])
	Li et al. 2002b (increases in HO-1, Los Angeles air)		Delfino et al. 2008 (decreased levels of anti-oxidant enzyme activity, in panel of 29 non-smoking elderly subjects with history of coronary artery disease associated with BC, NO_2, primary OC of outdoor origin, and ultrafine PM, for current day and multi-day averages, in study with excellent exposure characterization, using both indoor and outdoor monitors at Los Angeles residences)
	Li et al. 2003 (increases in HO-1, most harm caused by ultrafines in Los Angeles air, correlated with organics and PAHs)		
2. HRV alteration	NA	Anselme et al. 2007 (diesel emissions, HRV decreases in healthy and CHF rats immediately after exposure)	Adar et al. 2007 (changes in six different types of HRV associated with BC exposure; when subjects on bus with high BC levels, larger HRV changes roughly correspond with larger changes in BC; monitor followed subjects wherever they went)
			Schwartz et al. 2005b (changes in 4 types of HRV associated with BC concentrations, but not with concentrations of non-BC regional $PM_{2.5}$; subjects live on same road as monitor is located, both in close proximity to road, 0.5 miles apart)
			Creason et al. 2001 (HRV changes monotonically associated with increasing $PM_{2.5}$, after two days with high $PM_{2.5}$ from only rural sources eliminated from regression)
			Ebelt et al. 2005 (HRV associations found for ambient urban PM, not found for sulfate; personal monitors used)
			In studies using central monitors, Wheeler et al. (2006) and Park et al. (2005) show associations with BC in only one fourth of tests; Luttmann-Gibson et al. (2006) find no BC associations.
			Park et al. (2007) is same study as Park et al. (2005), but uses wind trajectories to determine sources, thus has better exposure information than Park et al. (2005); HRV associations found for urban air masses, not for rural air masses

Table 3 (continued)

Health endpoint	In vitro studies	In vivo studies	Human panel studies
3. ST-segment Depression	NA	Yan et al. 2008 (diesel exhaust particles impaired left ventricular functioning in healthy rats, with further impairment in rats with myocardial injury)	Mills et al. 2007 (ST-segment depression in subjects with CHD exposed to diesel emissions twice as great as for subjects without CHD, suggesting how diesel emissions could harm susceptible subjects) Gold et al. 2005 (in parallel study to Schwartz et al. 2005b HRV study, e.g., with accurate exposure information, ST-segment depression associated with BC but not with $PM_{2.5}$) Lanki et al. 2006 (in study of several local and regional pollutants lacking good exposure information, ST-segment depression associated with ABS [EU equivalent of BC] but not with sulfate or other pollutants)
4. Cardiac Arrhythmia	NA	Anselme et al. 2007 (diesel emissions, 200% to 500% increase in ventricular premature beats in CHF rats, but not in normal rats)	Albert et al. 2007 (risks of ICD shock elevated in hour after driving, RR=2.24; risks for ventricular fibrillation or tachycardia elevated in half hour after driving, RR=4.46) Riediker et al. 2004a, b (~40% increase in SVE beats for change of one SD in "speed change" factor reflecting diesel emissions and brake wear) Ebelt et al. (2005) (SVE associations found for ambient urban PM, non-sulfate ambient urban PM, not found for sulfate; personal monitors used) Peters et al. (2000), Dockery et al. (2005), Metzger et al. (2007), and Sarnat et al. (2006) are extant studies of arrhythmias using central monitor concentrations as proxies for subject exposure over large metropolitan areas, causing exposure misclassification; first study finds larger associations with vehicular emissions (BC and NO_2) than with $PM_{2.5}$; second study finds traffic emissions more likely cause of arrhythmias; third study finds no associations; associations in fourth study are with sulfate but not with BC; the first three studies discuss exposure misclassification as possible reason for underestimates of associations
5. Vascular Function	Miller et al. 2009 (diesel particles reduce bioavailability of endothelium-derived NO in aortic rat rings in vitro via oxidative stress, without prior interaction with lung or vascular tissue) Campen et al. 2005 (fresh diesel emissions and filtered diesel exhaust cause vasoconstriction in mice ex	Bartoli et al. 2009 (increases in mean, systolic and diastolic blood pressure found in dogs exposed to CAPs taken from near major urban roadway; BC, carbonaceous particle count associated with increases in blood pressure)	Urch et al. 2004 (significant increase in vasoconstriction in healthy human volunteers exposed to CAPs taken from near freeway associated only with EC and OC among 25 components of $PM_{2.5}$ analyzed) Urch et al. 2005 (significant increase in blood pressure in healthy human volunteers exposed to CAPs taken

Table 3 (continued)

Health endpoint	In vitro studies	In vivo studies	Human panel studies
	vivo, aldehydes and alkanes most likely involved)		from near freeway, possibly associated with increase in vasoconstriction in 2004 study, related to traffic emissions) Auchincloss et al. 2008 (in subjects aged 45–84, systolic blood pressure and pulse pressure associated with increased $PM_{2.5}$ only when traffic variables (NO_2 levels above median value; residence within 300 m of highway; or high density of roads near residence) were "positive," not when traffic variables were "negative") Lai et al. 2005 (toll workers exposed to traffic exhaust had significantly higher levels of plasma NO, which affects vascular tone) Peretz et al. 2007 (in healthy adult volunteers, diesel exhaust preferentially modulated genes involved in oxidative stress, inflammation, leukocyte activation and vascular homeostasis) Peretz et al. 2008 (in adult volunteers exposed to diesel exhaust, reduction in brachial artery diameter linearly related to increasing concentration of exhaust; plasma levels of endothelin-1, a vasoconstrictor, significantly increased only at 200 μg/m^3 of diesel exhaust, but not at 100 μg/m^3)
6. Inflammation	Bonvallot et al. 2001 (diesel emissions and diesel organic extracts induced increased levels of pro-inflammatory NF-κB in human bronchial epithelial cells; less intensive effects induced by stripped carbonaceous core)	McDonald et al. 2004 (increased levels of three inflammatory biomarkers (TNF-α, IL-6, and INF-γ) associated with exposure to diesel emissions, effects abolished with use of new catalyzing trap which eliminated BC completely, largely eliminated most organics, including many PAHs)	Delfino et al. 2008 (several biomarkers for inflammation [CRP, IL-6, TNF-α receptor] significantly increased with increased concentrations of BC, EC, CO, primary OC, and with increased particle number) Riediker et al. 2004a (CRP elevated with increased in-vehicle PM, in study of patrol officers after 9-h shift) Riediker 2007 (IL-6 elevated with increased in-vehicle PM, in study of patrol officers after 9-h shift) Tornquist et al. 2007 (diesel emissions increased TNF-α, IL-6 levels in healthy human volunteers, vs. filtered air) Zeka et al. 2006 (elevated BC levels, recorded at central monitor, associated with increased CRP levels in the obese, and in those lacking a measure of genetic protection against oxidative stress, e.g., GSTM1-null subjects. Authors discuss exposure misclassification, note that they would expect larger risks with better exposure assessment)

Table 3 (continued)

Health endpoint	In vitro studies	In vivo studies	Human panel studies
7. Atherosclerosis and lipoperoxidation	See oxidative stress and inflammation sections for in vitro work relevant to atherosclerosis, caused in large part by systemic interaction of oxidative stress and inflammation	Araujo et al. 2008 (increased early atherosclerotic lesions in ApoE $^{-/-}$ mice breathing CAPs ambient in PAHs from near LA freeway, exposure to ultrafine PM inhibited anti- inflammatory capacity of plasma HDL)	Sharman et al. 2002 (auto mechanics, regularly exposed to higher levels of vehicular emissions than controls, had significantly higher susceptibility of plasma to oxidation)
	Gong et al. 2007 (interaction between oxidized LDL lipids and organic diesel emission extracts affects gene expression relevant to vascular inflammation and atherosclerotic pathways in human microvascular endothelial cells; work then replicated in vivo, with similar findings – see in vivo, next column)	Gong et al. 2007 (interaction between oxidized LDL lipids and concentrated ultrafine diesel exhaust particles in Los Angeles air affects gene expression corresponding to atherosclerotic pathways in mice, viewed by authors as confirming in vitro findings in column to left)	Delfino et al. 2008 (levels of soluble P-selectin, important for platelet activation in atherosclerosis, significantly associated with increased levels of EC of outdoor origin, primary OC, in study of seniors in Los Angeles)
	Huang et al. 2003 (PM1.0 more likely to cause lipoperoxidation in human lung cells than larger fractions, OC and EC but not various ions associated with this effect)		

et al. (2005b), Gold et al. (2005), and Creason et al. (2001), in regions such as north-central Pennsylvania or in central New York State, where on most days emissions would reflect little industrial or vehicular emissions relative to urban locations. To be consistent with many of the studies reviewed above, recruitment of those living in a retirement center would be recommended. Would days with higher total $PM_{2.5}$, and/or with higher levels of sulfate, exhibit similar changes in inflammatory indicators (CRP, IL-6), levels of anti-oxidant enzyme activity, or adhesion molecules (soluble P-selectin), as in Delfino et al. (2008)? Such proposed studies should also examine blood pressure and vasoconstriction, as in Auchincloss et al. (2008) and Urch et al. (2004, 2005). ST-segment depression, oxidative stress, and arrhythmias should also be examined in studies paralleling those reviewed above.

Wind trajectory analysis, such as used in Park et al. (2007) and Creason et al. (2001), and which Lippmann et al. (2006) used to demonstrate associations with Ni from Canadian nickel smelters on reduced HRV in mice housed in a rural location in New York State, should also be used to see if on days with elevated measures of health effects the air masses might come from an unsuspected source, as in Lippmann et al. (2006).

These studies would allow a direct comparison with the studies examined in this assessment, and thus would enable researchers to see if ambient coal emissions, including reaction products, would cause the same cardiovascular health effects as diesel and/or vehicular emissions. Recommendation of research of this type, however, is not to recommend that more innovative research is any less important. For instance, the “highway gradient” studies are an example of the kind of innovation that caused researchers to focus on biological mechanisms of vehicular emissions.

More generally, the use of new personal monitoring tools, such as vests being developed by EPA which are easy to wear and monitor many different emissions, may broaden the endpoints which can be examined with regard to pollution associations. Arrhythmias would be one primary endpoint, since up to now, central monitors have been used to provide pollution data in studies of arrhythmias. Since this health endpoint has not yet apparently been examined in studies using accurate exposure information for vehicular emissions, arrhythmias would be an excellent candidate for use in studies with better monitoring, perhaps using the protocols of Schwartz et al. (2005b) and Gold et al. (2005). Furthermore, although V and Ni now tend to be relatively local emissions (e.g., near major ports as shipping fuel and in a few Northeastern locales), it is still important to separate effects of metals from carbonaceous materials.

Conclusions

Epidemiologic studies with good exposure information for locally variable levels of particulate emissions from motor vehicles consistently find associations between such exposure and cardiopulmonary disease mortality, circulatory disease mortality, ischemic heart disease mortality, and all-cause mortality, and with many CV morbidity endpoints, such as cardiovascular hospital admissions, markers of atherosclerosis, survival after heart failure, incidence of coronary heart disease, initial myocardial infarction, and acute myocardial infarction. For each of the cardiovascular health endpoints reviewed herein—oxidative stress, HRV changes, ST-segment depression, inflammation, arrhythmia, vascular function and blood pressure, and atherosclerosis—there are mechanistic studies supporting a pathophysiological basis for how diesel and/or vehicular emissions could cause such outcomes. The mechanistic studies for each endpoint are briefly summarized in Table 3. These cardiovascular health endpoints, in turn, provide multiple biological mechanisms with explanatory value for the mortality and morbidity findings in the epidemiology studies.

A number of the studies reviewed in this paper examined human subjects breathing ambient air. Such studies are likely to provide information most relevant to regulations designed to protect public health. Studies using genetically modified animals and highly concentrated components of ambient air, or using artificial atmospheres, are useful in generating hypotheses, but if these hypotheses are not verified in people exposed to ambient atmospheres, they may not provide an adequate basis for regulation. The database of ambient air studies does provide substantial evidence that the cardiovascular health effects associations with vehicular emissions likely reflect causality, rather than just statistical correlation.

Studies have shown that emissions from diesel engines may be especially potent in producing adverse health outcomes (U.S. Environmental Protection Agency 2002). As of January 2007, EPA regulations require a new catalyzing trap on all new on-road diesels. These devices reduce BC levels virtually completely, while also reducing emissions of many carbonaceous species by large percentages (McDonald et al. 2004). BC is likely an important causal agent of effects with which it has been associated in many studies, both intrinsically and because many carbonaceous species co-emitted from diesels and other vehicles can be adsorbed onto the surface of BC. In addition, BC is also likely a marker for harmful carbonaceous gasses which may be co-emitted with but not adsorbed onto the particles.

The EPA regulations do not extend to retrofits, however, and older diesels are the worst emitters. Several states are taking action to reduce such diesel emissions. In California, there are now proposals to restrict diesels from prior to a particular vintage year from operating in the ports of Los Angeles and Long Beach, unless retrofitted with the new catalyzing trap. Several localities are now requiring retrofit programs on certain classes of vehicles, e.g., school buses, or are advancing the replacement date for older diesel buses. A "speciated" BC standard would be more comprehensive than a patchwork of state requirements, and would likely cause many states to require retrofits of catalyzing traps on older diesels. This would reduce not just BC, but also the associated carbonaceous emissions which adsorb onto BC and also may cause health effects per se. Further, a speciated BC standard would require states to deal with BC in areas not in violation of standards for $PM_{2.5}$, but where diesel health effects would be of consequence to public health. If it made sense to require new technology on new on-road and off-road diesels—and we agree that it does—then it makes even more sense to control emissions from the older, dirtier diesels which will be in operation for perhaps another 30 years.

Disclaimer and Acknowledgements This work reflects the views only of the authors, and does not necessarily reflect views of the Department of Energy. The authors thank JoAnn Yuill for her exceptional help, not for the first time.

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Atmospheric Environment 45 (2011) 2611–2622

Contents lists available at ScienceDirect

Atmospheric Environment

journal homepage: www.elsevier.com/locate/atmosenv

Review

A review of commuter exposure to ultrafine particles and its health effects

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ARTICLE INFO

Article history:
Received 13 December 2010
Received in revised form
24 February 2011
Accepted 24 February 2011

Keywords:
Air pollution
Transport modes
Acute health effects
Travel
Public transport

ABSTRACT

Ultrafine particles (UFPs, <100 nm) are produced in large quantities by vehicular combustion and are implicated in causing several adverse human health effects. Recent work has suggested that a large proportion of daily UFP exposure may occur during commuting. However, the determinants, variability and transport mode-dependence of such exposure are not well-understood. The aim of this review was to address these knowledge gaps by distilling the results of 'in-transit' UFP exposure studies performed to-date, including studies of health effects.

We identified 47 exposure studies performed across 6 transport modes: automobile, bicycle, bus, ferry, rail and walking. These encompassed approximately 3000 individual trips where UFP concentrations were measured. After weighting mean UFP concentrations by the number of trips in which they were collected, we found overall mean UFP concentrations of 3.4, 4.2, 4.5, 4.7, 4.9 and 5.7×10^4 particles cm^{-3} for the bicycle, bus, automobile, rail, walking and ferry modes, respectively. The mean concentration inside automobiles travelling through tunnels was 3.0×10^5 particles cm^{-3}.

While the mean concentrations were indicative of general trends, we found that the determinants of exposure (meteorology, traffic parameters, route, fuel type, exhaust treatment technologies, cabin ventilation, filtration, deposition, UFP penetration) exhibited marked variability and mode-dependence, such that it is not necessarily appropriate to rank modes in order of exposure without detailed consideration of these factors. Ten in-transit health effects studies have been conducted and their results indicate that UFP exposure during commuting can elicit acute effects in both healthy and health-compromised individuals. We suggest that future work should focus on further defining the contribution of in-transit UFP exposure to total UFP exposure, exploring its specific health effects and investigating exposures in the developing world.

1. Introduction

The study of commuter exposure to traffic-related air pollutants is not a particularly new field of research. Among the first researchers to recognise its significance was Professor Arie Haagen-Smit, who is best-known for his pioneering and enduring work related to characterising photochemical smog and ozone. In 1966, he performed a series of carbon monoxide measurements on heavily trafficked Los Angeles roads (Flachsbart, 2007; Haagen-Smit, 1966). Given population growth and increased motor vehicle use since that time, coupled with the high degree of proximity to vehicle emissions when commuting, the issue of 'in-transit' exposure to air pollutants is of equal if not greater relevance 45 years later.

Previous reviews of in-transit pollutant exposure, of which there are few, have focussed on CO inside vehicles (El-Fadel and Abi-Esber, 2009), particle mass concentrations and composition in metro (subway) systems (Nieuwenhuijsen et al., 2007) and various pollutants in multiple transport modes (Weisel, 2001). Only the work of Kaur et al. (2007) included a review of ultrafine (<100 nm) particle (UFP) concentrations in several transport modes.

At present, although gaseous pollutants are still the focus of numerous in-transit exposure studies, UFPs are beginning to attract significant attention. They are produced in large quantities by fuel combustion, and have been identified as a causal component of various negative health effects in humans (Knol et al., 2009; Hoek et al., 2010). UFPs typically constitute ~90% or more of particle number count (PNC) in areas influenced by vehicle emissions (Morawska et al., 2008), and we use UFP to describe PNC throughout this article.

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doi:10.1016/j.atmosenv.2011.02.065

The primary aim of this review is to distil the results of work performed to-date in order to improve understanding of the measurement, characteristics and determinants of in-transit exposure to UFPs, prior to a discussion of gaps in knowledge and suggestions for future research. Here, we extend the work of Kaur et al. (2007) by confining our focus to UFPs and incorporating the substantial body of relevant work that has appeared in the 4 years since its publication, which now constitutes the large majority of available literature. Like Kaur et al. (2007), we restrict our investigation to UFP exposure concentrations, rather than average or integrated exposure for a given time period. We note that dose assessment, which is a complementary yet distinct concept to that of exposure (Ott, 1985), is not the main focus of this review.

This review begins with an overview of the nature of commuter travel prior to a description of the general characteristics of UFPs. This is followed by a detailed analysis of in-transit UFP exposure studies, a discussion of determinant factors, health effects, and suggestions for future research.

1.1. Commuting in modern society

The nature of modern society in many countries both affords and expects a high degree of personal mobility. Time-activity patterns define how people apportion their time across a range of environments, and are a keystone of effective exposure analyses. Time-activity pattern studies of varying magnitude performed in different regions have reported that time spent in-transit typically constitutes between about 5 and 10% of the day (Klepeis et al., 2001), depending on location. The transport microenvironment(s) within which this time is spent varies more substantially between regions than the occupancy time, and has a greater dependence on local factors, such as the availability and desirability of various transport options.

In general, there are scant 24 h time-activity pattern data for developing countries. Saksena et al. (2007) reported that time spent travelling among 4311 Delhi residents ranged from 0.8 to 10% of the day, and varied markedly depending on age, sex and occupation, as did the mode of transport used. It is likely that the time-activity patterns of people in rural areas differ significantly from those of their urban counterparts.

1.2. Children's and adult's travel choices

Children are particularly susceptible to negative health effects caused by exposure to air pollutants (Gauderman et al., 2004; Brugge et al., 2007; Ashmore and Dimitroulopoulou, 2009), and many millions are required to commute between home and school each weekday. The choice of which transport mode school children utilise is normally at the discretion of others. Whilst children and young people have been reported to possess informed and responsible opinions regarding transport choices and a clear ideal towards cycling and walking, their parent's choices are guided primarily by safety concerns, and place substantial reliance on private automobiles (Lorenc et al., 2008).

Unlike children, adults generally make their own travel choices. A recent survey of 745 employed adults in Queensland, Australia, found that while about half of respondents felt that exposure to air pollutants in-transit negatively affected their overall health and increased their risk of cardiovascular disease, only 13% indicated that exposure to pollutants was a barrier to their adoption of walking or cycling to work, and that other factors were more responsible for their high level (82%) of dependence on private transport (Badland and Duncan, 2009). Furthermore, Badland and Duncan (2009) found that adults who were better educated and lived in urban areas were most cognisant of the negative health effects of air pollutant exposure during transit. Marshall et al. (2009) reported that the optimum balance between high walkability and low pollution was identified sporadically and typically in higher income neighbourhoods in urban Vancouver (Marshall et al., 2009). Evidently, there may be a significant socio-economic component involved in air pollution exposure during transit, particularly for active transport modes, and this may reflect wider socio-economic and environmental inequalities reported for several traffic pollutants (Marshall, 2008; Tonne et al., 2008; Su et al., 2009). It should be noted that both children and adults in developing countries are unlikely to be afforded the luxury of a travel choice, *per se*, and a relatively high degree of dependency on walking and public transport may result from this (Saksena et al., 2007).

2. Characteristics of ultrafine particles

2.1. General

UFP concentrations reflect the contribution of anthropogenic processes to a pre-existing background concentration (Morawska et al., 2008). Background concentrations are ascribed to natural processes, such that in most environments free from the immediate influence of anthropogenic activities, UFPs are present and their concentrations readily measured. Despite the numerous natural sources of UFPs, vehicular fossil fuel combustion has repeatedly been shown to be their dominant source in urban areas, with heavy-duty diesel powered vehicles making a disproportionately large contribution to UFP concentrations (Morawska et al., 2008).

An important distinction is between primary and secondary UFPs. The primary variety are emitted from their source as particles, whilst secondary particles are formed following homogenous nucleation of gases (Koutrakis and Sioutas, 1996; Jacobson, 2002). This occurs when a gas, or gases, nucleate in the absence of a pre-existing surface (Jacobson, 2002).

UFPs from vehicles can be emitted as primary particles or generated as a secondary aerosol, such as following homogenous nucleation of SO_2, NH_3 and NO_x into SO_4^{2-}, NH_4^+ and NO_3^- (Koutrakis and Sioutas, 1996; Morawska et al., 2008). The ratio of primary to secondary particles varies substantially according to fuel type and operating and environmental conditions, but nucleation mode particles can comprise approximately 90% or more of UFPs in diesel exhaust (Kittelson, 1998). However, more recent research indicates that the number of nucleation mode particles in diesel exhaust can be reduced to 40–50% when ultra-low sulphur diesel fuel is used (Ristovski et al., 2006), which is more representative of modern vehicle fleets in many countries.

2.2. Typical concentrations

Morawska et al. (2008) performed a meta-analysis of 71 UFP studies performed across a diverse range of environments. They found mean concentrations of 2.6, 4.8, 7.3, 10.8, 42.1, 48.2, 71.5 and 167.7×10^3 particles cm^{-3} for clean background, rural, urban background, urban, street canyon, roadside, on-road and tunnel environments, respectively. This indicates that greater proximity to vehicles is associated with increased UFP concentrations, and underscores their importance as a UFP source.

2.3. Health significance

Once inhaled, UFPs can reach with the alveolar region of the human lung with greater efficiency than larger particles due to their smaller size, and can deposit in alveoli with greater efficiency as a consequence of their rapid diffusion (Daigle et al., 2003; Phalen et al., 2006; Frampton, 2007). Due to their content of reactive oxygen species (ROS) and large combined surface area, UFPs from vehicle emissions have the potential to damage pulmonary cells (Delfino et al., 2005). Transition metal components in UFPs are believed to play a role in producing ROS, along with pro-oxidative organic hydrocarbons (Li et al., 2003). Additionally, target cells, such as airway epithelial cells and macrophages, produce ROS during biologically catalysed redox reactions occurring in the mitochondria in response to UFP uptake (Li et al., 2003; Nel, 2005). UFPs can evade alveolar macrophage clearance from the lung and enter lung cells, the interstitium and possibly the vascular bed (Geiser et al., 2005; Frampton, 2007), and can travel from the lung via blood and lymphatic circulation to other organs (Elder et al., 2006; Samet et al., 2009). UFPs are more proatherogenic than larger particles due to their greater bioavailability of reactive compounds, content of redox-active compounds, high number concentration and increased lung retention (Araujo and Nel, 2009).

Epidemiologic investigations of UFPs have been constrained by the scarcity of UFP monitoring sites and the substantial spatial heterogeneity of concentrations (Brook et al., 2010). Studies performed to-date in Erfurt, Germany, have indicated that UFP effects on daily mortality may be of comparable magnitude to, yet independent of, those of fine particles (i.e. $PM_{2.5}$), albeit with greater time lag between UFP concentrations and their effects (Wichmann and Peters, 2000). More recent results from the same long-term study have shown statistically significant associations between UFP concentrations and both total and cardio-respiratory daily mortality with a four day lag period (Stölzel et al., 2007). Interestingly, this study found no association between $PM_{2.5}$ mass concentration and mortality. Mortality from stroke amongst aged residents of Helsinki during summer was associated with both $PM_{2.5}$ and UFP concentrations on the previous day, and effects were mostly independent (Kettunen et al., 2007).

The effects of UFP concentration on mortality and morbidity due to various causes are less well understood than those of larger particles. A recent elicitation of European experts found that short-term UFP exposure was rated to variously possess a medium to very high likelihood of causality for all-cause mortality, and a low to high likelihood for cardiovascular and respiratory hospital admissions (Knol et al., 2009). Long-term UFP exposure was generally rated to possess a slightly lower likelihood of causality for all-cause mortality, owing mainly to the lack of long-term studies (Knol et al., 2009). The same group of experts estimated that a permanent decrease in annual average UFP concentration of 1000 particles cm^{-3} across Europe would lead to median decreases of 0.3%, 0.2% and 0.16% in all-cause mortality, and cardiovascular and respiratory hospital admissions, respectively (Hoek et al., 2010). The relatively small number of epidemiological studies (14) and absence of long-term studies, however, resulted in most experts indicating a substantial degree of uncertainty in their estimates (Hoek et al., 2010).

3. Studies of UFP concentration in transport modes

3.1. Methods

We searched combinations of the terms "ultrafine particle", "transport mode", "commuter", "exposure" "public transport", "microenvironment", "vehicle", "car", "automobile", "bus", "cyclist", "bicycle", "train", "metro", "subway" on PubMed, ISI Web of Knowledge and Google Scholar until October, 2010. The reference lists of studies identified by this method were reviewed for links to additional literature. Furthermore, the authors' own literature collections were utilized.

We restricted our investigation to studies that presented numeric values of UFP concentrations, and identified 47 that fulfilled this requirement. Tables S1–S7 in the Supplementary Information file contain detailed information on the various studies. These spanned 6 distinct transport modes: automobile, bus, cycling, ferry, rail and walking. Some studies dealt with multiple transport modes, whilst others focussed on a single mode. Of the studies we identified, only 7/47 (15%) had previously been reviewed by Kaur et al. (2007), which highlights the rapid progression of research related to in-transit UFP exposure since publication of their work.

The mean concentrations extracted from the studies identified were weighted by the corresponding number of trips taken, and overall trip-weighted mean UFP exposure concentrations were calculated for each transport mode (see Tables S1–S7 in the Supplementary Information file). The overwhelming majority of studies (93%) reported the number of trips associated with a given mean; the means reported by those that did not report trip number were weighted by a conservative factor of 1 trip. Most studies reported arithmetic mean UFP concentration, while several reported geometric mean and one gave median values. Where possible, data were disaggregated to permit analyses of the effect of variables such as fuel type, presence of exhaust-treatment devices and route.

Given the range of conditions under which they were collected, we did not assess the statistical significance of differences in measured mean UFP concentrations between modes, and instead sought to identify general trends in the data. This is discussed further in sections 4 and 5.

3.2. Results

Across all modes, we identified approximately 3000 individual trips where UFP measurements were performed. There was an uneven distribution of measurement trips; very few have been performed in ferry (13) and rail (49) modes, while a substantial number have been undertaken in bus (505), walking (524), cycling (599) and automobile (1310) modes. The automobile mode was split into non-tunnel (977) and tunnel (333) trips, as previous results indicate that tunnels are a discrete UFP exposure microenvironment distinct from open air roadways (Kaminsky et al., 2009; Knibbs et al., 2010).

Fig. 1 shows the trip-weighted mean UFP concentrations for each mode, and the number of trips on which they were based. Error bars indicate the trip-weighted standard deviation (Bland and

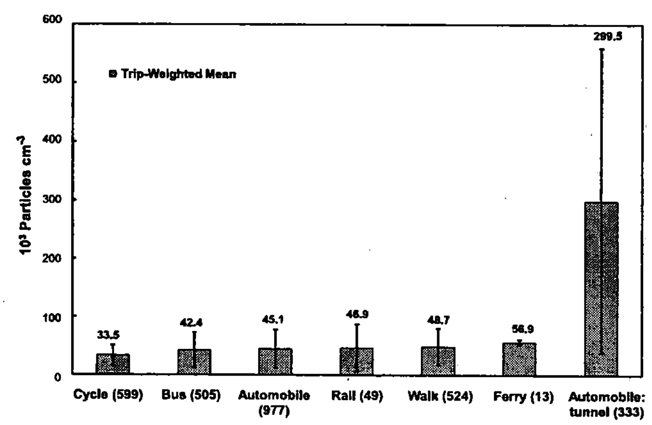

Fig. 1. Trip-weighted mean UFP concentrations in each transport mode, shown as bold numbers. The number of trips taken in each mode is shown in brackets. Error bars denote the trip-weighted standard deviation. The studies from which the data were extracted are listed in the Supplementary Information file.

Kerry, 1998). The range of mean UFP concentrations spanned one order of magnitude, with the lowest measured whilst cycling and the highest in automobiles during tunnel travel; 3.4×10^4 (s.d. = 1.8×10^4) and 3.0×10^5 (s.d. = 2.6×10^5) particles cm^{-3}, respectively. Means and standard deviations calculated for the automobile (non-tunnel), bus, ferry, rail and walk modes were 4.5 (3.3), 4.2 (3.1), 5.7 (0.5), 4.7 (4.1) and 4.9 (3.2) $\times 10^4$ particles cm^{-3}, respectively.

4. Comparison between modes

Considering the diversity of studies from which they were drawn, the trip-weighted concentrations measured in automobile (non-tunnel), cycle, bus, rail and walking modes exhibited notable coherence, with a maximum to minimum ratio (walk:cycle) of 1.5. A limited number of studies that measured concentrations in different modes simultaneously or near-simultaneously have been reported, and Briggs et al. (2008) found a walk:automobile ratio of 1.4, which is higher than the value of 1.1 presented here. Boogaard et al. (2009) found an automobile:cycle ratio of 1.05, whilst we found a value of 1.3, which was also higher than the value of approximately 1.0 reported by Int Panis et al. (2010).

While the above studies highlighted the relative concentrations encountered in each mode in the absence of bias due to fluctuating UFP concentrations, observed inter-mode contrasts were specific to the conditions of the study (e.g. the ventilation settings in an automobile, or the proximity to traffic on a bike route) and are should therefore not be extrapolated beyond the conditions under which they were collected without appropriate caution.

In studies that measured UFP concentrations in multiple modes non-simultaneously, the mode in which highest concentrations were recorded vacillated between automobiles and buses, whilst those in other modes were markedly lower (Levy et al., 2002; Kaur et al., 2005b; Weichenthal et al., 2008; Cattaneo et al., 2009; Kaur and Nieuwenhuijsen, 2009; Pattinson, 2009; Shrestha, 2009; Knibbs and de Dear, 2010). It is therefore noteworthy that our analysis found that UFP concentrations in buses and automobiles (non-tunnel) were relatively low. We pooled a large number of reported UFP measurements performed under a wide range of conditions, and while the ability to differentiate the observed differences is limited by the level of detail given by the various studies, such an approach is indicative of mean values and general trends. However, the mode in which highest exposures are experienced depends strongly on the determinant factors discussed in the following two sections, and generalisation of results may be of limited value (Int Panis et al., 2010); that is, within mode variability is likely to be substantial.

5. Determinants of UFP concentration in-transit

Despite the convenience it may provide, it is not necessarily appropriate to rank transport modes in order of UFP exposure without certain caveats. For example, Fig. 1 shows the trip-weighted mean UFP concentration in an automobile is higher than the equivalent for cycling. However, an occupant of a relatively air-tight automobile in which air is recirculated and filtered will likely experience markedly lower exposure concentrations than a cyclist on a high traffic route. Disentangling the relative roles of determinant factors, their interactions and variability in each mode is a key element required to advance understanding of in-transit UFP exposure. The data reviewed here suggest that while the relationship between UFP concentration and its determinants is often mode-dependent, exposure in all mode types is the result of interplay between multiple factors. These can be viewed as comprising two stages: the first determines the outdoor or on-road UFP concentration, and the second determines what proportion of this is able to come into contact with a commuter. These factors are addressed, in turn, in the following sections.

5.1. *Meteorological variables*

Temperature has been variously reported to be positively and negatively correlated with UFP concentrations, although in vehicle-dominated areas the correlation is more likely to be negative due to condensation of volatile compounds in emissions (Morawska et al., 2008). In-transit studies that assessed this relationship uniformly found a negative correlation between temperature and UFP concentration (Krausse and Mardaljevic, 2005; Vinzents et al., 2005; Thai et al., 2008; Weichenthal et al., 2008; Kaur and Nieuwenhuijsen, 2009; Pattinson, 2009; Laumbach et al., 2010). Among studies that reported correlation coefficients, those measured for cycling studies (Vinzents et al., 2005; Thai et al., 2008) were quite high (−0.62 and −0.76, respectively). Multi-mode and automobile studies reported correlations of −0.77 and −0.37, respectively (Kaur and Nieuwenhuijsen, 2009; Laumbach et al., 2010).

Wind speed, which affects dilution and transport of vehicle emissions, was also found to be negatively correlated with UFP concentration in-transit (Krausse and Mardaljevic, 2005; Vinzents et al., 2005; Briggs et al., 2008; Thai et al., 2008; Weichenthal et al., 2008; Kaur and Nieuwenhuijsen, 2009; Pattinson, 2009; Shrestha, 2009; Knibbs and de Dear, 2010), which is in agreement with results reported for various outdoor locations (Morawska et al., 2008). However, the results were not always statistically significant, indicating that temperature may be more consistently and strongly correlated with UFP concentrations. Correlations observed for active transport modes were −0.20 (walk), −0.52 (cycle) and −0.81 (cycle) (Briggs et al., 2008; Vinzents et al., 2005; Thai et al., 2008). Multi-mode and automobile studies reported correlations of −0.14 to −0.49 (Briggs et al., 2008; Kaur and Nieuwenhuijsen, 2009; Knibbs and de Dear, 2010).

For both temperature and wind speed, stronger correlations were generally observed for cycling compared to non-active modes, perhaps reflecting reduced influence of other factors on exposure concentrations encountered when cycling (and walking). The strength of the association between UFP concentration and both temperature and wind speed appears to be mode and location-dependent, and its variability is not well characterised.

While temperature and wind speed are the most frequently reported, other meteorological parameters may affect UFP concentration. The depth of the mixed layer within the atmosphere was found to be negatively correlated with in-transit UFP concentration (Weichenthal et al., 2008), which reflects the tendency of a shallow mixed layer to concentrate pollutants.

5.2. *Traffic volume and composition*

Very few studies have reported the relationship between traffic volume and in-transit UFP concentrations. Fewer still have examined the effect of traffic composition (i.e. gasoline vehicles, diesel vehicles). Briggs et al. (2008) observed statistically significant correlations between car and truck density and UFP concentrations encountered while walking ($r = 0.41–0.48$) or in an automobile ($r = 0.43–0.47$) in London. In their London-based study, Kaur and Nieuwenhuijsen (2009) similarly found a significant correlation ($\rho = 0.27$) between total traffic count and UFP concentrations in automobile, bus, cycle, taxi and walking modes. Krausse and Mardaljevic (2005) reported road link end description (e.g. signal, left turn, right turn etc.) was a significant determinant of total UFP exposure of car occupants. On-road studies have shown strong associations ($R^2 \sim 0.85$) between heavy diesel traffic volume and UFP concentrations (Fruin et al., 2008; Knibbs et al., 2009b). Other studies have reported more qualitative assessments of traffic effects; for example, that mean in-transit UFP concentrations increased on high traffic routes and vice-versa (Zhu et al., 2007; Thai et al., 2008; Strak et al., 2010; Zuurbier et al., 2010).

Vehicle emissions are the dominant source of UFPs in urban areas, and heavy diesel vehicles make a contribution that is disproportionate to their volume (Morawska et al., 2008). Coupled with the limited but consistent findings of in-transit studies, this suggests that traffic parameters (volume, density) and composition (gasoline vehicles, heavy diesel vehicles) are an important determinant of in-transit UFP exposure. It should be considered, however, that effects are likely to depend on mode, and that short-term traffic patterns not represented in hourly or daily average data, such as the impact of passing traffic, may be important (Fruin et al., 2008; Boogaard et al., 2009).

5.3. Route choice: active transport modes

There are generally fewer mode-specific variables that may affect pedestrians and cyclists compared to other transport modes; that is, traffic and meteorological conditions may be of greater importance as determinants. Most cycling studies were performed on or proximate to major urban roads, however, some studies compared measurements on high and low traffic routes, with the latter typically comprised of a dedicated cycle path. Separating the data into these two categories revealed that 18% of trips were undertaken on low traffic routes, and mean UFP concentrations were 2.6×10^4 particles cm^{-3}. The mean for high traffic routes was 3.5×10^4 particles cm^{-3}, suggesting that route selection, within the context of the few studies to address it, can affect cyclist UFP exposure (Pattinson, 2009; Strak et al., 2010; Zuurbier et al., 2010).

Route choice, as a proxy for traffic volume, is likely to be an important determinant of exposure (McCreanor et al., 2007; Hertel et al., 2008), and personal factors (e.g. walking or cycling patterns) may also exert an effect (Kaur et al., 2007). Microscale variations in UFP concentration proximate to roadways may result in higher exposures on the road side of the sidewalk/footpath compared to the building side (Kaur et al., 2005a). Also, the effect of roadway factors on pollutant dispersion (i.e. whether open to the environment or prone to trap pollutants due to geometry of urban canyons) has been shown to be a statistically significant determinant of UFP exposure concentrations encountered when walking (Briggs et al., 2008). Further work focussed on evaluating the effects of these local and microscale route phenomena on UFP exposure is required.

5.4. Cabin ventilation

Ventilation rates, whether driven by fans, natural leakage or open windows (Ott et al., 2008; Knibbs et al., 2009a), describe how rapidly outdoor air is capable of entering passenger cabins. Evidence suggests that ventilation is a key determinant of in-cabin UFP concentrations in automobiles, buses (Hammond et al., 2007; Rim et al., 2008; Knibbs and de Dear, 2010; Zhang and Zhu, 2010), ferries (Hill and Gooch, 2007; Knibbs and de Dear, 2010) and rail modes (Hill and Gooch, 2007; Cheng et al., 2009; Knibbs and de Dear, 2010). Quantitative studies support these observations, but are scarce and limited to automobiles (Xu and Zhu, 2009; Knibbs et al., 2010).

Knibbs et al. (2009a) found that air exchange increased linearly with vehicle speed in a group of six test automobiles operating under four distinct ventilation settings, which was in agreement with results obtained by Ott et al. (2008) based on tests performed in four vehicles. Knibbs et al. (2009b, 2010) found that the primary determinant of on-road UFP concentration in a tunnel bore was hourly heavy diesel vehicle volume ($R^2 = 0.87$), and that cabin ventilation rates explained 81% of the variation in the proportion of on-road UFPs reaching the occupants of 5 automobiles. The proportion reaching the cabin varied from 0.08 (recirculation) to ~ 1.0 (non-recirculation) depending on vehicle and ventilation setting. Thus, ventilation rates controlled the extent to which in-cabin exposure concentrations reflected on-road levels in the tunnel bore, which were largely determined by heavy diesel vehicle volume. Xu and Zhu (2009) reported that cabin ventilation and leakage were predominant factors in their model-based analyses of variables affecting in-cabin/on-road (I/O) UFP ratios, and explained up to $\sim 60\%$ of on-road UFP ingress. I/O ratios when windows are open can reach 1 due to higher air exchange, and such conditions may also occur when windows are closed but ventilation fan settings are high (Ott et al., 2008; Knibbs et al., 2009a).

Some investigators have successfully performed in-cabin UFP size distribution measurements during transit in automobiles (Zhu et al., 2007) and buses (Zhang and Zhu, 2010). These studies have shown that while in-cabin particle size distributions follow the general shape of those on-roads, the ability of on-road particles to reach the cabin is dependent on particle size and ventilation settings (Zhu et al., 2007). Particle penetration is discussed in section 5.6.

5.5. Filtration

Where a vehicle is fitted with a cabin air filter, its efficiency is a key determinant of what proportion of on-road UFPs reach the cabin, and efficiency varies substantially amongst the filters available. Standard automobile cabin filters afford single-pass UFP reductions of between approximately 30 and 60% (Pui et al., 2008; Qi et al., 2008), while this can increased by employing more advanced filtration technologies (Burtscher et al., 2008). It should be noted that filtration efficiency is affected by the ventilation rate; as filter face velocity increases with mechanical or natural ventilation rates, filtration efficiency decreases due to the reduced time available for particle diffusion inside the filter (Pui et al., 2008; Qi et al., 2008). When air is recirculated in an automobile, Qi et al. (2008) found that UFP concentrations decayed most rapidly in a vehicle capable of filtering recirculated air (single pass efficiency = 46%) than in a vehicle lacking this feature, where UFP removal efficiency without a filter was 27% per recirculation of cabin air. In the former and latter cases, on-road UFP concentrations were reduced to those typical of an office building (4000 particles cm^{-3}) in 3 min and 9–10 min, respectively, indicating the value of recirculation as a simple exposure minimisation mechanism. However, some older, less-airtight vehicles are characterised by outdoor air exchange rates up to 47 h^{-1} when air is recirculated (Knibbs et al., 2009a), and the benefit of recirculation in such cases can be substantially diminished (Knibbs et al., 2010).

5.6. UFP penetration and deposition

The penetration of UFPs through automobile envelopes is dependent on their size, the number and geometry of cracks, and the pressure difference across these and other ingress pathways (Xu et al., 2010). A recent study reported that penetration efficiency close to 100% was observed for diesel exhaust particles between 100 and 287 nm, and declined to $\sim 70\%$ for 10 nm particles due to diffusion; although penetration of 10 nm particles increased to $\sim 90\%$ when pressure differentials reached 200 Pa (Xu et al., 2010). No difference was observed in penetration efficiency amongst different materials.

Given the high surface to volume ratios of many automobile cabins, deposition can be an important UFP removal mechanism, especially under low ventilation conditions (Gong et al., 2009). Gong et al. (2009) found in-cabin deposition rates in automobiles exceed those of indoor environments by a factor of 3–20.

Studies describing UFP filtration, penetration and deposition in bus and rail modes are scarce and the limited data to-date is strongly skewed towards automobiles. Future studies addressing this knowledge gap will be of considerable value.

5.7. *Fuel type and presence of an emission control device*

5.7.1. *Automobile*

The effect of fuel type on UFP concentration in automobiles was assessed by Zuurbier et al. (2010), who found no significant difference in mean levels in diesel and gasoline-powered vehicles (diesel:gasoline concentration ratio = 0.96) based on 14 simultaneous trips under a standard ventilation setting. Their study focussed only on newer vehicles (<6 months) and its relevance to the wider passenger vehicle fleet is unknown. Additionally, it is difficult to separate the effects of fuel type from those due to differences in ventilation under a standard setting between vehicles of different manufacturer (e.g. Knibbs et al., 2009a). Further studies involving test vehicle groups more representative of the heterogeneity present in wider vehicle fleets are required.

5.7.2. *Bus*

Due to their frequency of door opening and the 'stop-start' nature in which they travel, buses have a tendency to self-pollute (Behrentz et al., 2004; Hill et al., 2005; Rim et al., 2008; Liu et al., 2010; Zhang and Zhu, 2010; Zuurbier et al., 2010). Accordingly, the variables most frequently reported by UFP exposure studies were fuel type and the presence of an exhaust or crankcase emission control device. We therefore disaggregated bus trips into 8 categories: diesel, biodiesel, compressed natural gas (CNG), electric, diesel with oxidation catalyst (DOC), diesel with diesel particulate filter (DPF), diesel with crankcase filtration system (CFS), and diesel with combined control (i.e. any combination of two or more of DOC, DPF, CFS and ultra low sulphur diesel). About 70% of trips were performed in diesel buses, with the remainder approximately evenly distributed across the other categories. Five percent of bus trips (26/505) were excluded due to lack of detailed data on fuel type or control device.

Fig. 2 shows the trip-weighted mean UFP concentrations for each category. The lowest mean (1.7×10^4 particles cm^{-3}; SD = 0.8×10^4) was recorded in CNG-powered buses, and the highest (4.9×10^4 particles cm^{-3}; SD = 2.6×10^4) was measured in diesel buses fitted with a CFS, although the latter result was based on a very limited number of trips (13). A similar mean was recorded in diesel buses with no control device (4.8×10^4 particles cm^{-3}; SD = 3.2×10^4). Means and standard deviations calculated for the biodiesel, combined control, DPF, DOC and electric categories were 1.7 (–), 2.0 (1.8), 2.4 (0.9), 2.8 (2.0) and 2.9 (0.8) $\times 10^4$ particles cm^{-3}, respectively. With the exception of the electric bus category, lowest concentrations were measured in buses powered by alternative fuels. Concentrations inside diesel-powered buses were generally lower when fitted with an emission control device.

Differentiating the effects of self-pollution from those of other factors on in-bus UFP concentrations is challenging. Previous work has shown that self-pollution can be the dominant source of vehicle emissions in the cabin when windows are closed, and constituted 0.01 to 0.3% of air in the cabins of 1975 through 2002 model school buses (Behrentz et al., 2004). Liu et al. (2010) found that self-pollution contributed an overall average of 1.8×10^4 particles cm^{-3} in two school buses (2000 and 2003 model); the average

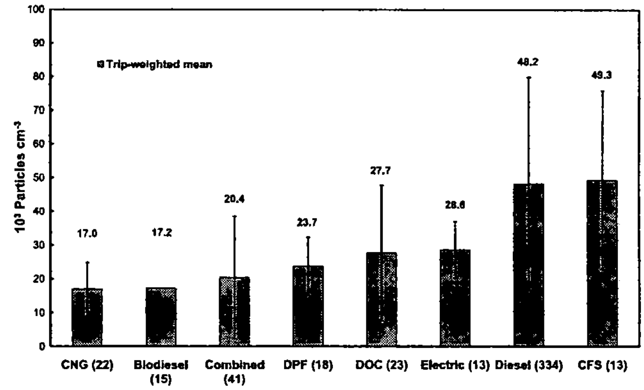

Fig. 2. Trip-weighted mean UFP concentrations measured in buses of different fuel type and emission control device. The number of trips taken in each category is shown in brackets. Error bars denote the trip-weighted standard deviation. See text for abbreviations.

contribution when windows were closed (1.0×10^4 particles cm^{-3}) was less than that when they were open (2.6×10^4 particles cm^{-3}). However, this trend was not in keeping with their results for other measured pollutants, and was attributed to UFP fluctuations due to unidentified non-vehicle sources on the low-traffic routes they studied. Generally, if on-road concentrations are low relative to those in-cabin, open windows will dilute self-pollution (Liu et al., 2010). The reverse can exacerbate its effects.

The relatively small number of trips taken in most categories we analysed and the lack of specific information regarding other possible determinants limits the conclusions that can be drawn, and precluded detailed statistical analyses. However, the results generally suggest that UFP concentrations are greatest in diesel-powered buses, and that reductions may be possible through use of alternative fuels or emission control devices, with best results achieved for diesel buses when two or more of the latter are combined.

5.7.3. *Rail*

In most rail studies we identified, trips were undertaken in vehicles driven by electricity. About 29% of trips were taken in diesel-powered trains, and the weighted mean UFP concentration during these was 9.0×10^4 particles cm^{-3}. The mean during travel in electric-powered vehicles was 3.0×10^4 particles cm^{-3}. Based on the limited data available, the power source of the rail vehicle therefore appears to markedly affect UFP exposure concentrations. Moreover, in diesel trains, the position of the locomotive relative to the passenger compartments can affect UFP concentrations; when a locomotive was located in front of passenger cabins, its emission plume can reach the cabin ventilation system intake Hill and Gooch, 2007.

There was insufficient data to investigate the effect of underground and above ground travel on UFP concentrations. Whilst there are numerous mechanical processes that can generate and resuspend particulate matter in electric-powered subway/metro systems, these are more likely to elevate levels of particle mass rather than UFP number count (Nieuwenhuijsen et al., 2007). The limited number of studies reporting UFP measurements on underground platforms tend to support this (Aarnio et al., 2005; Seaton et al., 2005; Raut et al., 2009; Cheng et al., 2009; Nystrom et al., 2010).

6. Correlation with other air pollutants

Several in-transit studies measured UFPs and other pollutants simultaneously. A summary of these is provided in Table S8 in the

Supplementary Information file. The correlation between UFP and $PM_{2.5}$ concentrations is generally reported to be positive, weak and not statistically significant, although stronger associations have been observed; correlation coefficients range from −0.07 to 0.69 (Aarnio et al., 2005; Kaur et al., 2005a,b; Seaton et al., 2005; McCreanor et al., 2007; Zhu et al., 2008; Berghmans et al., 2009; Boogaard et al., 2009; Knibbs and de Dear, 2010; Laumbach et al., 2010). Although correlation in the rail mode is moderate and relatively consistent across studies, in general there is no clear relationship between the strength of correlation and transport mode. The results are likely to be somewhat location-dependent, in keeping with those for outdoor environments, and the generally poor correlation reflects differences in the sources of particle number and mass and temporal scales involved in their dynamics (Morawska et al., 2008).

Black carbon (BC) and elemental carbon (EC) are often well-correlated with UFP concentrations in urban air, given their shared provenance in vehicle emissions and the large extent to which BC and EC contribute to UFP chemical composition (Morawska et al., 2008). On-road and subway platform studies have shown very good correlation between UFPs and BC; 0.88 and 0.84, respectively (Aarnio et al., 2005; Westerdahl et al., 2005). Correlations were relatively weak in automobile and bus studies (mean = 0.1–0.2), although in-bus relationships were strongly dependent on window position, and mean correlation improved (mean = 0.62) when windows were kept open, which the authors ascribed to self-pollution under the closed window setting (Zhu et al., 2008; Zhang and Zhu, 2010). Very good correlations between UFPs and EC (0.70 and 0.84) have been reported in walking studies (Kaur et al., 2005a; McCreanor et al., 2007).

The correlation between UFP concentrations and those of NO_x vary extensively from −0.33 to 0.90, and no clear relationship with transport mode is apparent (Westerdahl et al., 2005; McCreanor et al., 2007; Zhu et al., 2008; Laumbach et al., 2010). The relationship with CO concentrations is similarly variable; −0.16 to 0.70 (Kaur et al., 2005a,b; Westerdahl et al., 2005; McCreanor et al., 2007; Zhu et al., 2008; Laumbach et al., 2010). The specifics of the measurement location in terms of local emission sources are likely to explain the observed variation, and it is important to consider that in-transit measurements of particle and gaseous pollutants may exhibit poor temporal correlation due to the varying emission strength of proximate vehicles (Morawska et al., 2008; Zhu et al., 2008).

In summary, the relationship between in-transit UFP concentrations and those of other pollutants is generally inconsistent. Mode, location and environmental factors may all contribute to the observed variability, and the results gathered here from the limited pool of available studies require further validation in order to develop a more complete understanding of the associations. Currently, there is no data to support prediction of UFP concentrations from those of other pollutants, and such an approach is likely to be insufficient.

7. Relationship with fixed site monitors

Since the 1970s (Ott and Eliassen, 1973; Cortese and Spengler, 1976), numerous studies have investigated the ability of fixed site pollutant monitoring stations to estimate personal and commuter exposure. Generally, the ability of fixed site monitors to represent the substantial spatial and temporal variability of in-transit exposures has been sub-optimal, and carries with it numerous attendant limitations, the most important of which is underestimation of exposure (Kaur et al., 2007). UFPs are not a regulated pollutant, and are therefore not routinely monitored outside of research studies. Some investigators have assessed the association between fixed site UFP concentrations and those measured concurrently in-transit.

Aarnio et al. (2005) reported good correlation ($R^2 = 0.59$) between UFP concentrations in subway stations and those measured at an urban background site, while Seaton et al. (2005) found that the ratio of UFP concentrations measured on London Underground platforms to those above ground ranged from 0.38 to 0.68. These results are likely to reflect the absence of strong local UFP sources in subways (Aarnio et al., 2005). For above ground transport microenvironments, however, this is unlikely to be the case. Vinzents et al. (2005) reported a moderate correlation ($r = 0.49$) between UFP measurements performed at a fixed roadside location and those measured while cycling, but found that the only significant variables in a linear mixed effects model to predict cyclist exposure were temperature and concentrations of CO ($R^2 = 0.60$) and NO_2 ($R^2 = 0.74$) measured at urban background and roadside stations, respectively. Asmi et al. (2009) found that the ratio of UFP concentration in the driver's cabin of buses to that measured at an urban background site varied from 1.2 to 6.9 and was dependent on the age of the bus, time of day and route. Zuurbier et al. (2010) systematically evaluated the relationship between bus, car and bicycle UFP exposures and urban background concentrations in Arnhem, the Netherlands. They reported median mode to background ratios of 1.6 (diesel car, electric bus) to 2.5 (diesel bus) and correlations between 0.01 (diesel bus) and 0.87 (bicycle on low-traffic route).

The limited data available to-date indicates that fixed-site monitors may offer some ability to estimate UFP exposure of commuters in areas less affected by vehicle emissions, such as those using subways or low-traffic bike paths. However, depending on location, such persons are likely to constitute only a minor proportion of the commuting population. In the absence of widespread UFP monitoring networks, the utility of routinely monitored particle and gaseous pollutants or individual UFP monitors to represent in-transit UFP exposure appears significantly constrained (Krausse and Mardaljevic, 2005; Vinzents et al., 2005).

8. Health effects of in-transit UFP exposure

Studies of health effects due to commuter UFP exposure are summarised in Table S9 in the Supplementary Information file.

8.1. Healthy individuals

Nystrom et al. (2010) showed that while a cellular response in the airway epithelium was not elicited, minor biological responses such as increased systemic markers of inflammation and signs of lower airway irritation were observed in 20 healthy individuals exposed to subway air (mean UFP concentration 1.1×10^4 particles cm^{-3}) for 2 h while alternating between exercising on a bicycle ergometer and resting. However, road tunnel air (median UFP concentration 1.1×10^5 particles cm^{-3}) elicited an inflammatory response in the lower airways and elevated levels of T-lymphocytes and alveolar macrophages in brochoalveolar lavages from 16 healthy individuals who followed the same protocol (Larsson et al., 2007). The particle mass concentrations that subjects were exposed to in the two above studies were similar, while UFP and NO_x concentrations were an order of magnitude higher in the road tunnel study than in the subway study due to the presence of proximate vehicle emissions. Although it is not possible to ascribe the disparity in the results of the two studies to differences in UFP concentration alone, the results are suggestive of a causative role for UFP and NO_x in airway inflammation observed following exposure to vehicle emissions.

Thirty-eight healthy volunteers who cycled parallel to a major traffic corridor for 20 min (mean UFP concentration 2.9×10^4 particles cm^{-3}) experienced a minor increase in blood inflammatory cell distribution compared to cycling in a clean air environment, although the role of UFPs as distinct from $PM_{2.5}$ was not clear (Jacobs et al., 2010). UFP and EC exposure in 12 healthy non-smoking individuals cycling in traffic (mean UFP concentration 2.8 to 4.1×10^4 particles cm^{-3}) for 1 h was weakly associated with acute effects; decreased lung function and increased exhaled NO (as a marker of airway inflammation) were observed 6 h post-exposure (Strak et al., 2010). Oxidative DNA damage observed in 15 healthy subjects was positively correlated with cumulative UFP exposure, to which 1.5 h of cycling during rush hours (mean UFP concentration 3.2×10^4 particles cm^3) contributed substantially and resulted in greater damage compared to indoor cycling on an ergometer (Vinzents et al., 2005). Concentrations of other pollutants (PM_{10}, NO_x, CO) measured at fixed-sites were not associated with oxidative DNA damage.

UFP exposure resulted in modest effects among 34 healthy subjects that commuted by automobile, bus or bicycle for 2 h (median UFP concentration 2.7 to 4.4×10^4 particles cm^{-3}); peak expiratory flow decreased slightly and airway resistance increased immediately following exposure, and a significant increase in exhaled NO was observed 6 h post-exposure for automobile and bus commuters, but not cyclists (Zuurbier et al., 2011).

As the respiratory minute ventilation of cyclists is 2–4.5 times that of automobile and bus passengers (Zuurbier et al., 2009; Int Panis et al., 2010), the potential dose of inhaled UFPs received during active transport may be significantly higher than that in non-active modes, and recent health effects studies have already begun to adopt a more dose-oriented approach to reflect this (Zuurbier et al., 2011).

8.2. Health-compromised individuals

8.2.1. Asthmatics

Asthma exacerbations can be triggered due to oxidative stress and inflammation caused by UFPs in the lungs of susceptible individuals (Weichenthal et al., 2007). Reductions in lung function and increased daily symptoms in asthmatics and COPD patients attributable to elevated UFP concentrations have been observed in epidemiologic studies, with more immediate effects seen first in the respiratory system, and a delayed response of cardiovascular effects (Wichmann and Peters, 2000; Ibald-Mulli et al., 2002).

Consistent asymptomatic reductions in lung function (FEV_1, FVC) and increases in both inflammatory biomarkers and airway acidification were observed in 60 persons with mild or moderate asthma who walked for 2 h along a busy London street affected by diesel exhaust (median UFP concentration 6.4×10^4 particles cm^{-3}) (McCreanor et al., 2007). The effects were more frequently associated with UFP and EC concentrations than those of $PM_{2.5}$ and NO_2. Significantly reduced respiratory effects were observed when subjects walked along a route less affected by traffic emissions (median UFP concentration 1.8×10^4 particles cm^{-3}).

Fourteen mild asthmatics exposed to road tunnel air (median UFP concentration 2.3×10^5 particles cm^{-3}) for 2 h while alternating between exercising on a bicycle ergometer and resting experienced no changes in bronchial responsiveness and most lung function parameters, although peak expiratory flow decreased, and minor indications of inflammation were measured in nasal lavages, but not blood samples (Larsson et al., 2010).

8.2.2. Diabetics

Exposure to pollutants (median UFP concentration 4.3×10^4 particles cm^{-3}) during 1.5–1.8 h automobile highway trips made by 21 type 2 diabetics was shown to elicit a decrease in high-frequency heart rate variability the day after exposure, which was more associated with the interquartile range of UFP concentration compared to those of $PM_{2.5}$, NO_2 and CO, albeit not significantly (Laumbach et al., 2010). An increased low frequency to high frequency heart-rate variability ratio was observed immediately post-exposure that was not consistent with other observations, although confounding effects not present in the aforementioned finding may have influenced this result.

8.2.3. Elderly persons

Nineteen elderly subjects that were exposed to unfiltered and filtered air during 2 h automobile trips on Los Angeles freeways (mean unfiltered UFP concentration 0.78 to 1.1×10^5 particles cm^{-3}) experienced a 20% decrease in the incidence of atrial ectopic heartbeats and 30% decrease in cardiopulmonary stress biomarkers under the filtered compared to the unfiltered condition (Cascio et al., 2009; Hinds, 2010). Other measured parameters (lung function, indicators of inflammation, blood pressure) did not vary significantly between the two conditions. The observed atrial arrhythmia was ascribed to increased intra-atrial pressure, and was associated with UFP concentrations rather than gases or particle mass (Cascio et al., 2009; Hinds et al., 2010). The significance of such events is related to their role in causing more sustained arrhythmias.

8.3. Summary

Commute-time exposure to traffic and attendant pollutant emissions, noise and stress has been associated with increased risk of serious adverse health effects such as myocardial infarction (Peters et al., 2004). The specific role of UFPs as a causative agent of such effects is not clear, and the findings of the limited number of health effects studies addressing commuter exposure to vehicle emissions are mixed. However, some initial trends are emerging. While it is inherently difficult to separate the effects of UFPs from those other pollutants within the real-world exposure scenarios employed by the studies described above, the observed health effects were generally associated most strongly with UFP concentrations. Furthermore, the use of filtered air exposure scenarios in the Los Angeles freeway study (Cascio et al., 2009; Hinds, 2010) reduced particle concentration by >95% compared to the unfiltered condition but did not affect the level of gaseous pollutants, yet there was a marked difference in the cardiac effects observed between the two scenarios. The effects observed by McCreanor et al. (2007) were greater in those with moderate compared to mild asthma, and the degree to which this is true of other susceptible groups (i.e. increasing effects with increasing disease severity) is unclear. The 10 commuter health effects studies performed to-date have yielded valuable information, however, it is clear that further studies are required in order to better elucidate the role of UFPs.

9. Modelling exposure

9.1. Approaches employed to-date

The ability to accurately model in-transit UFP exposure concentrations has numerous attractive applications in urban planning, transport and policy development. The majority of published studies that developed models employed a multivariate regression approach that incorporated meteorologic, traffic or other pollutants as independent variables (Krausse and Mardaljevic, 2005; Vinzents et al., 2005; Weichenthal et al., 2008; Boogaard et al., 2009; Kaur and Nieuwenhuijsen, 2009). Given the potential for variability in the strength of associations between the independent variables and measured UFP concentrations discussed in sections 5, the external validity of these models is unknown. However, the models were of the explanatory type, and were developed in order to assess the effect of various parameters on UFP concentration measured in a specific location. Their ability to predict exposure concentrations varied from fair ($R^2 = 0.35$) to very good ($R^2 = 0.74$). The influence of mode-dependent parameters like ventilation were either included in a qualitative sense (e.g. ventilation setting or window position) or not included at all. This limitation was raised by both Briggs et al. (2008) and Weichenthal et al. (2008).

Several recent studies (Pui et al., 2008; Xu and Zhu, 2009; Knibbs et al., 2010) have sought to overcome the limitations described above by adopting a more mechanistic, mass-balance modelling approach for automobiles. This has been based on measurements of the effects of cabin ventilation, filtration, particle penetration or deposition on in-cabin concentrations (Qi et al., 2008; Gong et al., 2009; Knibbs et al., 2009a; Xu et al., 2010). These studies have generally shown very good results when validated with experimental data. The main limitation of such approaches is that they require the input of an initial on-road or in-cabin UFP concentration. Therefore, there is a clear need to couple models capable of predicting outdoor or on-road concentrations with those focussed on predicting what proportion of these concentrations reach occupants, and how particle dynamics will affect concentrations through time. Moreover, further refinement of models for predicting exposure in active transport modes will be of significant utility. In summary, there is both substantial need and scope for development of models capable of accurate prediction of UFP exposure concentrations in-transit.

9.2. *Spatial and temporal aspects of exposure*

Efforts to improve understanding of the spatial and temporal nature of UFP exposures during transit have benefited greatly from the use of Global Positioning Systems (GPS) and Geographic Information Systems (GIS), usually at the measurement and analytical stages, respectively. Gulliver and Briggs (2005) described the development and use of a GIS-based model for predicting exposure to PM_{10} (particles $< 10\ \mu m$) during transit, however, the application of spatial technologies to UFPs has to-date been limited to a handful of in-transit studies (Hvidberg, 2006; Thai et al., 2008; Berghmans et al., 2009; Boogaard et al., 2009; Pattinson, 2009; Int Panis et al., 2010). Synchronised video recordings have been included in some studies (Kaur et al., 2006; Berghmans et al., 2009), which affords an additional perspective from which analyses can be performed.

Given the good level of spatial data quality obtainable from even the more basic mobile telephones at present, the integration of such data into exposure studies will assist data interpretation and help to form a more complete and accurate assessment of pollutant exposure and dose for large study populations (Jerrett, 2010). The appropriateness and capability of mobile telephones to record spatial data and photographs during commuting has already been established by Pooley et al. (2010), and Pattinson (2009) collected such data in addition to UFP measurements when commuting by bicycle.

Land use regression (LUR) is an application of GIS that is gaining momentum as a tool with which to predict exposure to a variety of pollutants (see Hoek et al., 2008). The utility of LUR techniques to predict UFP concentrations and spatial variability is not well-established due to absence of extensive UFP monitoring networks; other (mainly gaseous) pollutants have been the focus of most work performed to-date. However, a recent study has reported reasonable performance of LUR when applied to UFP concentrations in Amsterdam, and comparable predictive utility was observed between the LUR model for UFPs and those for other pollutants (Hoek et al., 2011). LUR is an emerging technology that will increasingly find applications in prediction of personal exposure to a range of pollutants, albeit with an attendant need for validation based on measurements (Hoek et al., 2008). This highlights the need for high-quality databases of concomitant in-transit UFP and spatial measurements.

10. Further research needs

10.1. *In-transit contribution to daily exposure*

The significance of in-transit UFP exposure is highly dependent on personal, demographic and occupational context. UFP concentrations encountered on the commute to and from work will exert much greater influence on the total daily exposure of a non-smoking office worker than a smoker or someone who experiences high occupational exposure. Likewise, the health effects of the same exposure on an adult and child are likely to vary. Without better understanding of the characteristics of 24 h UFP exposure for numerous demographic groups, knowledge of in-transit exposure alone is of reduced utility. However, it is useful to be able to determine, for a given location, the transport mode in which highest concentrations occur and the factors that determine this. Such information has numerous valuable planning and policy applications.

A handful of studies have estimated the influence of measured in-automobile UFP concentrations on total exposure. Two were based on Los Angeles residents (Zhu et al., 2007; Fruin et al., 2008), and their estimates ranged from 10 to 50% and 33 to 45%, respectively. Wallace and Ott (2011) measured UFP concentrations in a wide range of microenvironments in two US cities and estimated the in-automobile contribution to total exposure to be 17%, which they attributed to the relatively low density of traffic and diesel trucks on the roadways they measured compared to LA. In all cases, the time spent in automobiles was assumed to be about 90 min per day. The applicability of the estimates reached by these studies to other regions is unknown, but they have established a range within which automobile commutes in urban areas may be expected to contribute to daily UFP exposure. These estimates have flagged this topic as one requiring further investigation, preferably including several transport modes.

It is important to consider the distinction between UFP concentration and exposure (Krausse and Mardaljevic, 2005). A high concentration experienced for a brief duration can result in a lower exposure than a low concentration for a longer period. This underscores the need for both accurate time-activity pattern data across broad demographic groups and representative UFP measurements within the various microenvironments in which time is spent. Until more expansive UFP exposure studies that follow large groups of people of varying time-activity patterns are completed, the ability to discern the range of commute-time's specific contribution to total exposure is constrained.

10.2. *High exposure professions*

The magnitude of UFP exposures incurred by people whose occupation requires them to spend extended period in-transit is poorly understood. Professional drivers, bicycle couriers, police officers and other groups whose work day is constituted by long periods in transport microenvironments may all be at risk of substantially elevated exposure compared to the general population. Riediker et al. (2004) reported the negative health effects of in-vehicle $PM_{2.5}$ exposure on young and healthy police officers during 9 h shifts in patrol cars. Similar studies focussed towards UFPs are required.

10.3. Exposure-health effects link

Various acute human health effects caused by UFP exposures have been investigated in controlled exposure studies using a range of subject groups. However, their relevance to in-transit exposures is unclear. There have been precious few studies that measured the effects of in-transit exposures on health end points, and these were described in section 8. There is a significant need for further studies in this area, as they will serve to bolster the link between exposure and health effects, and this will have implications across policy, planning and public health arenas (de Nazelle and Nieuwenhuijsen, 2010). Furthermore, given the substantial variability in minute ventilation between occupants of different modes (Zuurbier et al., 2009; Int Panis et al., 2010), the transition from an exposure to dose-oriented approach is likely to yield data of greater relevance to studies of health effects.

10.4. Data from the developing world

A striking feature of the English language literature we searched is the almost complete absence of studies performed in developing regions; with the exception of only the cycling study performed in Bogota, Columbia by Fanara (2003) and cited by Kaur et al. (2007), no other studies from developing countries were identified. This shortcoming is compounded by the generally poor air quality experienced in these regions (Han and Naeher, 2006) and their large populations and urban density. The effect of this combination of factors is that very high UFP exposures are likely to occur for large numbers of people, but the magnitude of such exposures is unknown. Studies of commuter exposure to particulate mass (RSP, PM_{10}) performed in Delhi and Hanoi have reported exceptionally high concentrations (Saksena et al., 2007, 2008). Moreover, in addition to walking, the most popular modes of transport, such as bicycles, scooters, motorcycles and 3-wheelers (tuk-tuks, auto-rickshaw etc), are unlikely to afford significant protection from the emissions of proximate traffic, which can include a substantial proportion of high emitting two-stroke vehicles. There is a clear need to redress the scarcity of research in this area.

10.5. Other needs

Major needs in future in-transit UFP exposure studies have been outlined above, and numerous other aspects requiring additional research have been suggested throughout this review. Further investigation of the variability inherent in the determinants of exposure discussed in section 5 is required to permit better appreciation of their effects. There is also an obvious need for improved modelling techniques, incorporating GIS, and for further comprehensive assessments of the health risk-benefit balance for active transport modes (de Nazelle et al., 2009; de Hartog et al., 2010).

11. Conclusions

In our analysis of 47 studies comprising approximately 3000 trips undertaken in 6 transport modes, we found that highest trip-weighted mean concentration occurred in automobile cabins during tunnel travel (3.0×10^5 particles cm^{-3}), and the lowest whilst cycling (3.4×10^4 particles cm^{-3}). Mean concentrations in bus, automobile (non-tunnel travel), rail, and walk modes were generally comparable. However, UFP exposure (and dose) during time spent in-transit is strongly dependent on a range of mode-specific and more general determinants, including, but not limited to, the effects of: meteorology, traffic parameters, cabin ventilation, filtration, deposition, UFP penetration, fuel type, exhaust treatment technologies, respiratory minute ventilation, route and microscale phenomena. Therefore, direct comparison of concentrations measured in different modes highlights general trends, but should not be extrapolated without detailed consideration of the above factors. Characterising the variability in the effects of these determinants will be an important aspect of future work.

There is preliminary evidence to suggest that time spent in-transit can contribute substantially to total daily exposure, and future studies require comprehensive assessment of 24 h UFP exposures across a broad demographic spectrum. Moreover, the range and variability of acute health effect associated with in-transit exposures are not well understood, and further studies are required to supplement the findings of the limited number performed to-date.

Transport is a ubiquitous component of life, and initial evidence suggests that UFP exposures incurred during this time can contribute substantially to daily exposure and be associated with adverse health effects in susceptible and healthy persons. Further research to better define this link is therefore well-justified, and will be of considerable benefit to urban planning, policy development and public health.

Acknowledgements

We thank Dr. Colin Solomon for his interest in this work and the useful feedback he provided.

Appendix. Supplementary information

Supplementary data associated with this article can be found in the online version, at doi:10.1016/j.atmosenv.2011.02.065.

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Atmospheric Environment 36 (2002) 4323–4335

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Study of ultrafine particles near a major highway with heavy-duty diesel traffic

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Received 6 March 2002; accepted 20 May 2002

Abstract

Motor vehicle emissions usually constitute the most significant source of ultrafine particles (diameter $<0.1\,\mu m$) in an urban environment. Zhu et al. (J. Air Waste Manage. Assoc., 2002, accepted for publication) conducted systematic measurements of the concentration and size distribution of ultrafine particles in the vicinity of a highway dominated by gasoline vehicle. The present study compares these previous measurements with those made on Interstate 710 freeway in Los Angeles. The 710 freeway was selected because more than 25% of the vehicles are heavy-duty diesel trucks. Particle number concentration and size distribution in the size range from 6 to 220 nm were measured by a condensation particle counter and a scanning mobility particle sizer, respectively. Measurements were taken at 17, 20, 30, 90, 150, and 300 m downwind and 200 m upwind from the center of the freeway. At each sampling location, concentrations of carbon monoxide (CO) and black carbon (BC) were also measured by a Dasibi CO monitor and an Aethalometer, respectively. The range of average concentration of CO, BC and total particle number concentration at 17 m was 1.9–2.6 ppm, 20.3–24.8 $\mu g/m^3$, 1.8×10^5–$3.5\times10^5/cm^3$, respectively. Relative concentration of CO, BC and particle number decreased exponentially and tracked each other well as one moves away from the freeway. Both atmospheric dispersion and coagulation appears to contribute to the rapid decrease in particle number concentration and change in particle size distribution with increasing distance from the freeway. Average traffic flow during the sampling periods was 12,180 vehicles/h with more than 25% of vehicles being heavy-duty diesel trucks. Ultrafine particle number concentration measured at 300 m downwind from the freeway was indistinguishable from upwind background concentration. These data may be used to estimate exposure to ultrafine particles in the vicinity of major highways.

Keywords: Ultrafine particles; Freeways; Diesel; Carbon monoxide; Black carbon

1. Introduction

Epidemiological data from air pollution studies have shown a consistent relationship between increases in particulate matter (PM) exposure and contemporary increases in mortality and morbidity (Schwartz, 1991; Dockery et al., 1993; Pope et al., 1995; Vedal, 1997). However, the underlying biological causes of the health effects of PM exposure and the correct measurement metric are unclear. For example, it is not clear whether the mass concentration (Osunsanya et al., 2001) or the number concentration (Peters et al., 1997; Penttinen et al., 2001) is most important in causing these adverse

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PII: S1352-2310(02)00354-0

PM health effects. Currently, there are several hypotheses used to explain the association of PM and observed adverse health effect. One argues that particle surface contaminants, such as transition metals, contribute towards ill health (Fubini et al., 1995; Gilmour et al., 1996), wherein the ultrafine particles are thought to act as vehicles for those contaminants, initiating local lung damage when the particles deposit on the epithelial surfaces. Another hypothesis is that the physical characteristics (e.g. number, size, shape, aggregation properties) are important in producing health effects (Bérubé et al., 1999). Particle shape and size are critical factor controlling where the inhaled particles deposit in the various regions of human respiratory system by the complex action of aerosol deposition mechanisms (Hinds, 1999).

Recent toxicological studies have concluded that ultrafine particles (diameter <100 nm) are more toxic than larger particles with the same chemical composition and at the same mass concentration (Ferin et al., 1990; Oberdörster, 1996, 2001; Donaldson et al., 1998, 2001; Churg et al., 1999; Brown et al., 2000). Currently, however, only the mass concentration of PM $<10\,\mu m$ in aerodynamic diameter (PM_{10}) and $<2.5\,\mu m$ ($PM_{2.5}$) are regulated. Information about ultrafine particles is usually not available. In fact, even though ultrafine particles represent over 80% of particles in terms of number concentration in an urban environment (Morawska et al., 1998a, b), the less numerous but much heavier particles of the accumulation (0.1–2 μm) and coarse (2.5–10 μm) modes dominate mass concentration measurements. Thus, number concentration, together with the size distribution of ultrafine particles, is needed to better assess ambient air quality and its potential health effects.

Emission inventories suggest that motor vehicles are the primary direct emission sources of fine and ultrafine particles to the atmosphere in urban areas (Schauer et al., 1996; Shi et al., 1999; Hitchins et al., 2000). Although traffic-related air pollution in urban environments has been of increasing concern, most studies have focused on gaseous pollutants, total mass concentration, or chemical composition of particulate pollutants (Kuhler et al., 1994; Clairborn et al., 1995; Williams and McCrae, 1995; Janssen et al., 1997; Roorda-Knape et al., 1998a, b; Wrobel et al., 2000). Booker (1997) found that particle number concentration was strongly correlated with vehicle traffic while PM_{10} was essentially uncorrelated with traffic. Since the majority of particle number from vehicle exhaust are in the size range 20–130 nm for diesel engines (Morawska et al., 1998a, b) and 20–60 nm for gasoline engines (Ristovski et al., 1998), it is important and necessary to quantify ultrafine particle emission levels, and to determine ultrafine particle behavior after emission as they are transported away from the emission source—busy roads and freeways.

Morawska et al. (1999) measured the horizontal and vertical profiles of submicrometer particulates (16–626 nm) near a major arterial route in the urban area of Brisbane, Australia. They found, with the exception of measurements in close proximity to the road (about 15 m), that the horizontal ground-level profile measurements did not show statistically significant differences in fine particle number concentration for up to 200 m distances away from the road. Hitchins et al. (2000) examined the particle size distribution and concentration in the size range from 15 nm to 20 μm at distances from a road ranging from 15 to 375 m at two sites in Australia. They conducted measurements under different wind conditions and found that when the wind is blowing directly from the road, the concentration of the fine and ultrafine particles decayed to about half of their maximum at a distance of 100–150 m from the road. Shi et al. (1999) measured ultrafine particle number concentrations and size distributions at a busy roadside and at nearby urban background sites in Birmingham, United Kingdom. They observed a faster decline of particle number concentration than mass concentration. In a recent study, Shi et al. (2001) reported that the fraction of particles <10 nm represents more than about 40% of the total particle number concentrations at 4 and 25 m from the roadside curb.

While there have been recent studies of ultrafine particles from traffic in other countries, except for Zhu et al. (2002), no comparable work has been done in the Los Angeles basin, a home to more than 15 million individuals and 10 million vehicles contributing to daily traffic. Previous studies have shown that meteorological conditions may affect substantially the characteristics of PM emitted from vehicles. Kittelson et al. (2001) found in their on-road PM measurements that the concentration of particles in the nuclei mode increases by nearly a factor of 10 as the (air) temperature is reduced from 25°C to 15°C. This observation suggests that there could be significant differences in the tendency to form semi-volatile nanoparticles between, for example, northern Europe and Southern California.

Zhu et al. (2002) conducted a systematic ultrafine particle study near one of the busiest freeways in the Los Angeles basin, Interstate 405. Traffic on that freeway was dominated by gasoline-powered cars and light trucks, with $<5\%$ of vehicles being heavy-duty diesel trucks. In the US, spark ignition vehicles usually account for most of the vehicles operating on highways. However, since diesel vehicles emit more PM on a fleet averaged, gram-per-vehicle mile mass basis (Kittelson et al., 2001), and that diesel engine exhaust has been proposed as carcinogen in animals and probably carcinogenic for humans (IARC, 1989), it is necessary and timely to conduct a comprehensive study of ultrafine particles in the vicinity of a diesel vehicle dominated freeway. Thus, the aim of the present paper is to systematically evaluate ultrafine particles in the vicinity of the 710 freeway in the Los Angeles basin, a freeway where more than 25% of vehicles are heavy-duty diesel trucks. Particle number concentration and size distribution in the size range from 6 to 220 nm are measured along with CO and black carbon (BC) as a function of distances upwind and downwind the 710 freeway. The results from the current study are compared to these by Zhu et al. (2002) which were obtained near the 405 freeway.

2. Experimental

2.1. Description of sampling site

This study was conducted in the City of Downey along Southern Avenue between 30 August and 27 October 2001. The location was chosen for its proximity to the freeway and the lack of other nearby ultrafine particle emission sources. Southern Avenue is located perpendicular to Interstate 710 Freeway and Garfield Avenue near the Los Amigos Country Club. Freeway 710 runs generally north and south near the sampling site and parallels the Los Angeles River.

This location is ideal for this study for several reasons. First, there are no other major roadways near the sampling sites along Southern Avenue. Second, businesses along Southern Avenue generally have large open land areas with little activities during the day. Thus, there is minimal local traffic influence at the sampling locations. Third, the freeway is at the same elevation as Southern Avenue. The only separation between the freeway and Southern Avenue is a metal chain link fence along the freeway. This allowed measurements as close as 3 m from the edge of the freeway. Fourth, a nearby residential area approximately 200 m upwind from the freeway was easily accessible for sampling.

During the sampling period, a fairly consistent eastward wind developed each day starting at approximately 11:00 AM. This wind carried the freeway vehicular emissions directly to the sampling location. The 710 freeway has eight lanes, four north bound and four south bound. It is approximately 26 m wide including a 1-m-wide median strip. Measurement site locations for this study were designated by their distance from the center of the median strip. Thus, the distance from each sampling location to the nearest traffic lane is 13 m less than the indicated distance.

Freeway 710 is a major truck route in Southern California with a large percent of the traffic consisting of heavy-duty diesel trucks. During the sampling period, traffic density ranged from 180 to 230 vehicles/min passing the sampling site, total for both directions, with approximately 25% of the vehicles being heavy diesel trucks.

2.2. Sampling and instrumentation

Wind speed and direction were measured at a fixed site 6 m above the ground level 20 m downwind of 710 freeway, which also served as a particle number concentration control site. Wind data were averaged over 1 min intervals and logged into a computerized weather station (Wizard III, Weather Systems Company, San Jose, CA). Throughout each measurement period, the traffic strength on the freeway, defined as number of vehicles passing per minute, was continuously monitored by a video recorder (camcorder), which captures all eight lanes of the freeway. After each sampling session, the videotapes were replayed and traffic density counted manually. Three 1-min samples were randomly selected from each 10-min interval. Cars, light trucks, and heavy-duty trucks were counted separately to estimate the traffic density by type of vehicle.

Particle number concentration and size distribution in the size range from 6 to 220 nm were measured by a condensation particle counter (CPC 3022A; TSI Inc., St. Paul, MN) and a scanning mobility particle sizer (SMPS 3936, TSI Inc., St. Paul, MN). The sampling flow rate of the SMPS was adjusted to 1.5 lpm in order to measure particles as low as 6 nm as well as to minimize the diffusion losses of ultrafine particles during sampling. Flexible, conductive tubing (Part 3001940, TSI Inc., St. Paul, MN) was used for sampling to avoid particle losses due to electrostatic forces. The sizing accuracy of the SMPS was verified in the laboratory by means of monodisperse polystyrene latex spheres (PSL, Polysciences Inc., Warrington, PA). Data reduction and analysis of the SMPS output was done by the Aerosol Instrument Manager software (version 4.0, TSI Inc., St. Paul, MN). Measurements were taken at 17, 20, 30, 90, 150, and 300 m downwind and 200 m upwind from the center of the freeway 710. At each location, three size distribution samples were taken in sequence with the SMPS. Scanning time for each was 180 s.

In addition to size distribution and the total number concentration, the concentrations of BC and carbon monoxide (CO), were monitored simultaneously at each sampling location. Before each measurement session, all instruments were time synchronized. Data were averaged after collection over the time periods corresponding to the scanning intervals of the SMPS. A Dual Beam Aethalometer (Model AE-20, Andersen Model RTAA-900, Andersen Instruments Inc., Smyrna, GA) was used to measure the BC concentrations every 5 min. Concentrations of CO were measured by a near-continuous CO monitor (Dasibi Model 3008, Environmental Corp., Glendale, CA) every minute. The CO monitor was calibrated by means of standard CO gas (RAE systems Inc., Sunnyvale, CA) in the laboratory and automatically zeroed each time the power was turned on.

Electric power for the control site CPC and Weather Station was obtained by an extension cord to a nearby office. Electric power for other sampling instruments at the sampling locations was supplied by a 1.2 kW gasoline-powered portable power generator (Model EU 1000i, Honda Motor Co., LTD., Tokyo, Japan). The generator was placed approximately 50 m downwind of each sampling location. Both total particle number and CO concentrations were measured at the control site with the generator turned on and with it turned off. No detectable difference was observed.

Table 1 gives the sampling dates and times and summarizes the instruments that were used on each date. The weather station and control CPC were placed at the 20 m downwind control site and sampled throughout the sampling period each day. All other applicable instruments were moved together and sampled simultaneously at each sampling location. It takes about 10 min to complete sampling at each location and 120 min to complete a set, all six locations. Three to four sets were performed on each sampling date.

3. Results and discussion

The results presented below include measurements of total particle number concentrations by a control CPC, wind velocity by a Weather Wizard III, both positioned at a fixed location 20 m downwind of the freeway; and CO, BC concentration, and ultrafine particles size distributions upwind and at six downwind distances from freeway 710.

3.1. *Wind effects*

Changes in wind conditions have been reported to modify dramatically the pattern of total particle number concentration versus distances from a major road (Hitchins et al., 2000). Consistency in wind speed and direction allows data from different days to be averaged together (Zhu et al., 2002). Wind speed and direction were measured, averaged and logged over every 1-min interval throughout each sampling period. One hundred wind data points were randomly selected out of more than 5000 observations from all the sampling dates and plotted in Fig. 1. The orientation of freeway 710 and the sampling road, Southern Avenue, are also shown in the Fig. 1. The Weather Wizard III instrument recorded wind direction at a 22.5° interval (e.g. 11.25° on either side of N, NNE, etc.) and wind speed at 0.4 or 0.5 m/s intervals. In the figure, duplicate observations were spread out slightly in both directions to better illustrate how strong the wind was and how often the wind came from certain directions. Based on all 5000 observations, the percent of sampling time that the wind came from each 22.5° segment is also shown in Fig. 1. As shown in Fig. 1, about 80% of the time, the wind was coming directly from the freeway towards the sampling road with a speed <3 m/s. The consistency of observed wind direction and speed is a result of a generally low synoptic wind velocities and a consistent sea breeze in the sampling area.

In this study, we found that not only wind direction, but also wind speed, played an important role in determining the characteristics of ultrafine particles near the 710 freeway, similar to the observations made by Zhu et al. (2002) near the 405 freeway. However the pattern of total particle number concentrations as a function of wind speed is somewhat different for the two studies. Fig. 2 shows total particle number concentrations measured by the control CPC, located 20 m downwind of the 710 freeway versus wind speed. Averaged data for the 405 freeway from Zhu et al. (2002) are also plotted for comparison. The CPC was programmed to archive averaged total particle number concentrations at 1-min interval in synchronization with the averaging time of the meteorological data. Only wind data within $\pm 22.5°$ of normal to the freeway was used in this figure which accounts for more than 60% of the total observations. The difference between the absolute value of total particle number concentration is due in part to the difference in the sampling distance. The control CPC was located 20 m downwind from the 710 freeway but 30 m from the 405 freeway. Assuming the fitted exponential decay characteristics of ultrafine particles holds right to the edge of the freeway, it is thus

Table 1
Sampling dates, time and instruments used

Date	Time	Weather Wizard III	Control CPC	SMPS	CO monitor	Aethalometer
08/30/01	10:00–15:30	×	×	×	×	×
09/05/01	10:30–16:00	×	×	×		
09/21/01	10:00–15:00	×	×	×	×	×
09/25/01	10:30–16:00	×	×	×	×	×
10/05/01	10:30–16:00	×	×	×	×	×
10/24/01	10:00–15:30	×	×		×	×
10/30/01	10:00–15:30	×	×	×		

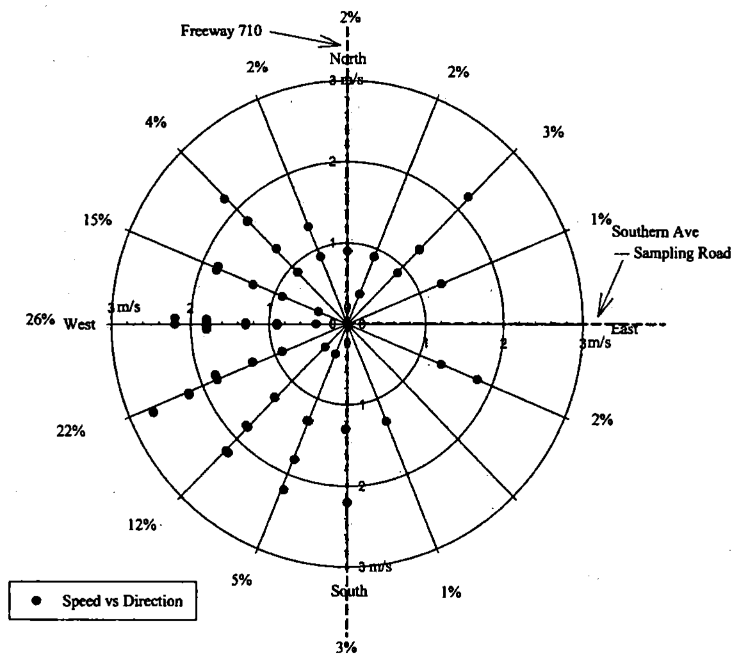

Fig. 1. Wind direction and speed at sampling site.

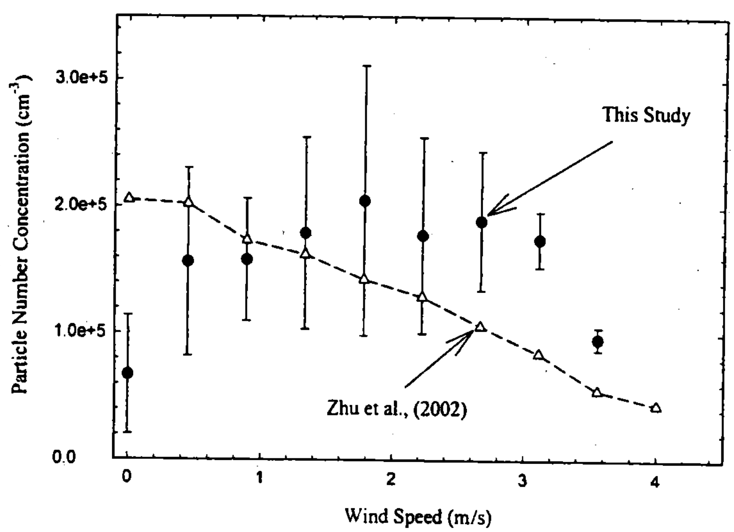

Fig. 2. Total particle number concentration measured by CPC located at 20 m downwind from freeway 710 versus wind speed. Bars indicate one standard deviation.

not surprising, as discussed below, that the CPC will read a greater total particle number concentration at 20 m in the present study than at 30 m in that by Zhu et al. (2002), given similar traffic load on both freeways. However, the relative particle number concentration as function of wind speed are somewhat different in these two studies. The relative particle number concentration decreased as the wind speed increased near the 405 freeway. In contrast, particle number concentration in the 710 freeway first increases, reaches a maximum around 1.5 m/s, and then decreases. There is no obvious explanation for the observed difference. In both studies, data showed large error bars, and the data of low wind speed (< 1 m/s) were very limited. In addition, the 405 freeway is elevated approximately 4.5 m above the surrounding terrain, while, the 710 freeway is at ground level, the same as the sampling location. Lower speed wind would be expected to cause less atmospheric dilution, and thus lead to greater particle number concentrations, as Zhu et al. (2002) reported. However, at extremely low wind speeds, it would take a considerably longer time for the wind to carry particles to the sampling port of the CPC, which gives ultrafine particles more time to coagulate with either themselves or with larger particles, a phenomenon that would decrease the total particle number concentration. This may partially explain the observed "n" shape curve in the current study.

3.2. *Traffic effects*

The portion of freeway 710 passing through the City of Downey is a major truck shipping route. The average traffic volume per hour during the measurement period was: 8730 cars, 870 light trucks, 2580 heavy trucks, and 12180 total vehicles. It is apparent from these numbers that diesel emission vehicles on the 710 freeway represent about 30% of vehicles while on the 405 freeway they represent <5% (Zhu et al., 2002). Fig. 3 compares the traffic volume on both the 405 and the 710 freeways. Error bars represent one standard deviation. It is seen that the 710 freeway has about 7 times as many diesel vehicles and 70% of gasoline vehicles as the 405 freeway. The total vehicle numbers on both freeways are quite similar 12,180 versus 13,900/h for the 405 freeway.

Zhu et al. (2002) reported that a traffic slowdown on freeway 405 was associated with a drop in total particle number concentration indicating that fewer ultrafine particles are emitted during such events. In this study, the traffic speed on the 710 freeway stayed constant through out the sampling period. No traffic slow down was observed. The difference in the variability of traffic volume on both freeways is indicated by the error bars in Fig. 3.

Zhu et al. (2002) reported that both wind speed and traffic density affected the characteristics of ultrafine particles near the 405 freeway, and the control CPC responded to these effects reasonably well. Thus, subsequent data for ultrafine particle analysis at increasing distances from the freeway were all normalized to the control CPC's reading. An average CPC reading, $\overline{C_N}$, was obtained based on all the measurements. In Figs. 4–6, number concentration and size distribution data were scaled to $\overline{C_N}$ by dividing each measurement by the ratio of CPC reading for the period of measurement to $\overline{C_N}$.

3.3. *Change in ultrafine particle size distribution with increasing distance*

Fig. 4 depicts ultrafine particle size distributions at 17, 20, 30, 90, 150 and 300 m downwind and 300 m upwind of freeway 710. The size distributions are smoothed and shown together with common scales for both axes. The horizontal axis represents particle size on a logarithmic scale, while the vertical axis represents normalized particle number concentration in the size range of 6–220 nm as measured by the SMPS. Data were averaged for all applicable sampling dates for each distance from the freeway. As shown in Fig. 4, ultrafine particle size

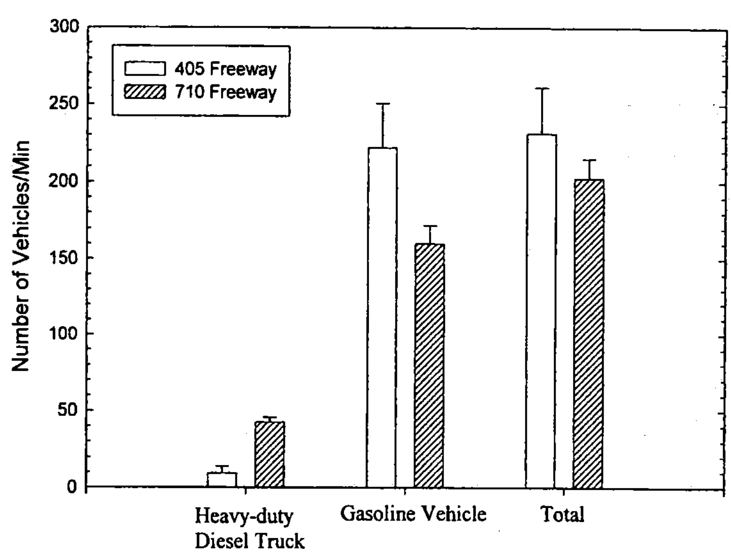

Fig. 3. Traffic volume comparison for the 405 and 710 freeway. Bars indicate one standard deviation.

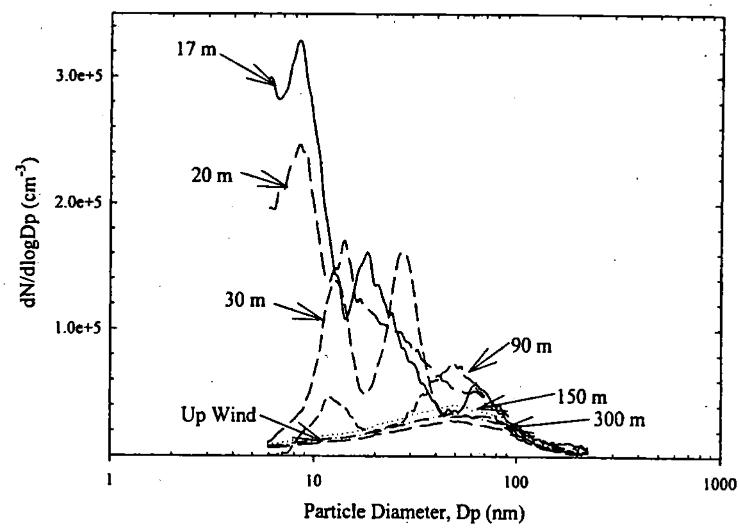

Fig. 4. Ultrafine particle size distribution at different sampling locations near the 710 freeway.

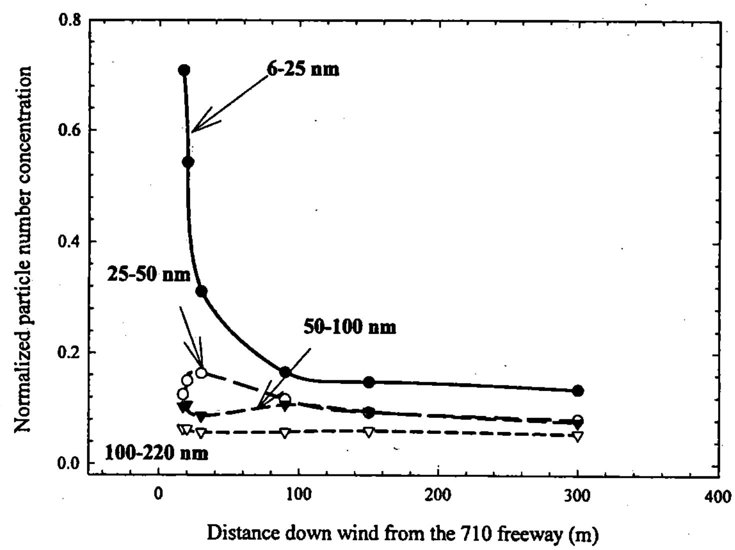

Fig. 5. Normalized particle number concentration for different size ranges as a function of distance from the 710 freeway.

distribution changed markedly and its number concentration dropped dramatically with increasing distance. At the nearest sampling location, 17 m downwind from the center of the freeway, the dominant mode was around 10 nm with a modal concentration of more than $3.2\times 10^5/cm^3$. This mode remained at 10 nm for the second sampling location, 20 m downwind from the freeway, but its concentration dropped to $2.4\times 10^5/cm^3$. It shifted to larger size range and its concentration kept decreasing for farther sampling locations. This mode was not observed at distance >150 m downwind from the freeway. The dramatic decrease of particle number concentration in the size range around 10 nm was likely due to atmospheric dilution and several atmospheric aerosol particle loss mechanisms that favor small particles, diffusion to surfaces, evaporation, and coagulation. The smaller the particle, the greater its diffusion coefficient and its Brownian motion. Particles of 10 nm diffuse about 80 times faster than particles of 100 nm (Hinds, 1999). As particle size gets smaller, the Kelvin effect becomes more important, making it easier for molecules to leave the particle's surface by evaporation. In addition, when two small particles collide due to their Brownian motion (coagulate), they form a bigger particle. Thus, coagulation reduces number concentrations and shifts the size distribution to larger sizes.

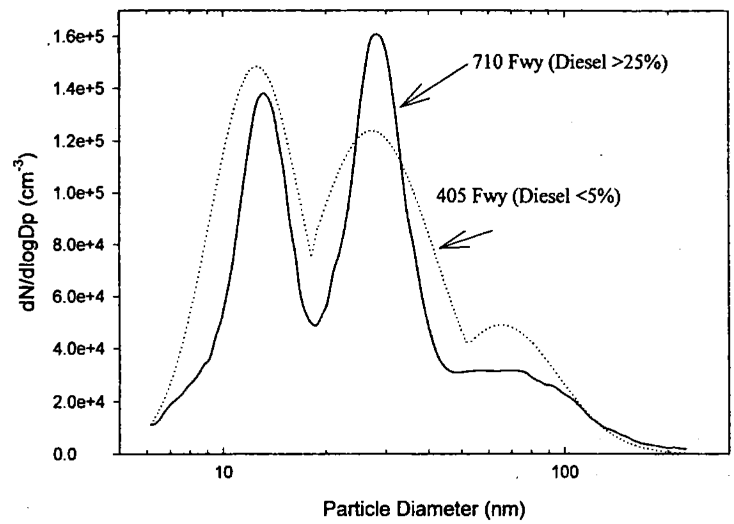

Fig. 6. Comparison of ultrafine particle number concentration at 30 m downwind from 405 and 710 freeway.

In Fig. 4, the second mode at 17 m downwind from the freeway was around 20 nm with a concentration of $1.5 \times 10^5/cm^3$. This mode remained at similar size range and concentration for the next sampling location, 20 m, but shifted to 30 nm at 30 m downwind from the freeway. It is of particular note that, while the concentration for the primary mode, 10 nm mode, decreased about 60% of its maximum value from 17 to 30 m with a slight shift in its mode, the 20 nm mode concentration did not change significantly but the modal size shifted noticeably. This second mode continued to shift to larger sizes with increasing distance from the freeway. In general number concentrations for smaller particles, $d_p < 50$ nm, dropped significantly with increasing distances from the freeway, but for larger ones, $d_p > 100$ nm, number concentrations decreased only slightly. These results are in excellent agreement with what Zhu et al. (2002) reported for freeways impacted mostly by gasoline vehicles, which suggests that coagulation is more important than atmospheric dilution for the smallest ultrafine particles and vice versa for large particles. Ultrafine particle concentrations measured at 150 and 300 m downwind of the 710 freeway were statistically within the variation of the 300 m upwind background concentration. The maximum number concentration that was observed next to the freeway was about 30 times greater than that for the background location. This suggests that people who live or work within 100 m downwind of major traffic sources, or spend a substantial amount of time commuting on such highways, will have a much higher ultrafine particle exposure than those who do not. This result can be used in epidemiological studies to estimate exposure to ultrafine particles.

Based on Fig. 4, it is clear that vehicle-emitted ultrafine particles of different size ranges behave quite differently in the atmosphere. Zhu et al. (2002) showed the decay of ultrafine particle number concentrations in four size ranges 6–25, 25–50, 50–100 and 100–220 nm. They found coagulation played a significant role in modifying the particle size distribution of vehicle-emitted ultrafine particle downwind of a freeway. Fig. 5 was prepared in the same ways as Zhu et al. (2002). The measured particle number concentrations in each SMPS size bin were combined in the corresponding size range, and the result was normalize to averaged wind speed. The general trends of sub-grouped ultrafine particle decay curves are quite comparable to those given by Zhu et al. (2002), Figs. 7a and b. Total particle number concentration in the size range of 6 to 25 nm accounted for about 70% of total ultrafine particle number concentration and dropped sharply, by about 80%, at 100 m, and leveled off after 150 m. Overall, it decayed exponentially through out the whole measured distance. Number concentrations in the next two size ranges 25–50 and 50–100 nm, all experienced a shoulder between 17 and 150 m. These results are in excellent agreement with what Zhu et al. (2002) observed and can be explained by particles, in smaller size ranges, coagulating with these particles to increase their size.

Fig. 6 compares the ultrafine particle size distributions at 30 m downwind from the 710 and the 405 freeways. Three-mode lognormal fitting was used for 405 freeway. Raw data were smoothed by averaging for 710 freeway. Heavy-duty diesel trucks on the 710 freeway represent more than 25% of traffic while on the 405 freeway they represent <5% (Zhu et al., 2002). Average PM emission rate for heavy-duty diesel trucks is about 0.4 g/mi (California ARB, 2000) while for passenger cars is

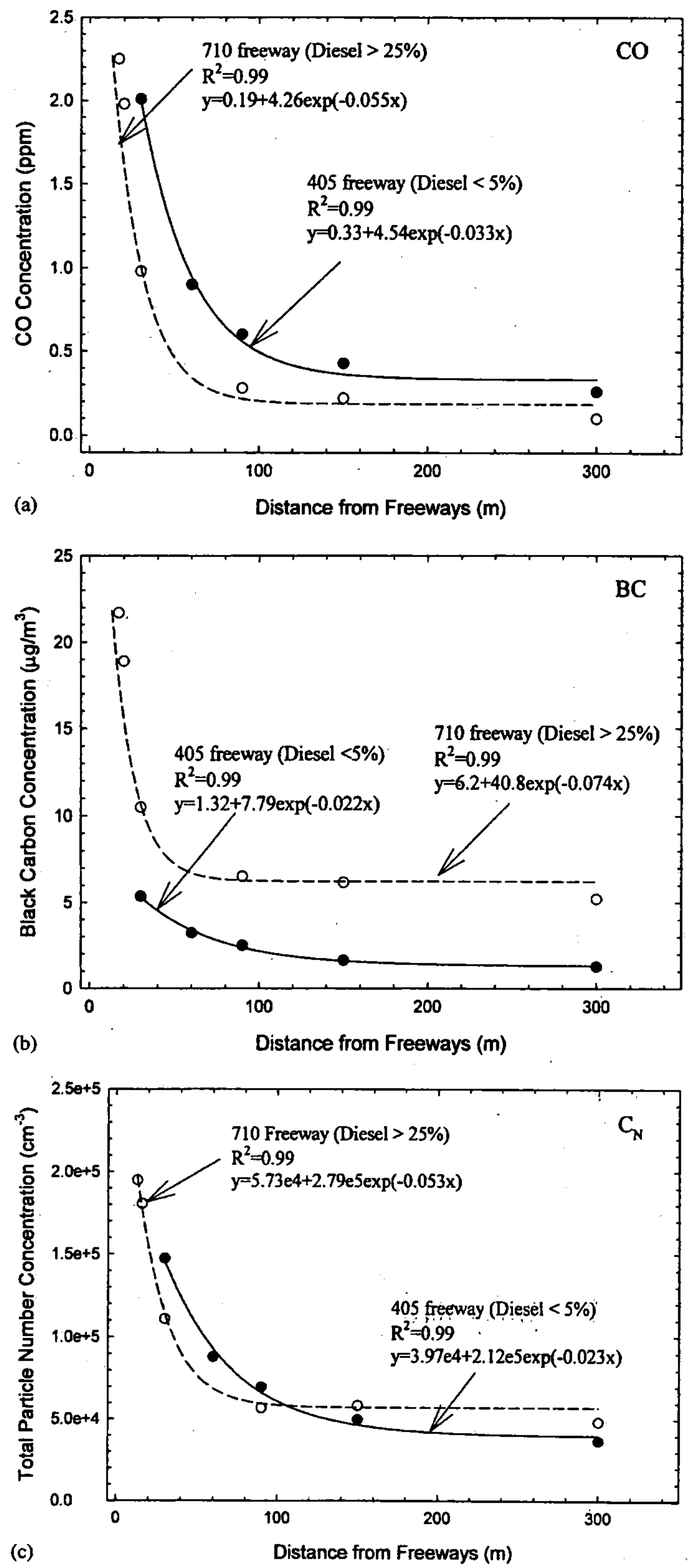

Fig. 7. Decay curves of: (a) CO, (b) BC and (c) particle number concentration near the 405 and 710 freeway.

about 0.08 g/mi (EPA, 2000). Thus, on the 710 freeway, about 60% of PM emission is due to heavy-duty diesel trucks $((0.25\times0.4)/(0.25\times0.4+0.75\times0.08)=62.5\%)$. In Fig. 6, both size distributions have three distinct modes. The concentration for the first mode, between 10 to 20 nm, is slightly higher near the 405 freeway. This mode is likely to arise from homogeneous nucleation of semi-volatile materials and is similar to that previously reported for direct laboratory measurement of gasoline vehicle emissions (Ristovski et al., 1998). The concentration for the second mode, around 30 nm, is about 30% higher near the 710 freeway than that near the 405 freeway. This mode probably comprises mainly of BC and is likely due to the much higher diesel emissions on the 710 freeway. The last mode, around 70 nm, represents an insignificant contribution to number concentrations for these two freeways and in both cases are comparable to the background concentrations.

3.4. *Decay of carbon monoxide, black carbon and particle number concentration*

To make this freeway study more comprehensive, the concentrations of CO, BC, and particle number were also measured at increasing distance from the freeway on selected dates, as shown in Table 1. CO and BC were intentionally selected because their ambient concentrations are closely related to vehicular emissions. Averaged concentration and range of values at different distances from the freeway of each measured property are summarized in Table 2. CO and BC concentrations decreased noticeably when moving away from the traffic sources, similar to the findings of the study by Zhu et al. (2002).

Figs. 7a–c were prepared by comparing the decay characteristic of CO, BC and particle number concentrations near the 405, gasoline vehicle dominated, and the 710, diesel vehicle dominated, freeways. Exponential decay was found to be a good estimator for predicting total particle number concentrations at different locations (Zhu et al., 2002). Each data point in the figure represents an averaged value for all measurements with similar wind directions. The solid line was the best fitting exponential decay curve, determined using SigmaPlot 2000 nonlinear curve fitting procedure. The best fitting exponential decay equations and R^2 values are also given in the figure. It can be seen, in general, all three pollutants decay at a similar rate near both freeways. This implies that atmospheric dilution plays a comparable role in both studies. As discussed previously, the average wind speed for these two studies are all close to 1.5 m/s. The discrepancies of the curves were mainly due to the different traffic fleet compositions on these two freeways. The 710 freeway has more than 25% heavy diesel trucks while the 405 freeway has $<5\%$. It is well known that diesel engines emit less CO and more BC comparing to spark ignition engines (Kittelson et al., 2001). Fig. 7a shows that the concentration of CO near the 710 freeway is generally half of that near the 405 freeway. By comparison, Fig. 7b shows the BC concentration near a diesel vehicle dominated freeway is more than three times greater than that near a gasoline vehicle dominated freeway. As shown in Fig. 7c, the total particle number concentration close to the 405 freeway is somewhat higher than that near the 710 freeway, but drops faster with downwind distance. Since the rate of coagulation increases with decreasing particle size down to 20 nm (Hinds, 1999), the observed result suggests more of the smallest ultrafine particles, mostly in nano-size range, were emitted from the 405 freeway. This may be explained by a total of 20% more vehicles on the 405 freeway. It was previously reported that number emission rates from the spark-ignition vehicles were much lower than from the diesel vehicles under most operating conditions, but were similar under high-speed highway cruise conditions (Rickeard et al., 1996; Kittelson, 1998). It should also be noted that the exponential decay characteristic appears to extend to about 3 m downwind from the edge of the freeway for all three pollutants. Based on our results we conclude that atmospheric dilution is so rapid that average concentration decays continuously after leaving the tailpipe.

Table 2
Measured averaged concentrations at increasing distances from the freeway[a]

Measurement	Upwind (m)	Downwind distance (m)					
	200	17	20	30	90	150	300
CO	0.1	2.3	2.0	1.7	0.5	0.4	0.2
(ppm)	(0.0–0.2)	(1.9–2.6)	(1.5–2.4)	(1.1–1.9)	(0.2–0.7)	(0.1–0.5)	(0.1–0.3)
Black carbon	4.6	21.7	19.4	17.1	7.8	6.5	5.5
($\mu g/m^3$)	(3.1–5.9)	(20.3–24.8)	(16.5–21.6)	(12.6–19.3)	(4.5–9.3)	(3.9–9.2)	(3.5–7.7)
Number concentration	0.48	2.0	1.8	1.6	0.72	0.61	0.49
($\times 10^{-5}/cm^3$)	(0.36–0.57)	(1.8–2.5)	(1.5–2.5)	(1.2–1.9)	(0.42–1.1)	(0.35–0.98)	(0.30–0.59)

[a] Range given in parenthesis.

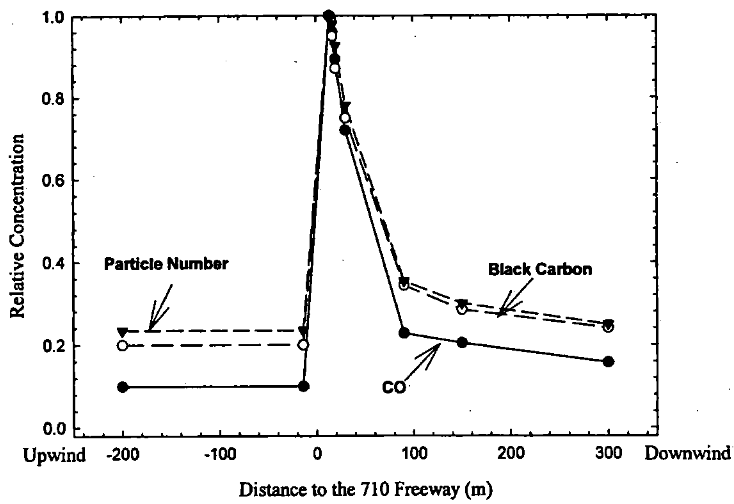

Fig. 8. Relative particle number, BC, CO concentrations versus distance from the 710 freeway.

Fig. 8 shows the decay curves for relative concentrations of CO, BC and total particle number. The curves are normalized and extended to reach 1.0 at the downwind edge of the 710 freeway. Background concentrations are also shown in the figure. It is seen that CO, BC and particle number concentration decreased about 60–80% in the first 100 m and then leveled off somewhat after 150 m, similar to what Zhu et al. (2002) reported. Background CO has a much lower relative concentration while background BC and particle number concentrations are comparable. Thus, CO was diluted more quickly and significantly than BC and particle number concentration. In general, CO, BC and particle number concentrations tracked each other very well. These results confirm the common assumption that vehicular exhaust is the major source for CO, BC and ultrafine particles near a busy freeway. They also support the conclusion made by Zhu et al. (2002) that for the conditions of these measurements the decreasing characteristics of any of these three pollutants could be used interchangeably to estimate the relative concentration of the other two pollutants near freeways.

4. Conclusions and summary

Wind speed and direction are important in determining the characteristic of ultrafine particles near freeways. The average concentrations of CO, BC and particle number concentration at 17 m was 1.9–2.6 ppm, 20.3–24.8 μg/m^3, 1.8×10^5–3.5×10^5/cm^3, respectively. Relative concentration of CO, BC and particle number tracked each other well as one moves away from the freeway. Exponential decay was found to be a good estimator for the decrease of these three pollutants' concentration with distance along the wind direction starting from the edge of the freeway. Measurements show that both atmospheric dilution and coagulation play important roles in the rapid decrease of particle number concentration and the change in particle size distribution with distance away from a freeway.

Acknowledgements

This work was supported by the Southern California Particulate Center and Supersite: US Environmental Protection Agency under grant number R82735201, and California Air Resources Board under contract number 98-316. The authors also would like to thank Mr. Yuqing Zhang, for his assistance with the field measurement.

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Atmospheric Environment 43 (2009) 2541–2549

Contents lists available at ScienceDirect

Atmospheric Environment

journal homepage: www.elsevier.com/locate/atmosenv

A wide area of air pollutant impact downwind of a freeway during pre-sunrise hours

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A R T I C L E I N F O

Article history:
Received 10 October 2008
Received in revised form
13 February 2009
Accepted 13 February 2009

Keywords:
Vehicle-related air pollutants
Ultrafine particles
Mobile platform
Roadway
Exposure assessment

A B S T R A C T

We have observed a wide area of air pollutant impact downwind of a freeway during pre-sunrise hours in both winter and summer seasons. In contrast, previous studies have shown much sharper air pollutant gradients downwind of freeways, with levels above background concentrations extending only 300 m downwind of roadways during the day and up to 500 m at night. In this study, real-time air pollutant concentrations were measured along a 3600 m transect normal to an elevated freeway 1–2 h before sunrise using an electric vehicle mobile platform equipped with fast-response instruments. In winter pre-sunrise hours, the peak ultrafine particle (UFP) concentration (~95 000 cm^{-3}) occurred immediately downwind of the freeway. However, downwind UFP concentrations as high as ~40 000 cm^{-3} extended at least 1200 m from the freeway, and did not reach background levels (~15 000 cm^{-3}) until a distance of about 2600 m. UFP concentrations were also elevated over background levels up to 600 m upwind of the freeway. Other pollutants, such as NO and particle-bound polycyclic aromatic hydrocarbons, exhibited similar long-distance downwind concentration gradients. In contrast, air pollutant concentrations measured on the same route after sunrise, in the morning and afternoon, exhibited the typical daytime downwind decrease to background levels within ~300 m as found in earlier studies. Although pre-sunrise traffic volumes on the freeway were much lower than daytime congestion peaks, downwind UFP concentrations were significantly higher during pre-sunrise hours than during the daytime. UFP and NO concentrations were also strongly correlated with traffic counts on the freeway. We associate these elevated pre-sunrise concentrations over a wide area with a nocturnal surface temperature inversion, low wind speeds, and high relative humidity. Observation of such wide air pollutant impact area downwind of a major roadway prior to sunrise has important exposure assessment implications since it demonstrates extensive roadway impacts on residential areas during pre-sunrise hours, when most people are at home.

1. Introduction

Air quality in the vicinity of roadways can be seriously impacted by emissions from heavy traffic flows. As a result, high concentrations of air pollutants are frequently present in the vicinity of roadways and may result in adverse health effects. These include increased risk of reduced lung function (Brunekreef et al., 1997), cancer (Knox and Gilman, 1997; Pearson et al., 2000), adverse respiratory symptoms (Van Vliet et al., 1997; Venn et al., 2001; Janssen et al., 2003), asthma (Lin et al., 2002; McConnell et al., 2006), and mortality (Hoek et al., 2002).

Previous studies have shown elevated vehicle-related air pollutant concentrations and gradients downwind of roadways during daytime. Hitchins et al. (2000) measured concentrations of fine and ultrafine particles (UFP) at a distance of 15–375 m from a major roadway during the daytime. They found concentrations decayed to about half of the peak value (at the closest point to the roadway) at approximately 100–150 m from the roadway on the normal downwind side. Particle concentrations were not affected by the roadway at a distance farther than 15 m on the normal upwind side, indicating a sharp gradient of fine and ultrafine particles. Similar studies were conducted by Zhu et al. (2002a,b), who measured ultrafine particles, CO, and black carbon (BC) on the

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doi:10.1016/j.atmosenv.2009.02.033

upwind (200 m) and downwind (300 m) sides of a freeway in Los Angeles during the daytime. Peak concentrations were observed immediately adjacent to the freeway, with concentrations of air pollutants returning to upwind background levels about 300 m downwind of the freeway.

The few near-roadway studies conducted at night indicated larger areas of impact than during daytime. UFP concentrations at night were reported by Zhu et al. (2006), who conducted measurements upwind (300 m) and downwind (500 m) of a freeway from 22:30 to 04:00. Although traffic volumes were much lower at night (about 25% of peak) particle number concentrations were about 80% of the daytime peak 30 m downwind of the freeway, with UFP concentrations of ~50 000 cm^{-3} about 500 m downwind of I-405, a major Los Angeles freeway during the night. Fruin and Isakov (2006) measured UFP concentrations in Sacramento, California, near the I-50 freeway between 23:00 and 01:00 and found 30–80% of maximum centerline concentrations (measured on a freeway overpass) 800 m downwind.

In the present study, the use of a full-size, motorized mobile platform (MP) allowed more pollutants to be measured than previous nighttime studies and with improved spatial and temporal resolution. While traveling at normal vehicle speeds, an instrumented mobile platform allows measurements over greater distances and in shorter times (Bukowiecki et al., 2002a,b, 2003; Canagaratna et al., 2004; Kittelson et al., 2004a,b; Khlystov and Ma, 2006; Kolb et al., 2004; Pirjola et al., 2004, 2006; Unal et al., 2004; Weijers et al., 2004; Westerdahl et al., 2005; Yao et al., 2005; Isakov et al., 2007; Baldauf et al., 2008; Fruin et al., 2008). However, to date, such studies have focused almost entirely on daytime and evening periods.

In the present study, air pollutant concentrations were measured over a wide area on the south and north sides of the I-10 freeway in west Los Angeles, California, 1–2 h before sunrise in the winter and summer seasons of 2008 using an electric vehicle mobile platform equipped with fast-response instruments. We observed a much wider area of impact downwind of the freeway than reported in previous daytime and evening studies, consistent with low wind speed, absence of turbulent mixing, and nocturnal radiation inversions. Our pre-sunrise results were also strikingly different from those we observed for the same route during the daytime. Our observation of a wide area of impact during pre-sunrise hours, up to about 600 m upwind and 2000 m downwind, has significant implications for exposures in residential neighborhoods adjacent to major roadways.

2. Methods

2.1. Mobile platform and data collection

A Toyota RAV4 sub-SUV electric vehicle served as the mobile platform, with self-pollution eliminated by the non-polluting nature of the vehicle. Table 1 shows a complete list of sampling instruments and equipment installed on the mobile platform. The time resolution for most instruments ranged from 5 to 10 s except the Aethalometer, which had 1 min time resolution. The instrument power supply and sampling manifold were similar to that described by Westerdahl et al. (2005).

Calibration checks and flow checks were conducted on a bimonthly and daily basis, respectively, as described in Kozawa et al. (2009). For calibrations, a standard gas containing a mix of NO and CO was diluted using an Environics 9100 Multi-Gas Calibrator and Teledyne API Zero Air System (Model 701) to calibrate the CO and NO/NO_x analyzers. CO_2 was calibrated with zero air and span gas cylinders from Thermo Systems Inc. A DryCal DC-lite flow meter, with a flow range of 100 ml min^{-1} to 7 L min^{-1} and an accuracy of ±1%, was used to check the flows of each instrument.

Table 1
Monitoring instruments on the mobile platform.

Instrument	Measurement Parameter	Time Resolution
TSI Portable CPC, Model 3007	UFP Count (10 nm-1um)	10 s
TSI FMPS, Model 3091	UFP Size (5.6–560 nm)	10 s
TSI DustTrak, Model 8520	PM2.5 Mass	5 s
Magee Scientific Aethalometer	Black Carbon	1 min
EcoChem PAS 2000	Particle Bound PAH	5 s
Teledyne API Model 300E	CO	20 s
LI-COR, Model LI-820	CO2	10 s
Teledyne-API Model 200E	NOx, NO, NO2	20 s
Vaisala Sonic Anemometer and Temperature/RH Sensor	Local Wind Speed and Direction, Temperature, Relative Humidity (RH)	1s
Stalker LIDAR and Vision Digital System	Traffic Documentation, Distance and Relative Speed	1s

2.2. Route

For pre-sunrise measurements, the mobile platform was driven on a fixed route over three days in the winter season and two days in the summer season of 2008. The route covered a total length of about 3600 m approximately perpendicular to the I-10 freeway in Santa Monica, California (Fig. 1). The solid line in Fig. 1 shows the section of the route over which the mobile platform traveled about 8–10 times during each monitoring period, reaching about 1200 m south of the freeway. The dashed line shows the extended section of the route, over which the mobile platform traveled 2–4 times during each monitoring period, reaching about 2600 m south of the freeway. The pre-sunrise route crossed a number of local surface streets; these are shown in Fig. 1 together with their normal distances to the freeway as measured from Google Map. The route was selected because it passed under the I-10 freeway, and because there was little traffic flow on the route itself or on the perpendicular surface streets (e.g. Olympic Blvd., Pico Blvd. etc.) during pre-sunrise hours. Hence, the majority of measurements were not significantly affected by local surface street traffic. The route also passed through a dense residential neighborhood where the elevated air pollutant concentrations have significant exposure implications.

During sampling, the mobile platform was intentionally stopped to avoid localized impacts from individual vehicles whenever necessary. During data reduction, pollutant concentration spikes, if verified from videotape to be caused by a nearby vehicle, were excluded from the analysis.

2.3. Real-time traffic flow

Traffic flows were collected or measured on the I-10 freeway, the pre-sunrise route itself, and the major surface streets transecting the pre-sunrise route. Real-time traffic flow on the freeway was obtained from the Freeway Performance Measurement System (PeMS) provided by the UC Berkeley Institute of Transportation. Sensors were located at the Dorchester Station, about 300 m from the intersection of the pre-sunrise route and the freeway. Since there were no on-ramps or exits between the Dorchester Station and our route, the PeMS data accurately represented the traffic flow on the I-10 freeway where our route passed under the freeway. Traffic flow on the pre-sunrise route itself was monitored and recorded by a Stalker Vision Digital System on the mobile platform. The recorded videos were replayed and vehicles on the pre-sunrise

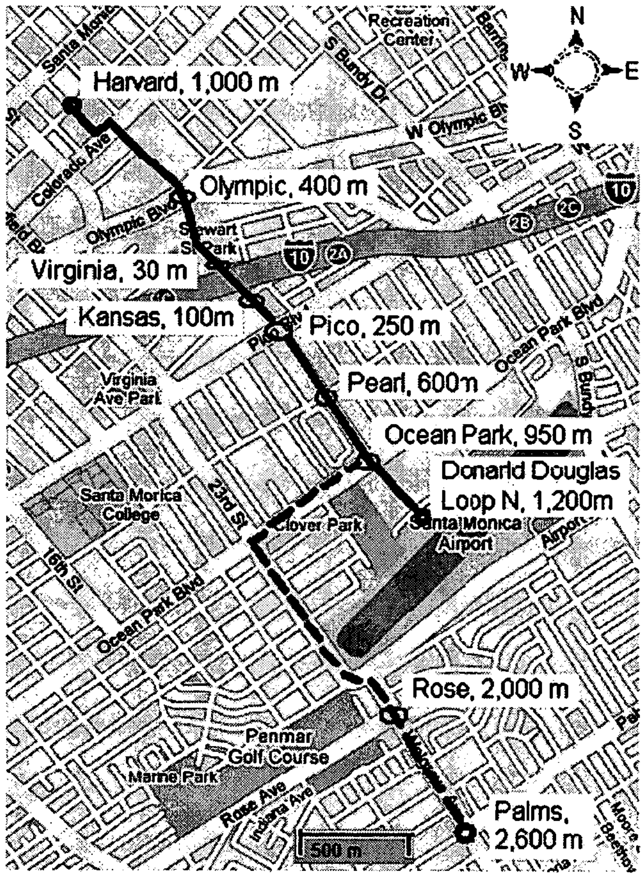

Fig. 1. Pre-sunrise route. The solid line indicates the route 1000 m and 1200 m north and south of the I-10 freeway, respectively. The dashed line indicates the route extended to 2600 m south of the I-10 freeway. Mobile platform measurements on this route were continuous; circles indicate location of cross streets, not fixed site monitoring.

route were manually counted. Traffic flows on the major cross streets (e.g. Olympic Blvd., Pico Blvd., and Ocean Park Blvd.) were manually counted during the winter season on a weekday at times similar to when the pre-sunrise measurements were conducted.

2.4. Data analysis and selection of key pollutants

Data were adjusted for the varying response times of the instruments on the mobile platform to synchronize the measurements. NO_X, CO, CO_2, and particulate data (UFP, BC, and PM2.5 mass) were synchronized with particle-bound polycyclic aromatic hydrocarbon (PB-PAH) data measured by the PAS instrument, which had the fastest response time. NO, UFP, and PB-PAH were selected in the present study for detailed spatial analysis because of their rapid and large variation on and near roadways. The overall response time for the PAS instrument was determined by comparing the time of signal peaks in the PB-PAH time-series to the corresponding time of acceleration of a vehicle in front of our mobile platform (as recorded on videotape). This time difference was less than 10–15 s and includes the transport time (typically a few seconds) for the plume from the emitting vehicle to reach the inlet of the sampling duct of the mobile platform. Given the short response times of our instruments and our driving speeds of 5–15 MPH, the spatial resolution of our mobile platform measurements was typically in the range of 25–75 m, with the finer spatial resolution (~25 m) near the edges of the freeway where we drove more slowly.

Measurements were made continuously over the entire route, not at fixed stationary sites. The measured real-time concentrations of UFP, PB-PAH, and NO along the pre-sunrise route were averaged for each intersection using a few data points measured at and immediately adjacent to the intersection. Although the peak air pollutant concentration always occurred downwind of the I-10 freeway, its value changed with time due to changing traffic volumes on the I-10 freeway and varying meteorological conditions, so peak pollutant concentrations were used to calculate normalized relative pollutant concentrations. For example, in the winter season, the measured averaged peak UFP concentration was about 95 000 cm^{-3}, but the instantaneous peak values varied in the range of 62 000–135 000 cm^{-3} (four to nine times the background concentrations).

3. Results and discussion

3.1. Meteorological data

Meteorological conditions, including atmospheric stability, temperature, relative humidity, wind speed and wind direction, play an important role in determining air pollutant concentrations and gradients along and downwind of roadways. During each run, the mobile platform was periodically stopped at locations along the pre-sunrise route to obtain wind data from on-board instruments (Table 2). These data were compared with the measurements from the Santa Monica Airport (SMA) located about 1500 m downwind of the I-10 freeway and in the immediate vicinity of the route. Both the averaged wind speeds measured by the mobile platform and by the SMA were quite low during pre-sunrise hours, in a range of 0–1.0 m s^{-1} and the averaged difference between the two measurements was about 0.3 m s^{-1}. Temperature and relative humidity were obtained from SMA data.

Fig. 2 shows the wind roses and vector-averaged wind orientation for five days, March 7, 12, 18, June 30, and July 2, from data collected by instruments on the mobile platform. Wind speeds were low during the pre-sunrise hours, with monitoring period averages ranging from 0.0 to 1.0 m s^{-1}. The averaged wind directions measured by the mobile platform indicated a predominant direction of N/NE/NW during the pre-sunrise runs, which agreed reasonably well with airport wind direction data. For this predominant wind direction, the north side of the I-10 freeway was upwind; the south side downwind. Although having a predominant direction from north, the wind was not completely perpendicular to the I-10 freeway. Hence, the distances pollutants traveled from the freeway to various locations along the route, including the major cross-surface streets, were generally longer than indicated by distances shown in Fig. 1. For example, the straight perpendicular distance of Ocean Park Blvd. to the I-10 freeway is ~950 m, whereas for the averaged wind direction of 25° for the pre-sunrise run, the distance pollutants traveled was ~1050 m. However, due to the variability of meteorological conditions, the perpendicular distances were used to indicate impact distances in the present study.

While detailed thermal structure data for the lowest layers of the atmosphere in the area of our pre-sunrise route were not available, the available data indicate the days sampled had stable (i.e., vertical) temperature profiles or strong nocturnal radiation inversions in the hours before sunrise. Data recorded at the Santa Monica Airport indicated the nights on which sampling took place were clear up to at least 3000 m, and had either offshore flow or a weak land breeze, also consistent with clear skies; clear skies are conducive to the formation of nocturnal surface inversions due to enhanced radiative heat loss in the infrared. Data collected by the

Table 2
Meteorological conditions during pre-sunrise runs (2008).

Date	Measurement period	Sunrise	Atmospheric Stability from LAX Profiler data	Wind Speed[a] ($m\ s^{-1}$)		Wind Direction[a] (°)		Temperature (°C)	Relative Humidity (%)
				MP	SMA	MP	SMA	SMA	SMA
March 7	6:20–7:50[b]	7:14[b]	N.D.[c]	0.9	1.0	13	5	11	79
March 12	6:00–7:30	7:07	Surface inversion to 250–300 m	1.0	1.0	53	20	13	66
March 18	6:10–7:20	6:59	Surface inversion to 190 m	0.8	1.0	6	45	9	61
June 30	4:00–6:30	5:45	Stable to 190 m, inversion above	0.7	0.0	288	0	17	87
July 2	4:30–6:45	5:45	Stable to 260 m, inversion above	0.7	1.0	315	340	17	84

[a] Averaged values for the measured period.
[b] Time corrected to Pacific Day Light Time (PDT); change from PST to PDT occurred on March, 9, 2008.
[c] Profiler came online the following evening. The following night (3/8) experienced a surface inversion for the entire night.

South Coast Air Quality Management District (SCAQMD) at the Los Angeles Airport (LAX), ~8 km south of pre-sunrise route, were also consistent with an inversion or stable conditions at the surface. On 3/10 and 3/18, the data showed temperature inversions from the lower edge of the measurements at 130 m up to 190 m or more, respectively. On 6/30 and 7/2, the profiles were stable from 130 to 190 or 260 m, respectively, with capping inversion layers above. Wind speeds during the pre-sunrise hours were too low to create

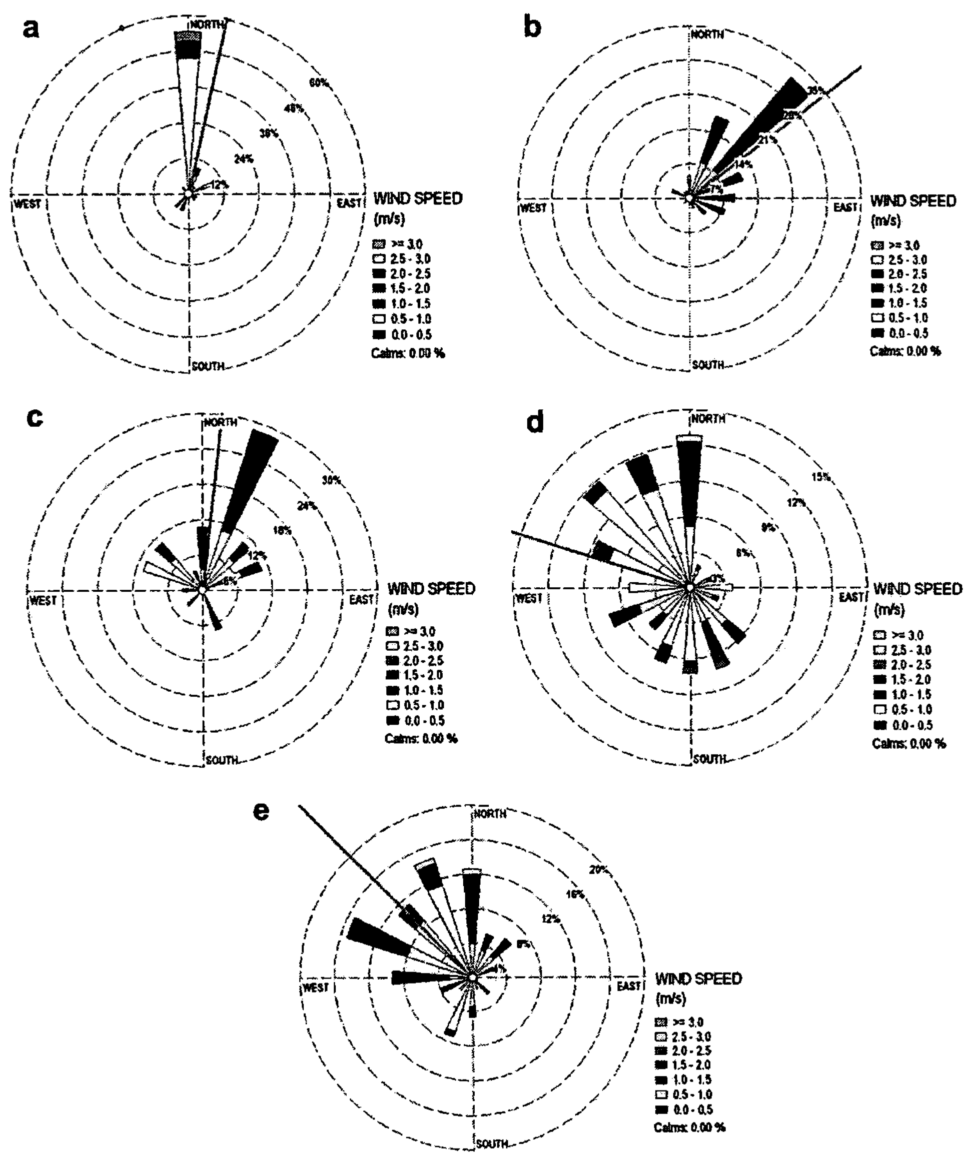

Fig. 2. Wind roses for pre-sunrise sampling hours. (a) March 7; (b) March 12; (c) March 18; (d) June 30; (e) July 2. The thin line in each wind rose indicates vector-averaged wind orientation.

appreciable vertical mixing in the presence of these temperature profiles, and the shallow mixed layer was likely thinner in March than in June/July.

3.2. Observation of a wide impact area downwind of the freeway during pre-sunrise hours

As shown in Fig. 3, a wide impact area of elevated UFP concentrations, up to 2000 m downwind and 600 m upwind of the I-10 freeway, was observed during the pre-sunrise hours on the monitoring days in the two seasons. In this wide impact area, elevated UFP concentration extended beyond Donald Douglas Loop N located on the south side and 1200 m downwind of the freeway (Fig. 3). Here, 1200 m downwind, the average UFP concentrations during the winter sampling hours, typically 06:00–07:30, were as high as ~40 000 cm^{-3}. Only at a downwind distance of about 2600 m (Palms Blvd.), did the UFP concentration drop to ~15 000 cm^{-3}, comparable to the upwind background level.

In the winter season, the peak UFP concentration was approximately 95 000 cm^{-3} a few tens of meters downwind of the freeway. Upwind, the concentration dropped sharply to around 40 000 cm^{-3} 30 m upwind (Virginia Avenue) and returned to background levels of ~15 000 cm^{-3} at ~800 m on the upwind side, creating a moderate upwind gradient north of the I-10 freeway (Fig. 3). Interestingly, the upwind impact distance during the pre-sunrise hours, ~600 m, was far greater than that of ~15 m observed during the day by Hitchins et al. (2000) and also greater than that measured by Zhu et al. (2002b). This may be caused by the occasionally variable wind direction during the pre-sunrise hours for which the nominal upwind side of the I-10 freeway could temporarily become downwind. These occasional impacts on the nominal upwind side of the freeway appear to have had substantial influence on the averaged upwind UFP concentrations due to their otherwise low levels.

As seen in Fig. 3, the UFP concentration also decreased on the downwind side, but much more slowly than on the upwind side. At a downwind distance of about 600 m from the freeway, UFP concentrations during winter were about twice those on the upwind side (50 000 cm^{-3} vs. 22 000 cm^{-3}). Even 950 m downwind, at the intersection of Ocean Park Blvd., the UFP concentration remained as high as 45 000 cm^{-3}, higher than at 30 m upwind. These pronounced differences in gradients of UFP concentrations resulted in strong contrasts between the upwind and downwind sides of the I-10 freeway during pre-sunrise hours (Fig. 3).

As shown in Fig. 4, NO and PB-PAH exhibited concentration gradients similar to UFP along the route during the pre-sunrise hours. Peak concentrations of NO and PB-PAH (on the downwind side) were about 165 ppb and 55 ng m^{-3}, respectively, in the winter season. Upwind, NO and PB-PAH concentrations dropped rapidly to 70 ppb and 30 ng m^{-3}, respectively, at a distance of about 150 m. In contrast, on the downwind side, NO and PB-PAH concentrations of 70 ppb and 30 ng m^{-3}, respectively, extended to a distance of about 1200 m from the freeway (NO and PB-PAH data were unavailable for summer measurement due to instrument problems during the pre-sunrise runs).

Fig. 5 shows normalized UFP concentrations on the two sides of I-10 freeway during the pre-sunrise hours in the winter and summer seasons. UFP concentrations were normalized for each complete run traveled on our route, and then averaged together for all the runs for each season. While there was little or no traffic on our route during the pre-sunrise hours, vehicle counts on the same route during the day were much higher and emissions from these vehicles significantly and frequently affected measurements by the mobile platform. Moreover, the pre-sunrise route was only driven once in the morning after sunrise and once in the afternoon, in contrast to multiple times in the pre-sunrise period. For both of these reasons, comparison between pre-sunrise and morning/afternoon measurements on the pre-sunrise route are not meaningful. Instead, we show normalized data from Zhu et al. (2002b), which were not affected by local traffic, to compare with our pre-sunrise measurements.

As Fig. 5 illustrates, pre-sunrise UFP concentration gradients in the present study exhibited very different behavior than the typical narrow daytime UFP gradients measured by Zhu et al. (2002a,b). In our pre-sunrise measurements, UFP concentrations remained elevated above the background level up to ~600 m upwind of the freeway versus only ~17 m upwind for the Zhu et al. (2002b) daytime measurements. On the downwind side in the Zhu et al. (2002b) measurements, UFP concentrations dropped to about 25% of the peak concentration 300 m downwind of the freeway during the day, but in the present study, in strong contrast, the UFP concentrations remained about 40% of the peak as much as 1200 m downwind of the freeway, and was above background levels out to ~2000 m during the pre-sunrise hours.

To quantify these differences in UFP concentrations an equation of the form $C = a + e^{-bx}$ was used to fit our observed relative UFP concentrations downwind of the I-10 freeway during pre-sunrise hours, as well as the daytime data reported by Zhu et al. (2002b). As seen in Fig. 6, the decay constant is a factor of five higher for the

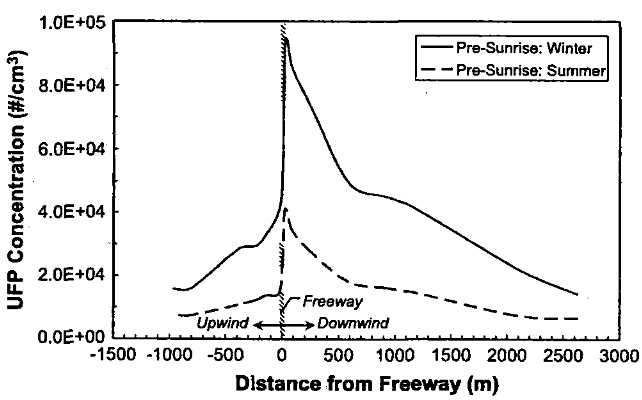

Fig. 3. Ultrafine particle concentrations and gradients along the pre-sunrise route. Positive distances are downwind and negative distances upwind from the I-10 freeway. Data were acquired continuously, up to the edges of the freeway.

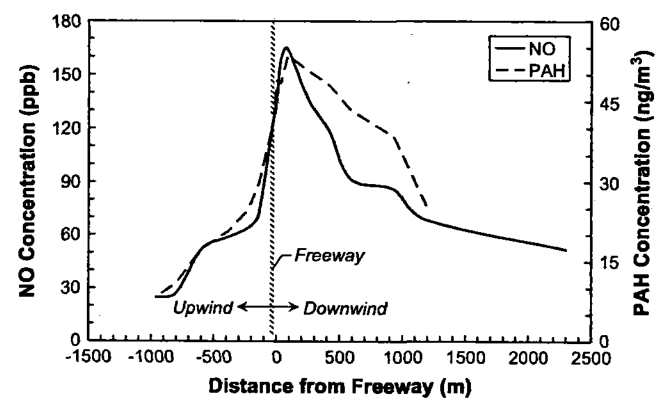

Fig. 4. Average NO and PB-PAH concentrations and gradients, along the pre-sunrise route in the winter season. Positive distances are downwind and negative distances upwind from the I-10 freeway.

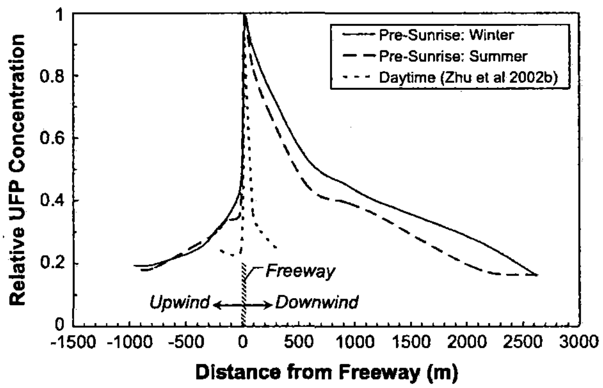

Fig. 5. Relative averaged UFP concentrations and gradients along the pre-sunrise route by season and compared with Zhu et al. (2002b). Positive distances are downwind and negative upwind from the I-10 freeway. Data were acquired continuously for pre-sunrise measurements, up to the edges of the freeway.

daytime vs. the pre-sunrise period, with values of b of 0.0098 and 0.0018, respectively.

Pre-sunrise relative UFP concentrations exhibited similar trends in both winter and summer (Fig. 5). Although UFP concentrations in the summer were about 40% those in the winter (due to lower traffic flows on the I-10 freeway, as discussed below), the similar trends in relative UFP concentration imply similar UFP propagation during the pre-sunrise hours in the two seasons although meteorological conditions were somewhat different.

3.3. *Correlation of pollutant concentrations with traffic counts on I-10 freeway*

PeMS data showed a similar diurnal traffic pattern on the I-10 freeway on different weekdays during the pre-sunrise hours in both winter and summer (Fig. 7b). Traffic counts on the freeway exhibited an approximately linear increase with the time. However, during 04:00–05:30 (when summer measurements were conducted) traffic counts were lower in summer than in winter. We attribute part of the lower traffic counts in summer to most schools being closed and vacation season in summer, as well as the dramatic increase in gasoline prices between March and July 2008, resulting in a significant overall reduction in vehicle miles traveled. Also, sunrise was about one hour and fifteen minutes earlier in

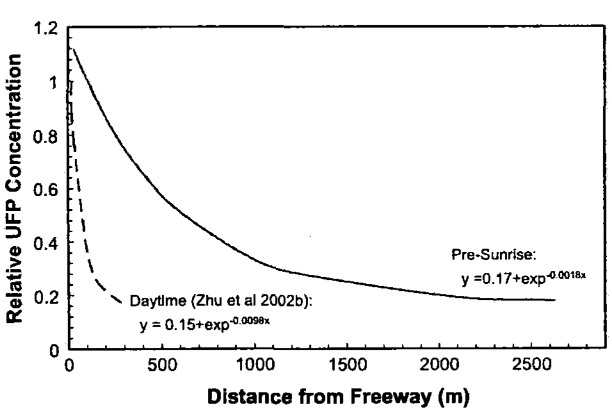

Fig. 6. Exponential fits to the downwind relative UFP concentrations with distance from the I-10 freeway during pre-sunrise hours, compared with fit to daytime data downwind of the I-405 freeway by Zhu et al. (2002b). Data were acquired continuously for pre-sunrise measurements, up to the edges of the freeway.

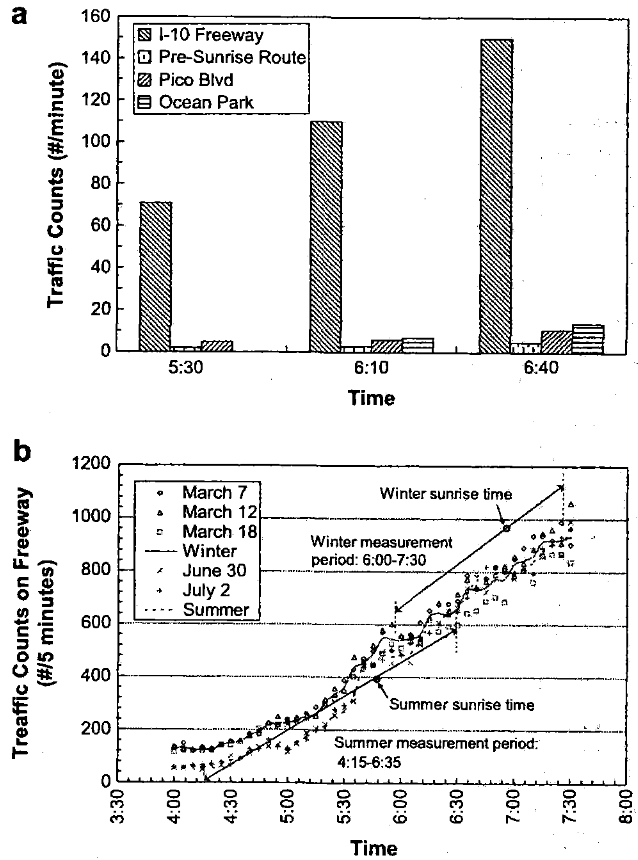

Fig. 7. (a) Comparison of traffic volumes on the I-10 freeway, pre-sunrise route, Pico Blvd., and Ocean Park Blvd. during pre-sunrise hours on a typical weekday; (b) Traffic counts on the I-10 freeway during pre-sunrise measurements; solid line represents averaged count of the three days in the winter season, and dashed line for two days in the summer season. Sunrise times shown here were averaged for each season.

summer (~05:45) than in winter (~07:00), which required an earlier measurement period in summer (~04:15–06:30) compared to winter (~06:00–07:30), and corresponds to much lower overall traffic counts during the pre-sunrise measurement periods in summer.

During the measurement period in winter, traffic counts on the freeway increased from ~530 to ~900 vehicles per 5 min, while in summer counts increased from ~60 to ~620 vehicles per 5 min. Assuming a linear increase of traffic counts with time, the average traffic counts during the pre-sunrise measurements periods, winter versus summer, were ~715 vs. 340 vehicles per 5 min, resulting a ratio of ~2.1. This ratio of seasonal traffic counts compares well with the ratio of the UFP concentrations measured in the winter vs. summer of ~2.2–3.0, depending on distance from the freeway (Fig. 3). It should be noted that the sunrise times during the winter (March) measurements, because they occurred just after the switch to Pacific daylight time (PDT), were close to the latest annual (local) sunrise times, and thus may represent roughly the upper limit for the freeway impact throughout the year.

We attribute the relatively high pollutant concentrations we observed downwind of the I-10 freeway during pre-sunrise hours to emissions of vehicles traveling on the I-10 freeway, combined with strong inhibition of vertical mixing due to stable or inverted temperature profiles near the surface. Fig. 8 shows the UFP and NO concentrations measured at Ocean Park Blvd., ~950 m downwind, vs. the traffic counts on the freeway during the pre-sunrise hours on

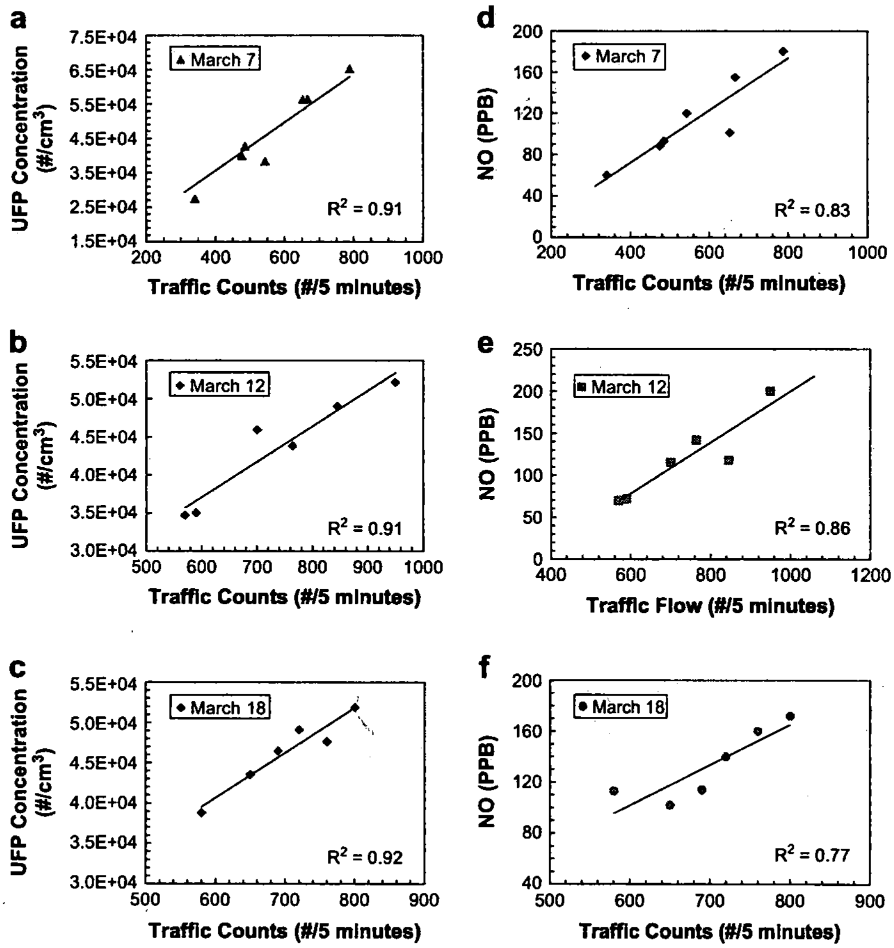

Fig. 8. Linear regressions between UFP and NO concentrations at Ocean Park Blvd. (950 m downwind of I-10 freeway), and traffic counts on the freeway during the pre-sunrise hours in the winter season.

three mornings of the pre-sunrise runs in the winter season. Both the freeway traffic counts (Fig. 7b) and pollutant concentrations increased rapidly during the pre-sunrise hours, and exhibited a strong correlation with each other. For UFP, the values of squared Pearson correlation coefficients (r^2) were above 0.90 and for NO, above 0.77 (nitric oxide data were unavailable for summer measurements due to instrument problems during the pre-sunrise runs). Strong correlations at other distances from the freeway were also found between UFP concentrations and traffic counts on the freeway. For example, the correlation coefficients, r^2 for UFP measured at Pearl St. for three winter sampling days, were above 0.85.

Based on our videotape observations and the traffic counts we conducted on surface streets, as well as the strong correlations presented in Fig. 8, we believe the measured concentrations of air pollutants during the pre-sunrise hours were predominantly determined by the traffic counts on the I-10 freeway, and that the impact of local surface street traffic was minor. Traffic volumes on the pre-sunrise route itself were only about 2% of those on the I-10 freeway at corresponding times. Traffic volumes on the three major surface streets crossing the pre-sunrise route, Ocean Park Blvd., Pico Blvd., (downwind of the freeway), and Olympic Blvd (upwind of the freeway) were also low, only about 8%, 6%, and 6%, respectively, of those on the freeway. Most of this early-morning cross traffic for our measurement route encountered green lights. If the emissions of the occasional vehicles on these surface streets were significant, the pollutant concentrations measured downwind of the streets should have been higher than upwind, but this was not the case; no significant gradients in concentration were observed between the two sides of these streets. Hence, the contribution of emissions from vehicles on the surface streets to our pre-sunrise measurements ranged from minor to insignificant compared to emissions from freeway traffic.

One case in which we find evidence of a minor contribution from non-freeway emissions involves the shallow shoulder in UFP concentrations on Ocean Park Blvd. (~950 m downwind) and shown in Fig. 3. Traffic counts on this major surface street were ~8% of the freeway counts (Fig. 7a), which may have resulted in a small local UFP, NO, and PB-PAH contribution to the measured concentration. A local contribution of ~6% traffic count on Pico Blvd. is not apparent in the measured UFP concentration in Fig. 3, probably due to the closer proximity of Pico Blvd. to the I-10 freeway (~250 m downwind).

Although the mobile platform measurements could be affected by emissions from vehicles occasionally encountered on the pre-sunrise route or cross-surface streets, these encounters typically exhibited only a short, transient spike of elevated concentrations. Furthermore, the overall pre-sunrise concentrations and gradients presented were averaged from 18 to 24 runs in winter and 12–16 runs in summer and for all these reasons were generally not significantly affected by emissions from occasionally encountered nearby vehicles. The Santa Monica Airport (SMA), a small local airport, located south of the pre-sunrise route, had no impact on any of our pre-sunrise measurements since it has severely restricted hours to minimize noise pollution, and was closed during all of our pre-sunrise experiments.

3.4. Size distribution of UFP along pre-sunrise route

The use of a fast mobility particle sizer (FMPS), with its 10 s scans, allowed accurate monitoring of the changing particle size distribution as a function of distance away from the freeway. Fig. 9 shows average UFP size distributions for five downwind and two upwind intersections during the pre-sunrise hours in the winter season, with decreasing particle numbers and increasing sizes as distance downwind increases, until the upwind size distribution was roughly matched at 2600 m. At the downwind intersections up to 1200 m from the freeway, two to four times higher concentrations of ultrafine particles less than 40 nm were observed compared with upwind locations (Fig. 9).

For the intersections nearest the freeway (e.g. Kansas, 100 m downwind, and Pico, 250 m downwind), bi-modal peaks in the size ranges of ~9–12 nm and 16–20 nm were observed. For downwind intersections farther away and for the upwind intersections, UFP peaks observed were typically ~9–12 nm and ~16–20 nm, and 28–35 nm, corresponding to freshly generated UFP and aged particles, respectively. UFP size distributions at a distance of 2600 m downwind (Palms Blvd.) and 1000 m upwind (Harvard St), considered "background" locations, were similar with a dominant mode at 30–60 nm.

In summer, downwind UFP size distributions also had a small mode of 9–12 nm. The persistence of the 9–12 nm peak in UFP concentrations during pre-sunrise hours over a wide area can be attributed to increased condensation of organic vapors and slower rates of conversion to larger particles for the cooler, stable air conditions prior to sunrise during our winter and summer campaigns. These conditions would also promote the more elevated UFP concentrations observed in our pre-sunrise runs compared with daytime runs.

3.5. Pre-sunrise vs. daytime concentrations in present study: exposure implications

Although traffic volumes on the freeway during the pre-sunrise hours were markedly lower than during the daytime (~30–80% of peak congestion traffic volumes), air pollutant concentrations measured prior to sunrise were significantly higher than in the

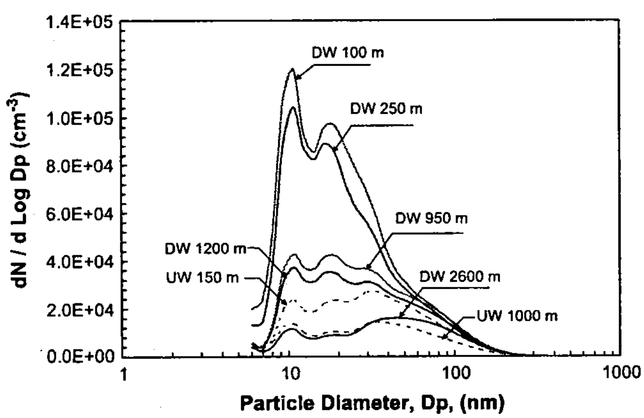

Fig. 9. Size distributions of ultrafine particles measured by a TSI Model 3091 FMPS at upwind (UW) and downwind (DW) intersections during the pre-sunrise hours in the winter season.

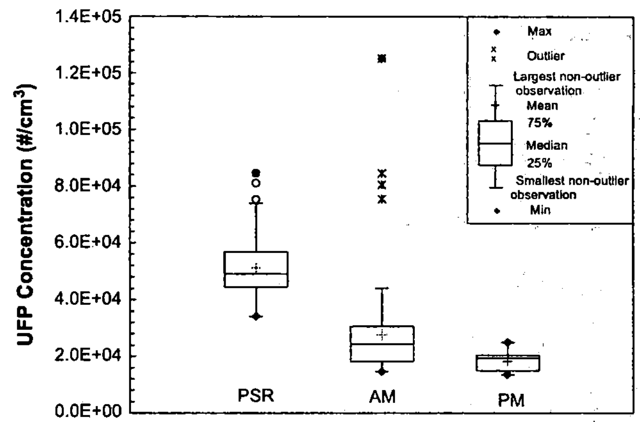

Fig. 10. Comparison of UFP concentrations on Pearl St. (600 m south of I-10 freeway) at different times in winter: pre-sunrise (PSR), morning (AM), and afternoon (PM).

morning or afternoon runs. Fig. 10 shows the UFP concentrations measured at Pearl St., ~600 m south of the freeway, during the pre-sunrise and daytime hours in winter. The median UFP concentrations were 49 000 cm^{-3}, 24 000 cm^{-3}, and 19 000 cm^{-3} for the pre-sunrise, morning, and afternoon, respectively. Clearly, there was sufficient traffic flow on the I-10 freeway combined with the meteorological conditions during pre-sunrise hours to result in elevated concentrations of UFP, NO, and PB-PAH over a wide area of the downwind (up to ~2000 m) and upwind (up to ~600 m) residential neighborhoods. Since the pre-sunrise hours are at a time when most people are in their homes, our observations imply the potential for elevated exposures for many more residents in these neighborhoods, adjacent to freeways; far above the numbers of people that live within the ~300–500 m range reported in earlier daytime and evening studies. Additional measurements in the pre-sunrise period downwind of other major roadways should be conducted to confirm our novel findings.

4. Conclusions

A wide impact area of elevated pollutant concentrations on the downwind (up to ~2000 m) and upwind (up to ~600 m) sides of a freeway was measured during the pre-sunrise hours under typical meteorological conditions characterized by weak winds and a strong radiation inversion. To make these measurements, a mobile platform, equipped with fast-response monitoring instruments, drove along a transect crossing under the I-10 freeway and passing through a large residential neighborhood. On the upwind side of the freeway, air pollutant concentrations dropped quickly, but remained elevated up to ~600 m. On the downwind side, air pollutant concentrations (UFP, PAH, NO) dropped much more slowly and extended far beyond the typical ~300 m distance associated with the return to background pollutant levels observed in previous studies conducted during daytime. For example, elevated ultrafine particle concentration of about 40 000 cm^{-3} extended to ~1200 m downwind of the freeway in the winter season, which was about 40% of the peak UFP concentration adjacent to the freeway.

Although traffic volumes during the pre-sunrise hours were lower than during the day, the UFP concentrations were significantly higher in the pre-sunrise period. We attribute this pre-sunrise phenomenon to strong atmospheric stability, low wind speeds (~0–1 m s^{-1}), low temperatures (-9–13 °C), and high humidities (~61–79%), facilitating longer lifetimes and slower transport of UFP before dilution and dispersion to background levels. Nocturnal inversions are a widespread phenomenon particularly on clear nights, and our results suggest broad areas of elevated pollutants around major roadways are expected to be common in the early-morning hours. The implications of these observations for exposures to vehicle-related pollutants should be further explored.

Acknowledgements

The authors acknowledge support for this study by the California Air Resources Board, Contract No. 04-348. The authors wish to express their appreciation to Drs. Jorn Herner, Ying-Kuang Hsu, and Dane Westerdahl of ARB for their assistance, and Joe Cassmassi and Kelvin Durkee of the SCAQMD for their technical support. We also wish to thank Dr. Richard Turco at UCLA and Dr. Jun Wu at UC, Irvine, as well as Douglas Houston, Albert Chung, Hwajin Kim, Daniel Curtis and Shahir Masri at UCLA, for their contributions to the study. Helpful discussions with James Murakami at UCLA regarding the sources of meteorological data and their interpretation are greatly appreciated.

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Ambient Particulate Pollutants in the Ultrafine Range Promote Early Atherosclerosis and Systemic Oxidative Stress

Jesus A. Araujo, Berenice Barajas, Michael Kleinman, Xuping Wang, Brian J. Bennett, Ke Wei Gong, Mohamad Navab, Jack Harkema, Constantinos Sioutas, Aldons J. Lusis and Andre E. Nel

Circ. Res. 2008;102;589-596; originally published online Jan 17, 2008;
DOI: 10.1161/CIRCRESAHA.107.164970
Circulation Research is published by the American Heart Association. 7272 Greenville Avenue, Dallas, TX 72514
 Print ISSN: 0009-7330. Online ISSN: 1524-4571

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Jesus A. Araujo, Berenice Barajas, Michael Kleinman, Xuping Wang, Brian J. Bennett, Ke Wei Gong, Mohamad Navab, Jack Harkema, Constantinos Sioutas, Aldons J. Lusis, Andre E. Nel

Abstract—Air pollution is associated with significant adverse health effects, including increased cardiovascular morbidity and mortality. Exposure to particulate matter with an aerodynamic diameter of <2.5 μm ($PM_{2.5}$) increases ischemic cardiovascular events and promotes atherosclerosis. Moreover, there is increasing evidence that the smallest pollutant particles pose the greatest danger because of their high content of organic chemicals and prooxidative potential. To test this hypothesis, we compared the proatherogenic effects of ambient particles of <0.18 μm (ultrafine particles) with particles of <2.5 μm in genetically susceptible (apolipoprotein E–deficient) mice. These animals were exposed to concentrated ultrafine particles, concentrated particles of <2.5 μm, or filtered air in a mobile animal facility close to a Los Angeles freeway. Ultrafine particle–exposed mice exhibited significantly larger early atherosclerotic lesions than mice exposed to $PM_{2.5}$ or filtered air. Exposure to ultrafine particles also resulted in an inhibition of the antiinflammatory capacity of plasma high-density lipoprotein and greater systemic oxidative stress as evidenced by a significant increase in hepatic malondialdehyde levels and upregulation of Nrf2-regulated antioxidant genes. We conclude that ultrafine particles concentrate the proatherogenic effects of ambient PM and may constitute a significant cardiovascular risk factor. (***Circ Res*. 2008;102:589-596.**)

Key Words: air pollution ■ ultrafine particles ■ atherosclerosis ■ oxidative stress ■ HDL

It is increasingly being recognized that exposure to ambient particulate matter (PM) contributes to significant adverse health effects and is a risk factor for the development of ischemic cardiovascular events via exacerbation of atherosclerosis, coronary artery disease, and the triggering of myocardial infarctions.[1] Although this association has been documented for PM with a mean aerodynamic diameter of <10 μm (PM_{10}), there is increasing evidence that smaller particles may pose an even greater health risk. A growing literature indicates that fine particles (FPs) with an average aerodynamic diameter of <2.5 μm ($PM_{2.5}$) exert adverse health effects of greater magnitude. For example, the "Women's Health Initiative study demonstrated a 24% increase in the incidence of cardiovascular events and a 76% increase in cardiovascular mortality for every 10 $\mu g/m^3$ increase in the annual average $PM_{2.5}$ level.[2] It appears that the smallest particles that exist in the urban environment are the most dangerous.[3] Ambient ultrafine particles (UFPs) that have an aerodynamic diameter of <0.18 μm are by far the most abundant particles by number in urban environments such as Los Angeles. Because these particles are emitted mainly by vehicular emissions and other combustion sources, they contain a high content of redox-cycling organic chemicals that could be released deep into the lungs or could even spill over into the systemic circulation. Thus, UFPs may be particularly relevant from the perspective of cardiovascular injury.[3]

In spite of the epidemiological evidence indicating that ambient PM can promote cardiovascular injury and atherosclerosis, the mechanisms of the cardiovascular injury and proatherogenic effects are not clear. However, experimental studies in susceptible animal models have shed some light on disease pathogenesis. For instance, intratracheal administration of ambient PM_{10} in Watanabe rabbits[4] or long-term exposure of apolipoprotein (apo)E-null mice to $PM_{2.5}$[5,6] enhanced atherosclerotic plaque growth. Moreover, a cross-sectional exposure study in humans showed a 5.9% increase in carotid intima–medial thickness for every 10 $\mu g/m^3$ rise in $PM_{2.5}$ levels,[7] and a prospective cohort study supported an association between long-term residential exposure to high-traffic levels of $PM_{2.5}$ and coronary atherosclerosis, as assessed by coronary artery calcification scores,[8] demonstrating

Original received September 27, 2007; revision received December 20, 2007; accepted January 3, 2008.

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This manuscript was sent to Joseph Loscalzo, Consulting Editor, for review by expert referees, editorial decision, and final disposition.

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Circulation Research is available at http://circres.ahajournals.org DOI: 10.1161/CIRCRESAHA.107.164970

that the proatherogenic effects of PM are clinically relevant.[7,8] Air pollution has also been linked to the triggering of acute coronary ischemic events in humans, including myocardial infarction.[9]

We have demonstrated that ambient PM exerts proinflammatory effects in target cells such as endothelial cells,[10] macrophages,[11] and epithelial cells[12] through the generation of reactive oxygen species (ROS) and oxidative stress.[11,12] These prooxidative effects are mediated, in part, by redox-cycling organic chemicals and transition metals that are present on the particle surface.[11] Ambient PM can synergize with oxidized phospholipids in the induction of a wide array of genes involved in vascular inflammatory processes such as atherosclerosis.[10] Moreover, when comparing concentrated ambient particles (CAPs) of various sizes in the Los Angeles basin, UFPs were shown to have the highest content of redox cycling chemicals and therefore displayed the largest prooxidant potential, both abiotically and biotically.[13] We hypothesized, therefore, that UFPs may concentrate some of the PM proatherogenic effects by promoting prooxidant and proinflammatory effects. We used the particle concentrator technology available in the Southern California Particle Center to evaluate the atherogenic potential of concentrated UFPs versus concentrated $PM_{2.5}$ in apoE-null mice. In addition, we evaluated the effects of particle exposures on the plasma high-density lipoprotein (HDL) antiinflammatory activity as well as markers of systemic oxidative stress. Our data show that UFPs are more proatherogenic, exert the strongest prooxidative effects, and are associated with the largest decrease in HDL protective activity. These data are of considerable significance from a regulatory perspective.

Materials and Methods

Detailed methods about histology, immunohistochemistry, blood chemistry, monocyte chemotactic assays, lipid peroxidation assay, RNA extraction, and real-time RT-PCR can be found in the online data supplement at http://circres.ahajournals.org.

Animals and Diet

The Animal Research Committee at The University of California at Los Angeles (UCLA) approved all animal protocols. $ApoE^{-/-}$ (C57BL/6J background) male mice were obtained from The Jackson Laboratory (Bar Harbor, Me). Animals were brought to the UCLA animal facility at 4 weeks of age. Mice were fed a regular chow diet (NIH-31 modified 6% diet; Harlan Teklad, Madison, Wis). Both water and food were administered ad libitum. Animals were randomly assigned to 3 groups (n=17/group) that were sent to a mobile inhalation toxicology laboratory located 300 meters from the 110 Freeway. This freeway carries a high volume of gasoline and diesel motor vehicle transit, resulting in high levels of $PM_{2.5}$ mass and UFP counts at the exposure site (Table). The mobile research laboratory (AirCARE 1) is owned by Michigan State University.[14] Mice were subjected to CAP exposures starting at 6 weeks of age over a 40-day period. One mouse in the FP group and 2 in the UFP group died during the course of the study. Animals were euthanized 24 to 48 hours after completion of the last CAP exposure, and aortas and various organs were harvested. Between exposures, mice were housed in a Hazelton chamber[15] that was ventilated with air from which 99.9% of the incident particles were removed by a HEPA filter.

CAP Exposures and Chemical Characterization

Whole-body exposures were performed simultaneously in sessions of 5 hours per day, 3 days per week, for a combined total of 75 hours.

Table. Characteristics of Experimental Exposure Protocol of ApoE-Null Mice Fed a Normal Chow Diet

Experimental Parameter	
Groups	FA, FP, UFP
Exposure time (dates)	11/03/2005 to 12/12/2005
Exposure time (hours)	75
Total ambient particle no. (particles/cm³)	3.42 (±0.96)×10⁴
No. concentration in FA chamber (particles/cm³)	<5000
No. concentration in FP chamber (particles/cm³)	4.56 (±1.06)×10⁵
Calculated UFP no. concentration in the FP chamber (particles/cm³)	3.88 (±1.06)×10⁵
No. concentration in UFP chamber (particles/cm³)	5.59 (±1.23)×10⁵
Ratio of UFP in the FP vs the UFP chamber*	1:1.44
FP chamber particle enrichment factor	13.35 (±1.6)
UFP chamber particle enrichment factor	16.4 (±1.8)
Mass in FP exposure chamber (μg/m³)	438.29
Mass in UFP exposure chamber (μg/m³)	112.61
$PM_{2.5}$ mass in ambient air (μg/m³)	26.78
UFP mass in ambient air (μg/m³)	8.43

FA, FP, and UFP groups were exposed in a mobile laboratory located in downtown Los Angeles. Values shown are means(±SD). *This ratio was obtained by reducing the particle no. in the FP chamber by 15%, which represents the contribution of particles in the 0.18–2.5 μm range. This also translates into an ≈2-fold increase in surface area if a spherical particle shape is assumed.

Particle concentrator technology was used to deliver the CAP exposures. Three animal groups were simultaneously exposed to atmospheres containing concentrated particles of <2.5 μm (FPs), particles of <0.18 μm (UFPs), and filtered air (FA). Briefly, ambient air was drawn through an aluminum duct into the VACES (Versatile Aerosol Concentration Enrichment System)[16,17] and delivered to whole-body exposure chambers.[18,19] The FP and UFP aerosol concentrators delivered 0.01- to 2.5-μm and 0.01- to 0.18-μm aerosols, respectively (Table). The FP atmosphere included sub-18 μm particles that were ≈40% fewer particles than in the UFP chamber. Temperature and airflow were controlled to ensure adequate ventilation and minimize buildup of animal-generated dander, ammonia, CO_2, and thermal stress. Mobilization of mice between the Hazelton chamber and the exposures chambers was performed over the shortest time period possible to limit the exposure to ambient air PM in the trailer. CAP number concentrations were measured with a TSI 3022 Condensation Particle Counter, and particle mass concentration was assessed with a DataRAM Model DK-2000.

Particle mass concentration and elemental CAP composition were measured by particle collection on 37-mm Teflon filters (PTFE 2-μm pore, Gelman Science, Ann Arbor, Mich). Concentrations of inorganic ions (sulfate and nitrate), elemental carbon, organic carbon (OC), polycyclic aromatic hydrocarbon (PAH) content, and particle-bound trace elements and metals was performed as previously described.[16–18]

Statistical Analysis

All data were expressed as means±SEM unless indicated otherwise. Differences between experimental groups were analyzed by 1-way ANOVA with a 1-tailed Fisher protected least-significance difference (PLSD) post hoc analysis test. Differences were considered statistically significant at $P<0.05$.

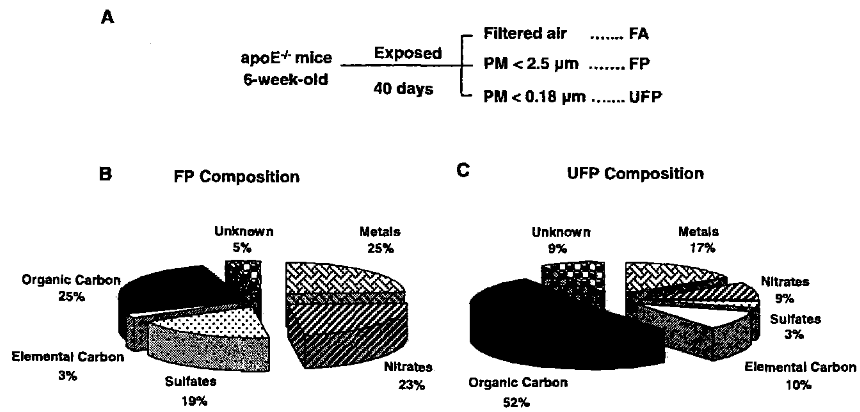


Figure 1. CAP exposures. A, Experimental protocol. Three groups (n=17) of 6-week-old male apoE-null mice were exposed to FA, $PM_{2.5}$, and PM of <0.18 μm (UFPs) for 40 days. B and C, Chemical composition of CAPs. UFP air had a greater content of organic and elemental carbon than FP air. Particle chemical composition of the FP (B) and UFP (C) chambers was performed as described in Materials and Methods.

Results

UFP Exposures Are Enriched in OC Substances Such As PAHs

Six-week-old male apoE-null mice were exposed in a mobile inhalation toxicology laboratory in downtown Los Angeles to CAPs in the size range of <2.5 μm (FP exposures) or <0.18 μm (UFP exposures). Controls consisted of mice exposed to FA (Figure 1A). Animals were simultaneously exposed to UFPs, FPs, and FA for a total of 75 hours over a 40-day time period while being kept on a chow diet. The atmospheric conditions and particle characteristics in the FP and UFP chambers are summarized in the Table. Because the FP atmosphere included particles of <0.18 μm (UFPs) that accounted for up to 85% of the total particle number, the actual number of these sub-0.18 μm particles was ≈44% greater in the UFP chamber (Table), despite a total UFP mass that was approximately one-quarter of the FP mass. Assuming a roughly spherical shape for the particles, this 44% increase in sub-0.18 μm particle numbers in the UFP chamber translates into an ≈2-fold increase in the particle surface area. This was also accompanied by an ≈2-fold increase in fractional OC content (Figure 1B and 1C), which is theoretically more bioavailable than the smaller organic fraction on FPs (Figure 1B). Thus, the increased particle number, greater surface area, and higher fractional carbon composition could combine to deliver a much higher biological effective dose of the injurious components in the UFP compared with the FP chamber. In fact, measurement of a set of signature PAHs in filter samples that were collected concurrently with the CAP exposures, demonstrated that the PAH content of the UFPs was roughly twice as high as the FP content when corrected for a per mass basis (Figure 2). Although there is no definitive evidence that PAHs are those responsible for adverse cardiovascular effects, we have previously demonstrated that their abundance is a good proxy for the prooxidant potential of PM.[13]

UFP Exposure Promotes Atherosclerosis

Exposure to the UFP atmosphere for 75 hours over a 40-day interval resulted in 55% greater aortic atherosclerotic lesion development (33 011±3741, n=15) as compared with FA controls (21 362±2864, n=14; P=0.002) (Figure 3). Exposure to the FP atmosphere resulted in a similar trend but of lesser magnitude (P=0.1). Interestingly, UFP mice exhibited a 25% increase in atherosclerotic lesions in comparison with FP mice (26 361±2275, n=16, P=0.04), which suggests that the smallest particles are indeed more proatherogenic.

Histological analysis revealed that lesions were predominantly comprised of macrophage infiltration with intracellular lipid accumulation (foam cells) (Figure 4). These cells contributed, on average, >85% of the total lesional area in all the groups (supplemental Table I). UFP-exposed animals developed more extensive as well as thicker atherosclerotic plaques that showed the same relative abundance of macrophages and smooth muscle cells, as determined by MOMA-2 and α-actin immunohistochemical staining (Figure 4 and supplemental Table I).

Exposure to Ambient CAPs Results in Loss of HDL Antiinflammatory Properties

FP but not UFP exposures resulted in a small but significant increase in plasma total cholesterol in comparison to other groups (supplemental Table II). Although all animals displayed similar levels of plasma HDL cholesterol (supplemental Table II), we did observe a change in HDL antiinflammatory properties. This was demonstrated by comparing the antiinflammatory protective capacity of HDL against LDL-

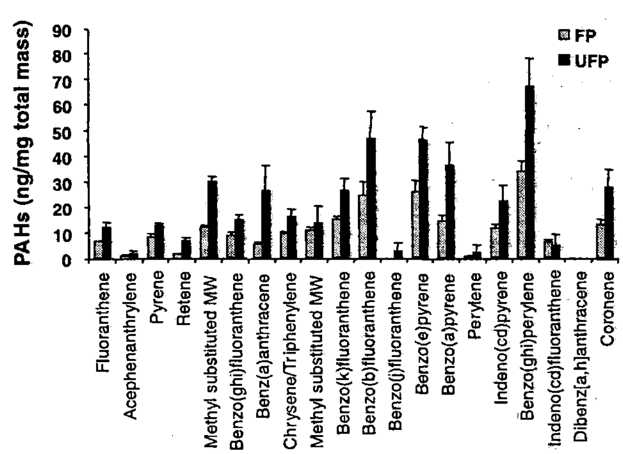
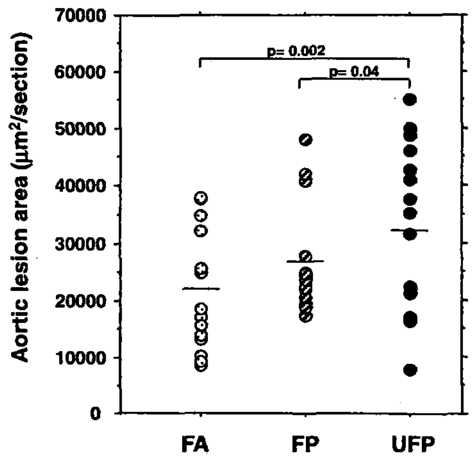


Figure 2. OC composition. Mass concentration fraction of PAHs in the FP (gray) and UFP (black) chambers. Data are shown as nanogram per milligram of PM mass and represent the average of composition analysis performed on filter samples collected for 2 experiments. PAH analysis was performed by means of gas chromatography–mass spectroscopy as described.[16–18]



# sub-0.18 µm (particles/cm³)	~ 5,000	$3.88x10^5$	$5.59x10^5$

Figure 3. UFP is the most proatherogenic PM fraction. Atherosclerotic lesions were quantitatively analyzed in serial aortic root sections and stained with oil red O. Lesional area was scored as square micrometer per section, averaged ≥25 sections per animal. Group averages are indicated by straight horizontal bars. One FA mouse was an obvious outlier in its group and removed from the atherosclerotic lesion analysis. However, its inclusion did not modify the overall significance. FA mice are represented by dotted circles (n=14), FPs by stripped circles (n=16), and UFPs by filled circles (n=15).

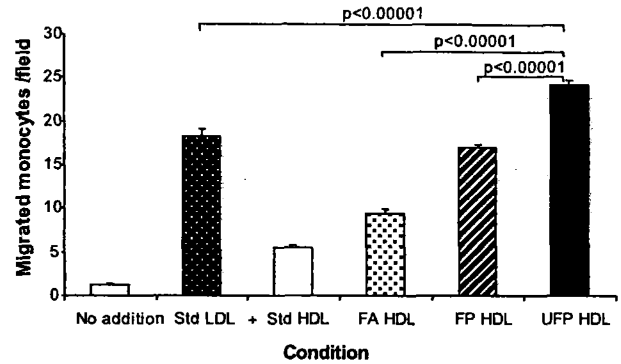


Figure 5. PM exposure leads to a loss of HDL antiinflammatory properties. Pooled plasma HDL from FA (n=16), FP (n=16) and UFP mice (n=15) was added to cocultures of human artery wall cells in the presence of standard (Std) human LDL, as described in Materials and Methods. Values are expressed as means± SEM of the number of migrated monocytes in 9 fields. Statistical analysis was performed by 1-way ANOVA (Fisher PLSD).

induced chemotaxis (Figure 5). Plasma HDL from both FP and UFP animals exhibited significantly less protective effect than HDL from the FA group (Figure 5). Moreover, the antiinflammatory effect of HDL from the UFP group was significantly decreased compared with the FP group. These results are in good agreement with the extent of vascular lesions in the different animal groups, suggesting that a PM-induced decrease in the HDL antiinflammatory protective capacity could contribute to atherogenesis.

UFP Exposure Leads to the Expression of Systemic Biomarkers of Oxidative Stress and Activation of the Unfolded Protein Response

One of the major mechanistic hypotheses regarding PM injury is the ability of the particles to induce ROS production and oxidative stress. To probe for the presence of oxidative stress, we explored whether CAP exposure could result in lipid peroxidation in the liver. We observed statistically significant increases in the hepatic malondialdehyde (MDA) levels in the UFP compared with the FA group (P=0.02) (Figure 6). FP mice also demonstrated increases in lipid peroxidation compared with the FA group (P=0.03). These data suggest that CAP exposure leads to systemic oxidative stress.

We also explored whether differences in lipid peroxidation were accompanied by phase II antioxidant responses that are mediated via the p45-NFE2–related transcription factor 2, Nrf2.[11] This constitutes one of the most sensitive oxidative stress effects that can be traced to prooxidative PM in vitro and in vivo.[11,20] UFP mice exhibited a significant increase in the expression of Nrf2 as well as genes that are secondarily regulated by this transcription factor (Figure 7). Indeed, UFP mice displayed Nrf2 mRNA levels that were 68% greater than FA and FP mice (P=0.01). Likewise, as compared with the FA group, UFP mice displayed significantly greater levels of catalase (3.7-fold), glutathione *S*-transferase Ya (5.3-fold), NAD(P)H-quinone oxidoreductase 1 (1.8-fold), and superoxide dismutase 2 (1.4-fold) (Figure 7). Interestingly, increased tissue oxidative stress was also accompanied by the activation

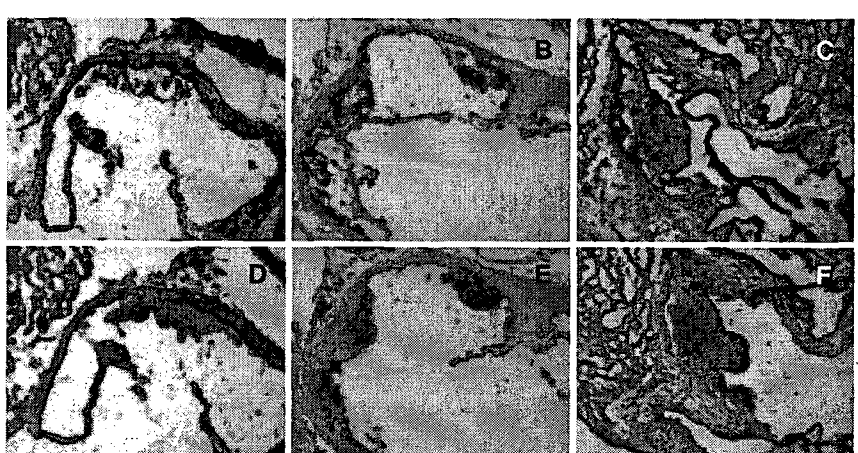


Figure 4. Representative histological photomicrographs. A through C, Oil red O staining for neutral lipids in representative aortic root sections of FA (A), FP (B), and UFP (C) mice. D through F, MOMA-2 immunohistochemical staining in adjacent aortic root sections to those shown in the top row, corresponding to the same FA (D), FP (E), and UFP (F) mice. Both oil red O and MOMA-2 staining yielded red-stained areas. UFP mice exhibited more extensive atherosclerotic plaques (C and F) than FP (B and E) or FA animals (A and D), all consisting primarily of foam cells and macrophages (fatty streaks). Original magnification, ×100.

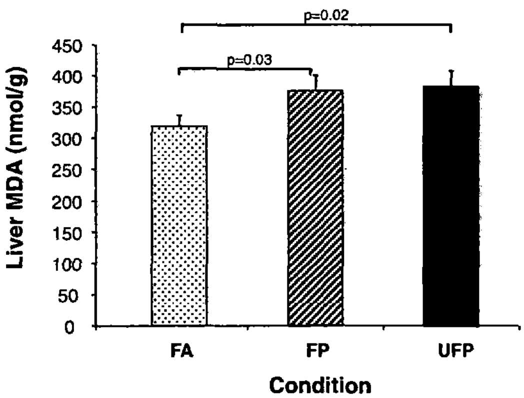


Figure 6. UFP exposure increases liver lipid peroxidation. MDA was assessed in liver homogenates as described in Materials and Methods. Values are expressed as the means±SEM of MDA (nmol/g) in animals from the FA (n=16), FP (n=15), and UFP (n=14) groups. Statistical analysis was performed by 1-way ANOVA (1-tailed Fisher PLSD).

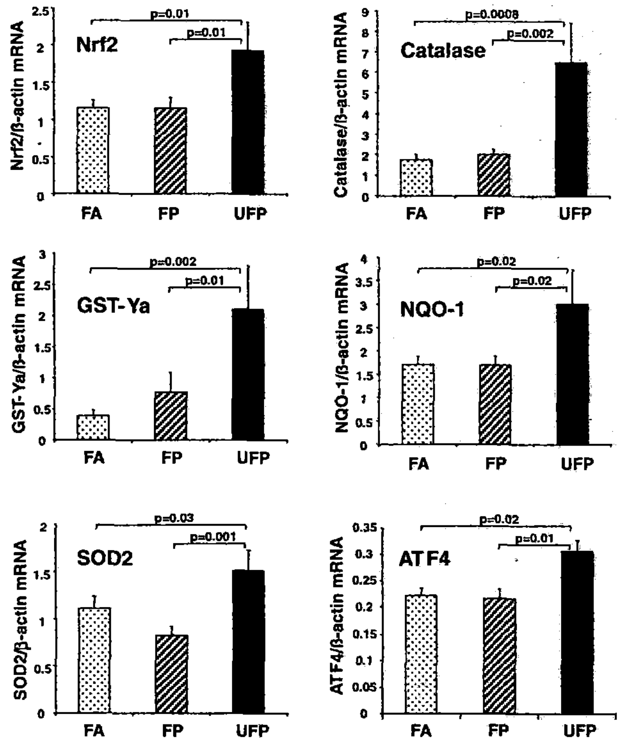


Figure 7. UFP exposure leads to upregulation of antioxidant genes in the liver. mRNA levels for antioxidant genes were determined by quantitative PCR in the livers of chow-fed mice exposed to CAPs for 40 days. Values are expressed as the means±SEM of mRNA levels normalized by β-actin mRNA. Ten samples per group were assayed in duplicate. Statistical analysis was performed by 1-way ANOVA (1-tailed Fisher PLSD; *$P<0.05$). ATF4 indicates activating transcription factor 4; GST-Ya, glutathione *S*-transferase Ya; NQO-1, NAD(P)H-quinone oxidoreductase 1; SOD2, superoxide dismutase 2.

of the unfolded protein response in the liver because the UFP-exposed mice displayed 41% and 37% greater expression of activating transcription factor 4 than FP mice ($P=0.01$) and FA controls ($P=0.02$) (Figure 7).

Discussion

We demonstrate that atherosclerotic plaque formation in apoE-null male mice is enhanced by exposure to sub-0.18 μm particles. Mice exposed to UFPs alone exhibited greater and more advanced lesions compared with FA- or FP-exposed animals. UFP mice also showed a comparatively greater decline in the antiinflammatory capacity of plasma HDL as well as increased phase II enzyme mRNA expression in the liver. These results support the hypothesis that exposure to UFPs may enhance atherosclerosis via the promotion of systemic prooxidant and proinflammatory effects.

Our study significantly extends previous data showing that PM potentiates atherosclerotic lesion development in animals.[4–6] The fact that FP mice displayed a nonstatistically significant trend to develop more atherosclerotic lesions than FA controls could be attributable to the relatively short duration of our exposure (40 days), which stands in contrast to the 5- to 6-month exposure period that was previously used to demonstrate a 45% to 58% increment in atherosclerotic lesion development during $PM_{2.5}$ exposure.[5,6] Of interest, our UFP animals exhibited a similar 55% increment over FA controls despite an exposure duration that was 4 to 5 times shorter, indicating the greater proatherogenic toxicity of sub-0.18 μm particles. This supports the notion that the adverse cardiovascular effects of PM are exaggerated by a small particle size.

A number of injury mechanisms have been proposed to explain the adverse health effects of PM, including its ability to stimulate oxidative stress and inflammation, alter blood clotting, stimulate autonomic nervous system activity, or act as a carrier for endotoxin.[1] A key injury mechanism appears to be the generation of inflammation as a direct consequence of the ability of ambient particles and their adsorbed chemicals to induce ROS and oxidative stress.[21] Oxidative stress initiates proinflammatory signaling cascades, including the Jun kinase and nuclear factor κB cascades[16,22,23] that are relevant to atherogenesis. According to the hierarchical oxidative stress hypothesis, the induction of Nrf2-induced phase II enzyme expression is an integral oxidative stress protective pathway that acts as a sensitive marker for oxidative stress.[24] Indeed, important cytoprotective, antiinflammatory and antioxidant phase II enzymes including catalase, superoxide dismutase 2, glutathione *S*-transferase Ya, and NAD(P)H-quinone oxidoreductase 1 were all significantly upregulated in the liver of UFP mice (Figure 7) and, together with Nrf2 upregulation, suggest the triggering of a Nrf2-driven antioxidant response.

Our results support the notion that the generation of systemic oxidative stress is responsible for the observed vascular effects. Possible explanations for these systemic effects are: First, inhaled particles may release organic chemicals and transition metals from the lung to the systemic circulation. Second, pulmonary inflammation could lead to the release of ROS, cytokines and chemokines to the systemic circulation. Although we did not observe any major increase in inflammatory cells during the performance of bronchoalveolar lavage in these mice, future studies will need to address whether any subtle proinflammatory effects in the lung could play a role. Third, UFPs could gain access to the systemic circulation by directly penetrating the alveolar/capillary barrier.[25] However, this possibility is still controversial. Although reports of the systemic translocation of ^{99m}Tc-labeled ultrafine carbon particles[25] or albumin nanocolloid particles of <80 nm[26] have appeared in the literature, skepticism has been expressed about the stability of the labeling procedures. Moreover, the same has not been demonstrated for ambient air "nanoparticles."

The particles or their chemicals may generate ROS systemically via a number of different pathways, including redox cycling of quinones, metabolism and functionalization of PAHs, activation of leukocyte NADPH oxidase and myeloperoxidase, or interference in 1-electron transfers in the mitochondrial inner membrane.[27] It is also possible that the particles themselves or their chemical components may synergize with oxidized LDL in promoting endothelial cell dysfunction. Indeed, we have shown that ambient PM can synergize with oxidized phospholipids in the induction of a large number of genes in a human microvascular endothelial cell line, many of which belong to antioxidant, proinflammatory, unfolded protein response, or proapoptotic pathways.[10] ROS generation and antioxidant responses constitute a dynamic equilibrium. The greater prooxidant stimulus delivered by the UFPs could be more prone to overwhelm the concomitant generation of a protective antioxidant response. On the other hand, it is interesting that no differences were noted between the FP and UFP exposures in the MDA assay. Although the methodology used is sensitive and specific for the determination of MDA,[28] there are several limitations in this assay in reflecting the degree of lipid peroxidation, as reviewed by Janero et al,[29], such as: (1) MDA yield as a result of lipid peroxidation varies with the nature of the polyunsaturated fatty acids peroxidized (especially its degree of unsaturation) and the peroxidation stimulus; (2) only certain lipid oxidation products decompose to yield MDA; (3) MDA is only one of several (aldehydic) end products of fatty peroxide formation and decomposition; (4) the peroxidation environment influences both the formation of lipid-derived MDA precursors and their decomposition to MDA; (5) MDA itself is a reactive substance that can be oxidatively and metabolically degraded; (6) oxidative injury to nonlipid biomolecules has the potential to generate MDA. Thus, if FP and UFP exposures impacted these factors in a different extent, it may explain a greater degree of lipid peroxidation not reflected by the MDA measurements.

PM-induced systemic inflammation and oxidative stress could also adversely affect lipoprotein function, including interfering in the beneficiary effects of HDL on reverse cholesterol transport[30] and the antiinflammatory[31] effects of this lipoprotein fraction. Indeed, both FP and UFP mice exhibited the development of dysfunctional HDL, which was more severe in the latter group in terms of its proinflammatory potential (Figure 5). Such proinflammatory effects were also supported by the greater expression of activating transcription factor 4 in liver, an unfolded protein response component that we have shown to exert proinflammatory effects in endothelial cells by inducing the expression of interleukin-6, interleukin-8, and monocyte chemotactic protein 1.[32] Likewise, we have also shown that prooxidative diesel exhaust particle chemicals induce an unfolded protein response in bronchial epithelial cells.[33] Changes in HDL function were observed in the absence of changes on HDL quantitative levels. On the other hand, FP exposures did result in greater total cholesterol levels in the FP versus FA mice, whereas UFP levels were unaffected. These higher cholesterol levels in the FP mice may have resulted in narrowing of the differences in atherosclerosis in between FP and UFP mice that otherwise could have been larger than the 23% observed difference. Consistent with our results, it has been reported that the HDL antiinflammatory profile can be hampered by environmental factors such as the exposure to prooxidative chemicals present in cigarette smoke.[34] For example, mice exposed to second-hand smoke develop dysfunctional HDL.[35] A possible mechanism could be interference with paraoxonase and lecithin cholesterol acyltransferase activities by redox-active chemical compounds. In particular, prooxidative PM chemicals may affect critical thiol groups that are responsible for the catalytic activity of paraoxonase, leading to increased susceptibility to atherosclerosis.[36]

The fact that the FP atmosphere contains both UFPs and particles of >0.18 μm makes interpretation of those data complex. However, we have shown that the 25% difference in atherosclerotic lesion scores could be explained by the 44% increase in UFP particle number (Table and Figure 3). Total particle mass was clearly not a determining factor because the FP atmosphere had ≈3.9-fold greater mass than the UFP aerosol. What is likely significant is that UFPs have an ≈2-fold increase in the OC and PAH content on a per mass basis (Figures 1 and 2). It is possible that these prooxidative components could be delivered from a surface area that is twice as big in particles associated with the UFP atmosphere. Although we cannot claim that the PAHs are actually responsible for the lesion development, these organic chemical compounds are a good proxy for the prooxidative potential of UFPs.[13]

How do our experimental atmospheres relate to real life exposures? The particle numbers in our study were 2- to 6-fold higher than the in-vehicle exposures that commuters may encounter while traveling on Los Angeles freeways.[37] It was not logistically feasible to perform detailed dose– and time–response studies; this type of data will be important to obtain in future studies. Although it would clearly be advantageous to know the minimum exposure that is required for proatherogenic effects, previous epidemiological studies have shown that cardiovascular morbidity and mortality increase linearly without a threshold effect.[38,39] Differences in the physiology of genetically susceptible animals and humans also have to be taken into consideration when extrapolating this work to cardiovascular disease in humans.

In conclusion, we demonstrate that UFP exposures have a higher proatherogenic potential than FP exposures. These effects could be linked to a greater propensity of UFPs to generate systemic oxidative stress and to interfere with the antiinflammatory capacity of plasma HDL. Our findings are important in explaining how ambient PM may contribute to daily total and cardiovascular mortality.[40] Although such an association has been established previously for PM_{10} and $PM_{2.5}$,[2,41,42] we demonstrate that UFP exposure could be of even greater relevance. Further epidemiological and experimental data collection are required to determine the critical physicochemical and toxicological properties of UFPs in humans.

Acknowledgments

We thank Larry Castellani for the plasma lipoprotein determinations.

Sources of Funding

This work was supported by National Institute of Environmental Health Sciences grant RO1 ES13432 (to A.N.); National Institute of Allergy and Infectious Diseases grant U19 AI070453 (to A.N.); a U.S. Environmental Protection Agency ENERGY STAR Award to the Southern California Particle Center; a Robert Wood Johnson Foundation Harold Amos Medical Faculty Development Program Award (to J.A.A.); and National Heart, Blood, and Lung Institute grant HL30568 (to A.J.L.).

Disclosures

None.

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ONLINE SUPPLEMENT

MATERIALS AND METHODS

Histology and immunohistochemistry

Atherosclerotic lesions in the aortic root were quantitatively analyzed as previously described [1]. Briefly, the upper portion of the heart and proximal aorta was excised and embedded in OCT compound (Tissue-Tek) and frozen [2]. Serial 10-μm-thick cryosections in the aortic root, beginning at the level of the appearance of the aortic valve, were collected for a distance of 500 μm. A total of 25 sections, selected as every other section collected over the entire region, were stained with Oil Red O and counterstained with hematoxylin. The lipid-containing area on each section was determined by using a microscope eyepiece grid and expressed in μm^2 lesional area/section. The mean value of lesional areas among the 500 μm-spanning sections was referred as the aortic lesion score (μm^2/section). Cellular composition was assessed by immunohistochemical staining of alternating sections to those stained with Oil Red O, in 3 sections per animal and averaged over four animals per group. Assessment was performed for macrophages (MOMA-2, Beckman Coulter) and smooth muscle cells (smooth muscle α-actin, Spring Bioscience). Planimetric analysis was performed at 10X using ImagePro Plus software. Relative content of macrophages and/or smooth muscle cells was determined by the percentage of the positively-stained area over the entire lesional area.

Blood chemistry

Retro-orbital bleeding was performed under isoflurane anesthesia in 6-hour fasting animals, 1 week prior to the onset (5 weeks of age) as well as at the termination of the exposure protocols (11 weeks of age). Plasma total and HDL cholesterol were determined by enzymatic assays as previously described [3].

Monocyte Chemotaxis Assay

This assay evaluates the protective capacity of HDL against LDL-induced monocyte chemotactic activity. Monocytes were isolated from blood obtained from a large pool of healthy donors at the UCLA Division of Cardiology, Atherosclerosis Research Unit. Human aortic endothelial cells

(HAEC) and human aortic smooth muscle cells (SMC) were isolated from trimmings of fresh surgical aortic specimens from normal donor hearts during transplantation. Endothelial and smooth muscle cells were grown, propagated and used for forming an artery wall model in culture. Cocultures of HAEC and SMC were treated for 18 hours with a standard source of human LDL (100 µg LDL protein/ml), in the absence or presence of a standard source of human or murine HDL (50 µg HDL protein/ml). The LDL and HDL were isolated from normal standard plasma by FPLC[4]. The cells were then washed and incubated in fresh culture medium for 8 hours, following which supernatants were collected to assess monocyte chemotactic activity after 40-fold dilution, which is expressed as the number of monocytes that have transmigrated per high power field, HPF [4]. LDL-induced monocyte chemotactic activity is mostly (70 +/- 4%) a result of the induction of MCP1 secretion, stimulated by oxidized phospholipids that form during the oxidation of LDL by the artery wall cells to generate minimally oxidized LDL [5]. HDL ability to block monocyte chemotaxis correlates with its antioxidant capacity that decreases the generation of minimally oxidized LDL, resulting in inhibition of MCP1 induction and decreased monocyte binding and migration [6-8].

Lipid Peroxidation Assay

Malondialdehyde (MDA) content was measured in liver homogenates with a colorimetric assay (OxisResearch, OR) according to the manufacturer's instructions [9]. A standard curve was used to calculate the concentration (nmol/g) of MDA for each sample. The final MDA level represents the average of 14-16 age-matched animals/group.

RNA extraction and real-time RT-PCR

Total RNA was extracted from liver tissue with the Trizol method (Invitrogen). Reverse transcription was performed using 1 µg of RNA with the iScript cDNA Synthesis kit (Bio-Rad, Hercules, CA). Quantitative real-time polymerase chain reaction (qPCR) was used to measure tissue mRNA expression for heme oxygenase-1 (HO-1), NF-E2-related factor-2 (Nrf2), catalase, superoxide dismutase 2 (SOD2), NAD(P)H-quinone oxidoreductase 1 (NQO1), glutathione S-transferase-Ya (GST-Ya), activating transcription factor (ATF4) and β-actin, utilizing specific PCR primers [10]. The reactions were performed in duplicate on an ABI Prism 7000 (Applied

Biosystems, Foster City, CA, USA) using iQ Sybr Green Supermix (Bio-Rad). Reactions were performed with 0.4 μM of primers and 1 μg of cDNA template as follows: 95°C for 3 min, 40 cycles of 95°C for 15 sec, 58 - 64°C for 30 sec and 72°C for 30 sec. A standard curve was created from serial dilutions of a pooled sample of cDNA. Gene expression was normalized to β-actin. PCR levels were displayed as arbitrary units.

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Supplemental Table I. Cellular composition of atherosclerotic lesions

Group	MOMA-2 (%)	p (vs. FA)	SMC actin (%)	p (vs. FA)
FA	88±7	-	14±5	-
FP	86±2	0.60	10±5	0.58
UFP	88±3	0.91	5±7	0.42

MOMA-2 and SMC α-actin immunohistochemical staining were performed in 3 sections/animal (n=4 animals/group). Planimetric analysis was performed at 10X using ImagePro Plus software. Data shown represent mean ± SE of positive stained area/total lesion area x 100. Statistical analysis was performed by one-way ANOVA with Fisher's PLSD post hoc analysis. FA: filtered air, FP: fine particles, UFP: ultrafine particles.

Supplemental Table II. Plasma lipoproteins.

	Total cholesterol (mg/dl)	HDL cholesterol (mg/dl)
Baseline		
FA (n=17)	349 +/- 13	11 +/- 1
FP (n=17)	355 +/- 13	11 +/- 1
UFP (n=17)	352 +/- 12	11 +/- 1
End of protocol		
FA (n=16)	397 +/- 13	9 +/- 1
FP (n=16)	459/- 21†‡	8 +/- 1
UFP (n=15)	402 +/- 19	8 +/- 0.5

Mice were bled after 6-hour fasting. Baseline samples were collected one week prior to the beginning of exposure protocols. Samples taken at the end of the protocols were collected 24 hours after the last exposure. Values are given as mean ± SE (mg/dl). NM: not measured. † p (vs. FA group) ≤ 0.01, ‡ p (vs. UFP group) < 0.05. FA: filtered air, FP: fine particles, UFP: ultrafine particles.

Ultrafine Particulate Pollutants Induce Oxidative Stress and Mitochondrial Damage

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The objectives of this study were to determine whether differences in the size and composition of coarse (2.5–10 µm), fine (< 2.5 µm), and ultrafine (< 0.1 µm) particulate matter (PM) are related to their uptake in macrophages and epithelial cells and their ability to induce oxidative stress. The premise for this study is the increasing awareness that various PM components induce pulmonary inflammation through the generation of oxidative stress. Coarse, fine, and ultrafine particles (UFPs) were collected by ambient particle concentrators in the Los Angeles basin in California and used to study their chemical composition in parallel with assays for generation of reactive oxygen species (ROS) and ability to induce oxidative stress in macrophages and epithelial cells. UFPs were most potent toward inducing cellular heme oxygenase-1 (HO-1) expression and depleting intracellular glutathione. HO-1 expression, a sensitive marker for oxidative stress, is directly correlated with the high organic carbon and polycyclic aromatic hydrocarbon (PAH) content of UFPs. The dithiothreitol (DTT) assay, a quantitative measure of *in vitro* ROS formation, was correlated with PAH content and HO-1 expression. UFPs also had the highest ROS activity in the DTT assay. Because the small size of UFPs allows better tissue penetration, we used electron microscopy to study subcellular localization. UFPs and, to a lesser extent, fine particles, localize in mitochondria, where they induce major structural damage. This may contribute to oxidative stress. Our studies demonstrate that the increased biological potency of UFPs is related to the content of redox cycling organic chemicals and their ability to damage mitochondria. *Key words:* concentrated ambient particles, dithiothreitol assay, heme oxygenase-1, mitochondrial damage, oxidative stress, polycyclic aromatic hydrocarbon, ultrafine particles. *Environ Health Perspect* 111:455–460 (2003). doi:10.1289/ehp.6000 available via *http://dx.doi.org/* [Online 16 December 2002]

Epidemiologic studies have shown associations between ambient air particulate matter (PM) and adverse health outcomes, including increased mortality, emergency room visits, and time lost from work and school [Dockery et al. 1993; Health Effects Institute (HEI) 2002; Samet et al. 2000; Wichmann et al. 2000]. The underlying toxicologic mechanisms by which air pollutant particles induce adverse health effects are of intense scientific interest and have been earmarked as a key scientific priority by the National Academy of Sciences [National Research Council (NRC) 1998]. This includes a call for research on the physicochemical properties that promote particle toxicity (NRC 1998). PM with aerodynamic diameter < 2.5 µm ($PM_{2.5}$) is currently regulated by the U.S. Environmental Protection Agency. Within that spectrum of particle sizes, ultrafine particles (UFPs), defined as having an aerodynamic diameter < 0.1 µm, may have a central role in health effects of PM (Oberdörster and Utell 2002; Samet et al. 2000). Primary UFPs are formed during gas-to-particle conversion or during incomplete fuel combustion (HEI 2002). Due to their small size, high number concentration, and relatively large surface area per unit mass, UFPs have unique characteristics, including increased adsorption of organic molecules and enhanced ability to penetrate cellular targets in the lung and systemic circulation (Frampton 2001; HEI 2002; Nemmar et al. 2002; Oberdörster 1996; Utell and Frampton 2000).

Particle composition may also be critical in PM toxicity. We are interested in organic PM compounds because organic extracts made from diesel exhaust particles (DEPs) mimic intact particles in their ability to form reactive oxygen species (ROS) (Hiura et al. 1999, 2000; Kumagai et al. 1997; Nel et al. 1998). One of the major advances in PM research has been the recognition that the organic and metal PM components can induce proinflammatory effects in the lung due to their ability to cause oxidative stress (Kumagai et al. 1997; Nel et al. 1998, 2001; Saldiva et al. 2002). Quinones present in PM can act as catalysts to produce ROS directly and may be key compounds in PM-based oxidative stress (Monks et al. 1992; Penning et al. 1999). PAHs can induce oxidative stress indirectly, through biotransformation by cytochrome P450, expoxide hydrolase, and dihydrodiol dehydrogenase to generate redox active quinones (Penning et al. 1999). The involvement of quinones and PAHs was confirmed by demonstrating that compounds present in aromatic and polar fractions of DEP extracts mimic the pro-oxidative effects of intact particles in bronchial epithelial cells and macrophages (Li et al. 2000, 2002b). DEPs also induce cytochrome P450 1A1 induction in bronchial epithelial cells (Bonvallot et al. 2001). Animal and human experiments confirm that DEPs and PAHs derived from DEPs promote allergic airway inflammation and cytochrome P450 1A1 induction in the lungs of exposed mice (Miyabara et al. 1998; Nel et al. 1998; Takano et al. 2002; Tsien et al. 1997). Epidemiologic studies have also shown an association between PM exposure and asthma exacerbation (Nemmar et al. 2002; Penttinen et al. 2001; Utell and Frampton 2000).

The Versatile Aerosol Concentration Enrichment System (VACES), which uses three parallel sampling lines to collect concentrated ambient coarse, fine, and ultrafine particles for biological analysis, is now available for use in toxicologic studies aimed at identifying the relative toxicity of the different particle sizes (Kim et al. 2001a, 2001b). This technology enables us to probe the relationship between particle size, chemical composition, and toxicity (Li et al. 2002a). These concentrators are mobile and can be used to test hypotheses about particle toxicity in the Los Angeles basin in California. Concentrated air particulates (CAPs) of different sizes were collected to study their oxidative stress effects and subcellular localization in cultured macrophages and epithelial cells. We demonstrate that UFPs are more potent than fine (< 2.5 µm) or coarse (2.5–10 µm) particles

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This study was supported by the National Institute of Environmental Health Sciences (grant RO1-ES10553) and the Southern California Particle Center and Supersite, funded by the U.S. Environmental Protection Agency (STAR award R82735201) and the California Air Resources Board (grant 98-316).

This manuscript has not been subjected to the U.S. EPA peer and policy review.

Received 18 September 2002; accepted 16 December 2002.

toward inducing oxidative stress. This effect may be explained by adsorbed chemicals (organics and metals) capable of generating ROS and the ability of UFPs to localize in mitochondria.

Materials and Methods

Ambient particle collection. Ambient coarse particles (2.5–10 µm), fine plus ultrafine particles (< 2.5 µm), and UFPs (< 0.15 µm) were collected in the Los Angeles basin during November 2001–March 2002 using the VACES (Kim et al. 2001a, 2001b). Coarse particles were concentrated using a single nozzle virtual impactor, while fine and ultrafine particles were concentrated by drawing air samples through two parallel lines, using 2.5 µm and 0.15 µm cut-point preimpactors, respectively, to remove larger-sized particles. These particles are drawn through a saturation–condensation system that grows particles to 2–3 µm droplets, which are subsequently concentrated by virtual impaction. Highly concentrated particle suspensions were obtained by connecting the VACES output to a sterilized liquid impinger (BioSampler; SKC West Inc., Fullerton, CA) (Willeke et al. 1998). Aerosols were collected using ultrapure (Milli-Q; Millipore Corp., Bedford, MA) deionized water (resistivity 18.2 megaohm; total organic compounds < 10 ppb; particle-free; bacteria < 1 colony forming unit/mL) as the collection medium. The concentration enrichment process does not alter the physical, chemical, and morphologic properties of the particles (Kim et al. 2001a, 2001b). We determined the total amount of particulate loading in the collection medium by multiplying the ambient concentration of each PM mode by the total air sample volume collected by each VACES line. The particle concentration in the aqueous medium was then calculated by dividing the particle loading by the total volume collected in that time period. Five sample sets were collected, two at the University of Southern California (USC), and three at Claremont. USC is a typical urban site located 3 km south of downtown Los Angeles. This is a site in which aerosols are mostly generated from fresh vehicular emissions. Claremont is a receptor site approximately 45 km east (i.e., downwind) of downtown Los Angeles. In that location, ambient PM originates mostly from advection of polluted air parcels originally emitted in urban Los Angeles, after "aging" in the atmosphere for a few hours, as well as from secondary photochemical processes.

Particle chemical analysis. Samples were collected on Teflon and quartz filters with a Micro Orifice Uniform Deposit Impactor (MOUDI; MSP Corporation, Shoreview, MN) for chemical analysis (Li et al. 2002a). We used Teflon filters to determine the metal and trace element content by X-ray fluorescence and quartz filters to determine the organic carbon (MnO_2-catalyzed CO_2 formation), sulfate (ion chromatography), and nitrate (ion chromatography) contents (Li et al. 2002a). PAH content for each CAPs set was determined by an HPLC-fluorescence method that detects a signature group of 16 PAHs (Li et al. 2002a).

Cellular stimulation and heme oxygenase 1 (HO-1) immunoblotting. We used two cell lines in the study: RAW 264.7 and BEAS-2B. RAW 264.7 is a murine macrophage cell line that mimics the oxidative stress response of pulmonary alveolar macrophages in response to DEP exposure (Hiura et al. 1999, 2000; Li et al. 2002b). BEAS-2B is a transformed human bronchial epithelial cell line, which mimics the oxidative stress response of primary bronchial epithelial cells (Li et al. 2002b). For RAW 264.7 culture, particle suspensions were reconstituted with Dulbecco's Modified Eagle's Medium powder, a culture medium component that rapidly dissolves in deionized water. This culture medium was further replenished with 10% fetal calf serum and a 1:200 dilution of penicillin/streptomycin/amphotericin B (Li et al. 2002a). For BEAS-2B cells, particle suspensions were made up in hormonally defined F12 medium (Kawasaki et al. 2001). After incubating cells for 16 hr, we used 100 µg of lysate protein for HO-1 immunoblotting (Li et al. 2000, 2002a, 2002b). Densitometric analysis was performed on a laser Personal Densitometer SI using ImageQuant software (both from Amersham Biosciences, Piscataway, NJ).

GSH/GSSG assay. Total glutathione and oxidized glutathione (GSSG) were measured in a glutathione reductase recycling assay (Tietze 1969). We calculated the amount of total glutathione and GSSG in the samples from the standard curves. The amount of reduced glutathione (GSH) was calculated by subtracting the amount of GSSG from that of the total glutathione.

DTT assay. The dithiothreitol (DTT) assay quantitatively measures the formation of ROS by quinone catalysis (Kumagai et al. 2002). In the presence of quinones, 1 mol DTT + 2 mol O_2 generate 1 mol DTT-disulfide + $2O_2^{\bullet -}$

$$\text{a: Q + DTT} \rightarrow \text{semi-Q + DTT-thiyl}$$

$$\text{b: Q + DTT-thiyl} \rightarrow \text{semi-Q + DTT-disulfide}$$

$$\text{c: 2 semi-Q} + 2O_2 \rightarrow 2Q \pm 2O_2^{\bullet -}$$

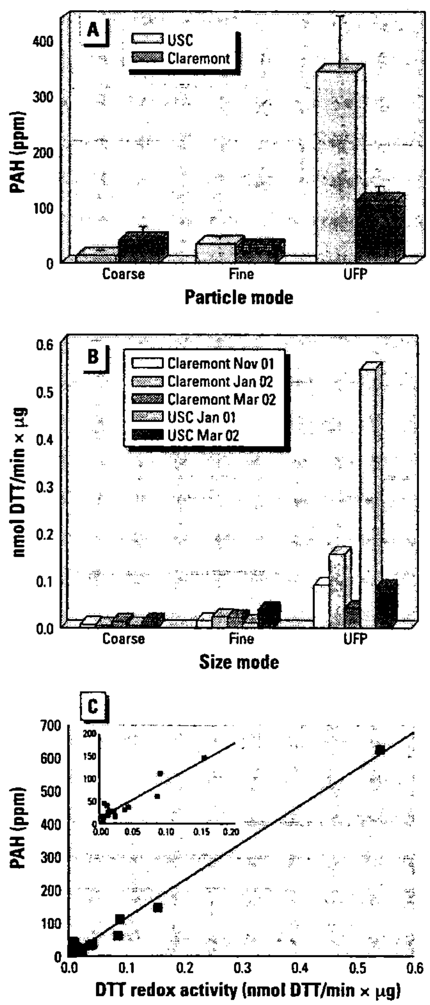

Figure 1. Correlation of PAH content with ROS formation. (*A*) PAH content for each set of CAPs determined by HPLC-fluorescence; values shown are mean ± SEM for Claremont ($n = 3$) and USC ($n = 2$). (*B*) *In vitro* electron transfer capacity of CAPs measured by a colorometric assay that distinguishes oxidized from reduced DTT (Kumagai et al. 2002). The mean was calculated for three separate measurements; SEM < 0.1. (*C*) Linear regression analysis demonstrating the correlation between PAH content and 15 DTT data points (5 sites × 3 samples/site); $r^2 = 0.98$. Inset: With the highest point removed, r^2 remains significant at 0.86.

Table 1. Mass concentration and fractional composition of CAPs collected in the Los Angeles basin.

	Claremont ($n = 3$)			USC ($n = 2$)		
Chemical composition	Coarse	Fine	Ultrafine	Coarse	Fine	Ultrafine
Mass concentration (µg/m³)	12.3	17.3	1.9	21.1	20.9	3.9
Organic carbon (%)	16	40	69	20	52	71
Elemental carbon (%)	1	3	13	1	3	11
Nitrate (%)	27	31	4	35	23	3
Sulfate (%)	5	13	5	7	8	6
Metals/total elements (%)	51	13	9	37	14	9

Values represent the mean fractional composition (%) in which SEM varied < 10%.

Net reaction: DTT + $2O_2 \rightarrow$ DTT-disulfide + $2O_2^{\bullet-}$

The loss of DTT is followed by its reaction with 5,5′-dithiobis-(2-nitrobenzoic acid) (DTNB), which is converted to 5-mercapto-2-nitrobenzoic (Kumagai et al. 2002). We incubated the PM sample (5–50 μg/mL) with 10 μM DTT in a Tris buffer at pH 8.9 for 10–90 min. Aliquots of the incubation mixture were transfered to the DNTB solution and the optical density read at 412 nm.

Electron microscopy. We performed electron microscopy as previously described (Yang et al. 1987). Thin sections were cut with a Reichert-Jung ultracut and ultramicrotome (Leica, Stuttgart, Germany). Copper grids were stained with lead citrate and uranyl acetate and photographed in a Hitachi electron microscope (Hitachi Instrument Inc., Tokyo, Japan).

Results

Particulate organic carbon and PAH content. To determine whether there is a link between UFP composition and biological effects, CAPs were collected at two outdoor sites in the Los Angeles basin with the VACES. Chemical analysis of the CAPs indicate that UFPs have a significantly higher organic ($p < 0.01$) and elemental carbon (($p < 0.001$) content than fine plus ultrafine (designated "fine") or coarse particles (Table 1). Coarse and fine particles had a higher metal content than UFPs (Table 1). PAH content for each set of CAPs was determined and averaged for both collection sites; there was a statistically significant difference in total PAH content in UFPs compared to fine ($p = 0.04$) and coarse ($p = 0.03$) PM (Figure 1A). The PAH content of UFPs at USC was significantly higher than the PAH content at Claremont (Figure 1A), which reflects the fact that particles collected at the source site (USC) are derived from primary emissions that are far more abundant in the urban areas of Los Angeles than in receptor areas.

The DTT assay of ROS formation by particles of varying size. The ability of PM to generate ROS was assessed with the DTT assay. Quinones with appropriate redox potentials can transfer electrons from DTT to oxygen (Kumagai et al. 2002). We used this reaction to determine the ability of PM to generate ROS *in vitro*. The DTT assay demonstrated that UFPs had significantly higher redox activity than fine and coarse PM (Figure 1B). Averaging of the data revealed that the redox cycling capacity of UFPs was 21.7- and 8.6-fold greater than coarse and fine PM, respectively (Figure 1B). Regression analysis of the DTT assay and PAH content showed a correlation coefficient (r^2) of 0.98, suggesting the electron transfer capacity of CAPs is consistent with their organic chemical content (Figure 1C).

Particle chemical composition and oxidative stress. Quinones and other redox-active compounds present in PM generate ROS and oxidative stress (Kumagai et al. 1997; Nel et al. 1998). We have demonstrated that DEP-induced oxidative stress generates hierarchical effects in pulmonary alveolar macrophages and bronchial epithelial cells (Li et al. 2002a, 2002b). Low levels of oxidative stress activate antioxidant defenses, whereas higher levels of oxidative stress lead to proinflammatory and cytotoxic effects (Li et al. 2002a, 2002b). An example of an antioxidant response is HO-1 expression via the antioxidant response element in its promoter (Choi and Alam 1996; Li et al. 2000). Utilizing an immunoblotting technique to assess HO-1 expression in RAW 264.7 cells, UFPs were more potent than fine or coarse particles (Figure 2A). Densitometric analysis demonstrated significantly higher HO-1 expression in ultrafine over fine ($p = 0.001$) and coarse ($p = 0.001$) particles, respectively.

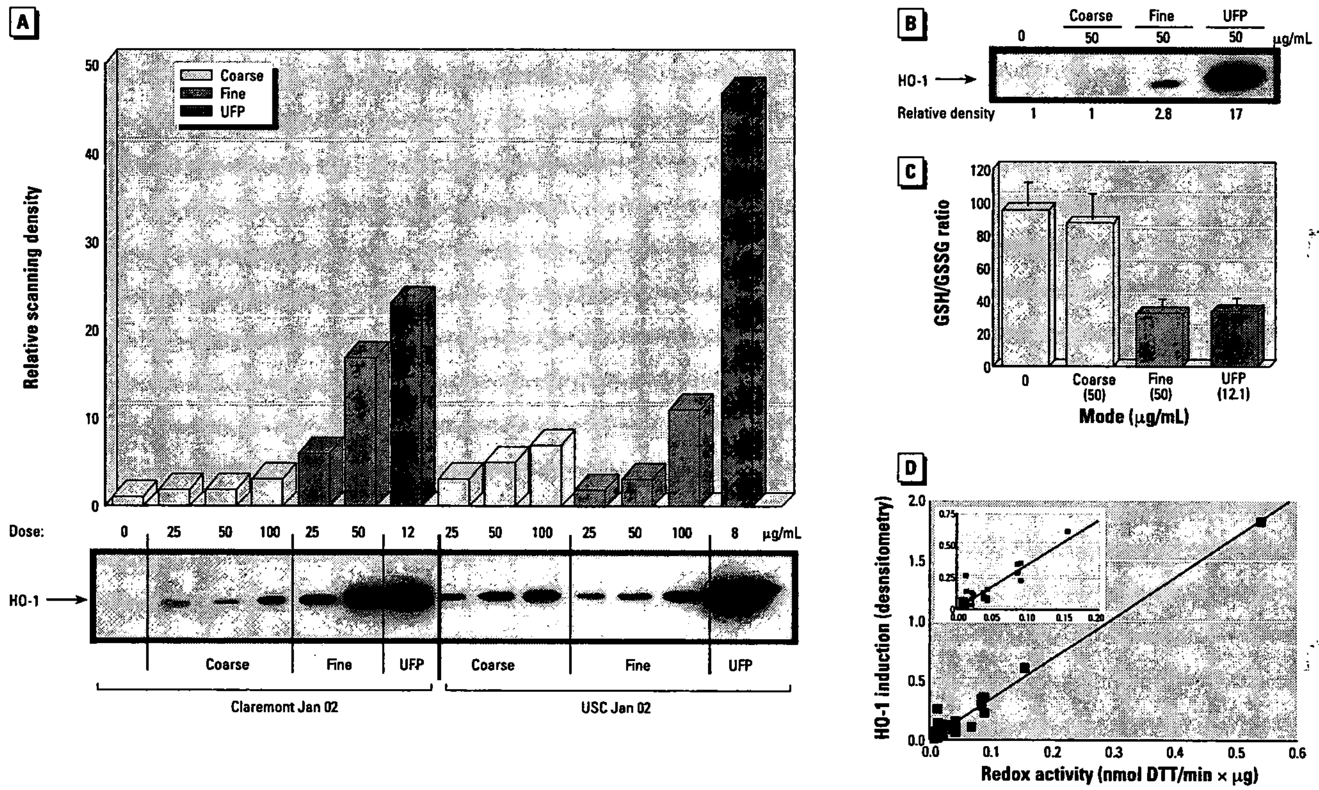

Figure 2. Induction of oxidative stress and HO-1 expression. (*A*) HO-1 expression in RAW 264.7 cells exposed to CAPs for 16 hr. (*B*) HO-1 expression in BEAS-2B cells treated with CAPs (Claremont Mar 02) for 16 hr. (*C*) Effects of CAPs (Claremont Jan 02) on the intracellular GSH/GSSG ratio in RAW 264.7 cells after 16 hr exposure; GSH/GSSG values shown are mean ± SEM from two separate experiments, with duplicate measurements per experiment (Tietze 1969). (*D*) Regression analysis demonstrating the correlation between *in vitro* redox activity of CAPs and HO-1 induction (15 data points); $r^2 = 0.97$. Inset: After removal of the highest data point, $r^2 = 0.81$.

The increased potency of UFPs was seen for all CAPs collections (data not shown).

Sufficient CAPs were collected in March 2002 to study HO-1 expression in the bronchial epithelial cell line, BEAS-2B, in parallel with RAW 264.7. The BEAS-2B response mimics the DEP-induced oxidative stress response in human bronchial epithelial cells (Li et al. 2002b). Immunoblot analysis shows that UFPs but not coarse or fine particles induce HO-1 expression in BEAS-2B cells (Figure 2B). To demonstrate that these effects reflect differences in the level of oxidative stress, we compared HO-1 expression to changes in the reduced (GSH) to oxidized (GSSG) glutathione ratio. These data show abundant HO-1 expression by UFPs or 50 µg/mL fine PM (Figure 2A, Claremont Jan 02), which is accompanied by a sizable drop in glutathione ratios (Figure 2C). In contrast, coarse particles had no effect on either biological response (Figure 2C). Regression analysis showed a correlation coefficient (r^2) of 0.97 between HO-1 expression and the DTT assay (Figure 2D). Overall, there is a strong correlation between particle size, chemical composition, ROS-generating capacity, and cellular oxidative stress.

UFP localization and mitochondrial damage. In defining the mechanistic features of PM toxicity, a key question is the subcellular localization of PM. This may determine ROS generation, as demonstrated by $O_2^{\bullet -}$ generation in lung microsomes during incubation with DEP extracts (Kumagai et al. 1997). Subcellular DEP targets include mitochondria, as demonstrated by the ability of organic DEP extracts to induce structural mitochondrial damage (Hiura et al. 1999, 2000; Li et al. 2002b). After exposure to CAPs, there were clear differences in the ultramicroscopic features of RAW 264.7 cells exposed to different particle sizes (Figure 3). Whereas coarse particles collected in large cytoplasmic vacuoles (Figure 3C and 3D), UFPs frequently lodged inside mitochondria (Figure 3G and H). Mitochondrial architecture remained intact in coarse PM incubations, but cells incubated with UFPs showed extensive disruption of mitochondrial cristae, resulting in a vacuolar cellular appearance (Figure 3H). These changes were time dependent, with fewer particles collecting inside mitochondria during shorter incubations (not shown). In cells exposed to fine particulates (which includes some UFPs), some particles lodged inside mitochondria but did not show the same degree of ultrastructural damage (Figure 3E and F).

Electron microscopy showed similar features in BEAS-2B cells—namely, considerable mitochondrial damage by UFPs, resulting in the formation of concentric structures, known as myelin figures (Figure 4). These structures result from the disassociation of lipoproteins, which facilitates water uptake and intercalation

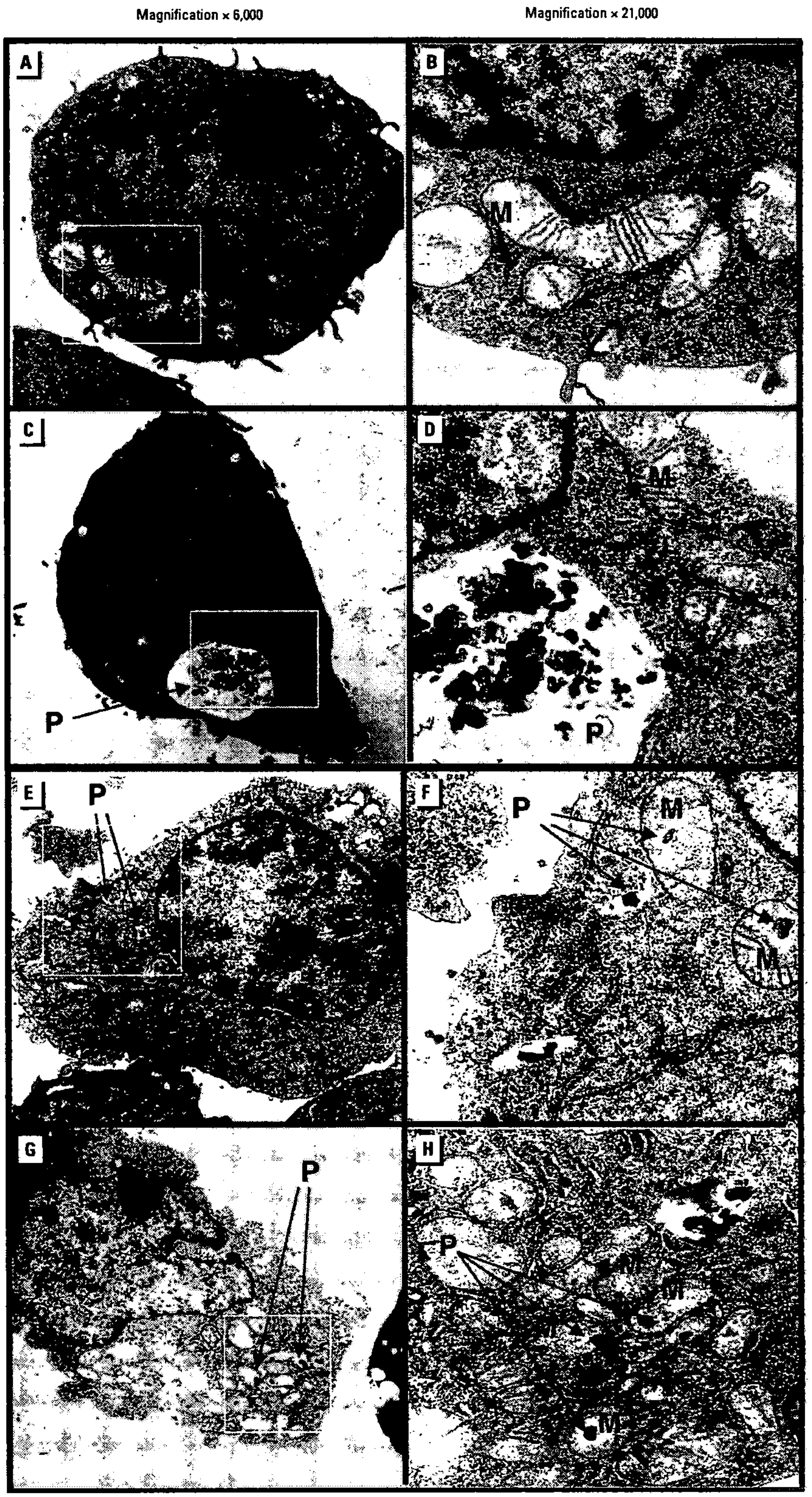

Figure 3. Electron micrographs demonstrating effects of different sized particles in RAW 264.7 cells treated with USC-Jan 02 CAPs for 16 hr. (*A*) and (*B*) Untreated RAW 264.7 cells. (*C*) and (*D*) RAW 264.7 cells exposed to coarse particles. (*E*) and (*F*) RAW 264.7 cells exposed to fine particles. (*G*) and (*H*) RAW 264.7 cells exposed to UFPs. Notice damage to cristae as well as the presence of particles (P) inside mitochondria (M) in UFP- or fine + UFP-exposed cells.

between lamellar membrane stacks (Figure 4C). Similar to RAW 264.7 cells, UFPs lodged inside damaged mitochondria (Figure 4C). Cells incubated with coarse or fine particles showed lesser mitochondrial damage (not shown). The extent of mitochondrial damage is in accordance with the redox cycling potential of the particles, as well as the HO-1 and glutathione results.

Discussion

Our data demonstrate that the UFP mode in the Los Angeles basin is more potent than fine and coarse PM toward inducing oxidative stress as measured by the DTT, HO-1, and glutathione assays. Electron microscopy also indicates subcellular penetration and mitochondrial damage by UFPs and, to a lesser extent, fine particles. The findings correlate with PM organic carbon and PAH composition, suggesting a role of organic agents in generating redox activity.

The results from the DTT assay indicate UFPs are capable of producing greater ROS on a microgram basis than fine and coarse particles. This is the first time that a quantitative assay has been used to directly measure ROS generation by CAPs. Kumagai et al. (2002) focused the assay on assessment of quinones, whereas we have applied the assay to UFPs and fine and coarse particles. The DTT assay provides a quantitative measure of the relative redox activity of different PM sizes in the Los Angeles basin.

UFPs contain a higher percentage of organic carbon than fine and coarse particles, and this has relevance to the biologic potency of these particles. The enhanced biologic potency of UFPs is directly correlated with the PAH content. Although PAHs are capable of inducing ROS production in macrophages, it is also possible that these compounds may be a surrogate for other redox cycling chemicals in the DTT assay. We do not exclude a contribution by transition metals, which may interact with organic PM components in ROS generation (Saldiva et al. 2002).

These data are in accordance with the growing awareness that oxidative stress plays a key role in the induction of airway inflammation (HEI 2002; Nel et al. 1998). Recently, we demonstrated that macrophages and epithelial cells exhibit a stratified oxidative stress response to increasing concentrations of DEPs (Li et al. 2002a, 2002b). The stratified response commences with HO-1 expression when the GSH/GSSG ratio is minimally disturbed, proceeds to *Jun* kinase activation at intermediary levels of oxidative stress, and culminates in cellular toxicity at high oxidative stress levels. Ambient CAPs mimic the effects of organic DEP extracts (Li et al. 2002a), with UFPs showing increased potency in depressing the cellular GSH/GSSG ratio (Figure 2C). The significance of *Jun* kinase activation is the transcriptional activation of cytokine, chemokine, and adhesion receptor promoters (Nel et al. 1998). These products play a role in the proinflammatory effects of PM in the lung and possibly also the cardiovascular system (Nel et al. 1998). The finding of a significant correlation between heme oxygenase activity, GSH/GSSG ratio, and redox activity as measured by DTT production provides further evidence for the role of ROS generation in PM toxicity.

The biological significance of HO-1 expression in the lung is the antioxidant effect of its catabolic product, bilirubin (Choi and Alam 1996). In the process of heme catabolism, HO-1 also generates a gaseous substance, CO, which exerts anti-inflammatory effects in the lung and is exhaled in the expired air (Horvath et al. 1998; Maines 1997). It is interesting, therefore, that in a study in which normal human volunteers were exposed to DEPs, CO levels in the expired air was a more sensitive exposure marker than the presence of inflammatory products in the bronchoalveolar fluid (Nightingale et al. 2000). This is in agreement with the exquisite sensitivity of the HO-1 promoter to oxidative stress *in vivo* and *in vitro* (Choi and Alam 1996; Nightingale et al. 2000). HO-1 expression and CO generation are markers for airway inflammation in asthma (Horvath et al. 1998). Monitoring of CO levels in the expired air may be a useful marker for evaluating the pro-oxidative and proinflammatory effects of CAPs in the respiratory tract.

How exactly UFPs gain access to and induce mitochondrial damage is unknown. One possibility is that ROS generated outside of the mitochondrion may damage this organelle, allowing access to the particles. This is compatible with the ability of organic DEP extracts to induce ultrastructural mitochondrial damage in the absence of particles (Hiura et al. 2000; Li et al. 2002b). Our previous studies have demonstrated that organic DEP chemicals induced pro-apoptotic effects in macrophages and bronchial epithelial cells (Hiura et al. 1999, 2000; Li et al. 2002b). This effect may be mediated through the perturbation of mitochondrial permeability transition pore, which sets in motion cytochrome *c* release, caspase activation, and superoxide production in the mitochondrial inner membrane (Hiura et al. 2000). Ultramicroscopic visualization of human macrophages and BEAS-2B cells incubated with organic DEP extracts showed that the appearance of apoptotic bodies were accompanied by changes in mitochondrial morphology, including mitochondrial swelling and a loss of cristae (Li et al. 2002b). Another possibility is that UFPs gain access to mitochondria because of their small sizes. These particles might then release redox cycling chemicals that damage the inner membrane. All considered, we propose that enhanced tissue penetrance and ability to generate oxidative stress render UFPs more damaging at cellular level and consequently contribute to the adverse health effects of UFPs in the Los Angeles basin.

These findings may be of importance for PM regulation. Currently, the manufacture of cleaner combustion engines relies on mass output standards but do not consider the output of large numbers of UFPs, which have very low mass. Our data show that UFPs are more potent than $PM_{2.5}$ and PM_{10} that contribute the majority of mass in the HO-1 and DTT assays. It may be necessary to consider standards based on particle number instead of mass if further studies confirm the differential toxicity of UFPs. Further research to more fully characterize the toxicity of UFPs in relation to particle number, surface area, and chemical composition is needed.

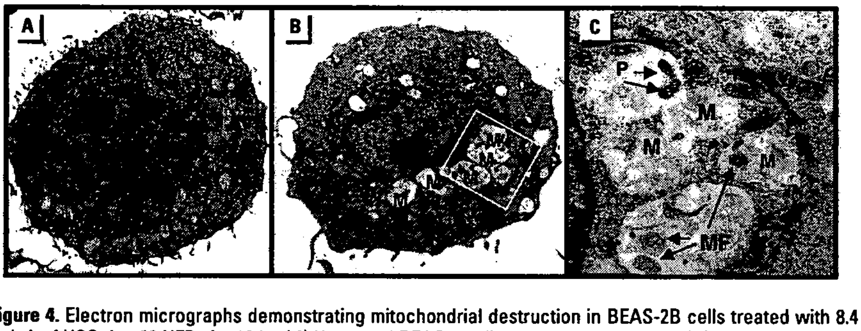

Figure 4. Electron micrographs demonstrating mitochondrial destruction in BEAS-2B cells treated with 8.4 µg/mL of USC-Jan 02 UFPs for 16 hr. (*A*) Untreated BEAS-2 cells; magnification ×8,500. (*B*) UFP-treated cells; magnification ×8,500. (*C*) UFP-treated cells; magnification ×26,300. Notice the disappearance of cristae, formation of myelin figures (MF), and presence of particles (P) inside mitochondria (M).

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Association of Biomarkers of Systemic Inflammation with Organic Components and Source Tracers in Quasi-Ultrafine Particles

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BACKGROUND: Evidence is needed regarding the air pollutant components and their sources responsible for associations between particle mass concentrations and human cardiovascular outcomes. We previously found associations between circulating biomarkers of inflammation and mass concentrations of quasi-ultrafine particles ≤ 0.25 µm in aerodynamic diameter ($PM_{0.25}$) in a panel cohort study of 60 elderly subjects with coronary artery disease living in the Los Angeles Basin.

OBJECTIVES: We reassessed biomarker associations with $PM_{0.25}$ using new particle composition data.

METHODS: Weekly biomarkers of inflammation were plasma interleukin-6 (IL-6) and soluble tumor necrosis factor-α receptor II (sTNF-RII) (n = 578). Exposures included indoor and outdoor community organic $PM_{0.25}$ constituents [polycyclic aromatic hydrocarbons (PAHs), hopanes, *n*-alkanes, organic acids, water-soluble organic carbon, and transition metals]. We analyzed the relation between biomarkers and exposures with mixed-effects models adjusted for potential confounders.

RESULTS: Indoor and outdoor PAHs (low-, medium-, and high-molecular-weight PAHs), followed by hopanes (vehicle emissions tracer), were positively associated with biomarkers, but other organic components and transition metals were not. sTNF-RII increased by 135 pg/mL [95% confidence interval (CI), 45–225 pg/mL], and IL-6 increased by 0.27 pg/mL (95% CI, 0.10–0.44 pg/mL) per interquartile range increase of 0.56 ng/m³ outdoor total PAHs. Two-pollutant models of $PM_{0.25}$ with PAHs showed that nominal associations of IL-6 and sTNF-RII with $PM_{0.25}$ mass were completely confounded by PAHs. Vehicular emission sources estimated from chemical mass balance models were strongly correlated with PAHs (R = 0.71).

CONCLUSIONS: Traffic emission sources of organic chemicals represented by PAHs are associated with increased systemic inflammation and explain associations with quasi-ultrafine particle mass.

KEY WORDS: air toxics, biomarkers of effect, cytokines, epidemiology, longitudinal data analysis. *Environ Health Perspect* 118:756–762 (2010). doi:10.1289/ehp.0901407 [Online 2 February 2010]

Cardiovascular hospital admissions and mortality have been associated with ambient mass concentrations of fine particulate matter (PM) air pollution ≤ 2.5 µm in aerodynamic diameter ($PM_{2.5}$) (Pope and Dockery 2006). Questions remain regarding the underlying causal chemical components and sources responsible for these associations. A recent time-series study of 106 U.S. counties showed stronger associations of cardiovascular hospital admissions with countywide averages of $PM_{2.5}$ when there were higher fractions of elemental carbon (EC), nickel (Ni), and vanadium (V), suggesting that important sources included fossil fuel combustion, biomass burning, and oil combustion (Bell et al. 2009).

Unlike $PM_{2.5}$, ultrafine particles (UFPs; generally defined as < 0.1 µm in diameter) are not regulated by the U.S. Environmental Protection Agency (EPA), yet this is the size fraction that may have the highest toxic potential because it has magnitudes greater number concentrations and surface area than the larger particles that dominate $PM_{2.5}$ mass (Oberdörster et al. 2005). On that large surface area, UFPs carry and deliver redox-active organic chemicals, including polycyclic aromatic hydrocarbons (PAHs), to the respiratory tract in disproportionately higher concentrations than do larger particles (Ntziachristos et al. 2007), possibly leading to a cascade of effects related to oxidative stress and inflammation in the lungs and at extrapulmonary sites (Delfino et al. 2005). These and other effects could underlie associations of morbidity and mortality with air pollutants.

Except for some studies with personal or microenvironmental air pollution data (Chan et al. 2004; Delfino et al. 2008, 2009; Folino et al. 2009; Vinzents et al. 2005), regional ambient air monitoring has been the primary data source used in epidemiologic research on the importance of UFP exposure to cardiovascular outcomes and circulating biomarkers in individual-level studies (de Hartog et al. 2003; Henneberger et al. 2005; Ibald-Mulli et al. 2004; Lanki et al. 2008; Pekkanen et al. 2002; Rückerl et al. 2006, 2007; Timonen et al. 2006). These studies of ambient air were all conducted in Europe, and UFPs were measured as particle number concentrations at central regional sites. Exposure error from the use of ambient data is likely, because air monitors may be far from subject locations and subjects may be exposed to pollutants from local sources, including traffic. UFPs have much higher spatial variability than does $PM_{2.5}$ (Sioutas et al. 2005), so exposure error is likely. In addition, UFP mass and particle number do not specifically indicate which particle components or sources are important, although generally in urban areas UFP compositions are dominated by organic chemicals and EC and originate from combustion sources.

We conducted a panel cohort study of elderly subjects with a history of coronary artery disease living in the Los Angeles Basin. This is considered a population that may have among the greatest susceptibility to the adverse effects of air pollution (von Klot et al. 2005). We made repeated measurements of blood biomarkers and air pollutant exposures. To assess the potential importance of UFPs to cardiovascular health, we measured quasi-ultrafine particle mass < 0.25 µm in diameter ($PM_{0.25}$). To address the issue of exposure error, we monitored $PM_{0.25}$ at the retirement communities of subjects. We previously

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Supplemental Material is available online (doi:10.1289/ehp.0901407 via http://dx.doi.org/).

We appreciate the effort of staff from the Wisconsin State Laboratory of Hygiene; the Department of Epidemiology and General Clinical Research Center, University of California–Irvine; the Department of Civil and Environmental Engineering, University of Southern California; the California Air Resources Board; and the South Coast Air Quality Management District.

This project was supported by the National Institute of Environmental Health Sciences (grant ES12243) and the National Center for Research Resources (grant M01 RR00827) of the National Institutes of Health, by the California Air Resources Board (contract 03-329), and by the U.S. Environmental Protection Agency's Science to Achieve Results program (grant RD83241301) to the University of California–Los Angeles.

The contents of this article are solely the responsibility of the authors and do not necessarily represent the official views of the funding agencies, and no official endorsement should be inferred.

The authors declare they have no actual or potential competing financial interests.

Received 31 August 2009; accepted 2 February 2010.

reported positive associations of blood biomarkers of inflammation with $PM_{0.25}$ but not with larger accumulation-mode particles 0.25–2.5 µm in diameter ($PM_{0.25-2.5}$) (Delfino et al. 2009). However, particle mass alone does not provide sufficient information about composition or sources. We also previously found positive associations between the biomarkers and $PM_{2.5}$ EC (Delfino et al. 2009). Based on these findings, we hypothesized that traffic emission sources of organic chemicals in $PM_{0.25}$ would be positively associated with systemic inflammation. In the present analysis, we aimed to better delineate which underlying PM components may be responsible for the associations we observed for EC and $PM_{0.25}$ mass using new data on chemical species in the archived $PM_{0.25}$ filter samples.

Materials and Methods

Population and design. This was a longitudinal study of repeated measures where each subject acted as his or her own control over time. This limits the impact of confounding by between-subject characteristics. We recruited subjects from four retirement communities. Subjects were eligible for participation if they had a confirmed coronary artery disease history and were ≥ 65 years of age, nonsmokers, and unexposed to environmental tobacco smoke. Of 105 volunteers, 21 were not eligible, 19 dropped out, 2 had too few blood draws or valid biomarker data (> 5 of 12 weeks), and 3 had insufficient biomarker data due to exclusions for frequent infections, leaving 60 subjects. We excluded biomarker measurements during weeks with acute infectious illnesses given their well-known impact on measured biomarkers. Table 1 lists subject characteristics.

Two retirement communities were studied in 2005–2006 and two in 2006–2007. Subjects were followed for a total of 12 weeks with weekly blood draws for circulating biomarkers of inflammation in plasma. Each subject contributed 5–12 weekly blood draws (n = 578 total samples).

Each community was studied in two 6-week seasonal phases, a warmer period characterized by higher photochemistry followed by a cooler period characterized by higher air stagnation and lower mixing heights. This seasonal approach was intended to increase the variability in pollutant characteristics, with higher secondary organic aerosols (SOAs) in the warmer phase and higher primary organic aerosols (POAs) in the cooler phase when traffic-related air pollutants increase at ground level. POAs are formed during or shortly after the combustion of fossil fuels. SOAs are largely photochemically produced from gas-to-particle conversion when volatile reactive organic gases from anthropogenic and biogenic sources, and anthropogenic semivolatile organic compounds (SVOCs), are oxidized to form low-volatility products that condense to produce SOAs. There are few data on the importance of variations in this multipollutant characteristic of PM to human health outcomes. In the present study, POAs are represented by PAHs and hopanes, whereas SOAs are represented by water-soluble organic carbon (WSOC) and organic acids. Most PAHs are considered to be components of POAs. Hopanes are found in the lubricant oils of diesel and gasoline vehicles and are thus tracers of primary vehicular aerosols in the Los Angeles Basin (Schauer et al. 1996, 2000). WSOC (Snyder et al. 2009) and organic acids (Robinson et al. 2006) are tracers of SOAs, although a fraction of WSOC comes from biomass burning (Docherty et al. 2008).

The research protocol was approved by the Institutional Review Board of the University of California–Irvine, and we obtained informed written consent from subjects.

Biomarkers. We focused on an informative set of biomarkers of inflammation from the previous analysis of peripheral blood biomarkers and $PM_{0.25}$ mass (Delfino et al. 2009). We drew blood samples in ethylenediaminetetraacetic acid tubes on Friday afternoons and processed them and froze the plasma on site within 30 min. Samples were stored at –80°C until assayed. Plasma biomarkers were thawed and assayed using 96-well immunoassay kits for the proinflammatory cytokine interleukin-6 (IL-6) and the cytokine receptor–soluble tumor necrosis factor-α (TNF-α) receptor II (sTNF-RII; Quantikine HS, R&D Systems, Minneapolis, MN). sTNF-RII has a longer half-life than TNF-α (Aderka 1996) and may thus better reflect sustained or lagged effects. Thawed erythrocyte lysates were assayed spectrophotometrically for activities of the antioxidant enzymes copper/zinc-superoxide dismutase (Cu,Zn-SOD) and glutathione peroxidase-1 (GPx-1) (Cayman Chemical, Ann Arbor, MI, USA). Cu,Zn-SOD and GPx-1 values were normalized to units per gram of hemoglobin. These and related biomarkers are predictive of cardiovascular disease risk (Flores-Mateo et al. 2009; Kritchevsky et al. 2005; Pai et al. 2004).

Exposures. The methods used to measure components and their relevance to sources of $PM_{0.25}$ are described in detail in the Supplemental Material [Chemical Measurement Methods (doi:10.1289/ehp.0901407)] and by Arhami et al. (2010). There we also discuss in detail differences by season and community and describe the relation between indoor and outdoor measurements.

Air sampling occurred in the immediate outdoor environment of each retirement community and at an indoor site located in the common areas of the main community buildings. The indoor data are thus representative to some degree of the same indoor environment of each subject. Our main interest here is in the effects of outdoor-source PM components.

More than 5 days before each blood draw, we collected indoor and outdoor size-segregated particle samples using Sioutas Personal Cascade Impactors (SKC Inc., Eighty Four, PA, USA) with Zefluor filters (3-µm pore size; Pall Life Sciences, Ann Arbor, MI, USA). We evaluated components only in the quasi-ultrafine fraction ($PM_{0.25}$). Mass concentrations were determined gravimetrically by weighing the impactor filters and substrates with a microbalance (uncertainty, ± 2 µg; Mettler-Toledo, Columbus, OH, USA) in a temperature-controlled and relative humidity–controlled room.

The five weekly $PM_{0.25}$ filters were composited for chemical analyses. These composites were cut into three sections (one half-section and two quarter-sections). We analyzed the composited half section for 92 different organic compounds using gas chromatography/mass spectrometry (GC/MS) (Stone et al. 2008). For the present analysis, compounds are grouped by their structures, which is the primary control of their chemical interactions. Selected representative organic components were grouped as PAHs, organic (n-alkanoic) acids, n-alkanes, and hopanes [see Supplemental Material, Table 1 (doi:10.1289/ehp.0901407)]. PAHs were further subdivided into low- (two- to three-ring), medium- (four-ring), and high- (five-ring or larger) molecular-weight PAHs (LMW, MMW, and HMW, respectively), which is loosely connected to volatility and solubility.

Table 1. Subjects and biomarker outcomes.

Variable	Value
Age (years)	84.1 ± 5.60
Sex	
Male	34 (56.7)
Female	26 (43.3)
Cardiovascular history	
Confirmation of coronary artery disease[a]	
Myocardial infarction	27 (45.0)
Coronary artery bypass graft or angioplasty	20 (33.3)
Positive angiogram or stress test	10 (16.7)
Clinical diagnosis[b]	3 (5.0)
Congestive heart failure	13 (21.7)
Hypertension (by history)	42 (70.0)
Hypercholesterolemia (by history)	43 (71.7)
Medications	
Angiotensin-converting enzyme inhibitors and angiotensin II receptor antagonists	24 (40.0)
3-Hydroxy-3-methylglutaryl-coenzyme A reductase inhibitors (statins)	31 (51.7)
IL-6 (pg/mL)	2.42 ± 1.85
sTNF-RII (pg/mL)	3,610 ± 1,489

sTNF-RII, soluble tumor necrosis factor-α receptor II. Values are mean ± SD or n (%).
[a]Each category is hierarchical and excludes being in the above diagnostic category. [b]Includes subjects with anginal symptoms relieved with nitrates plus echocardiogram and electrocardiographic evidence of past infarct.

The first composited quarter-section was digested with concentrated acid using microwave digestion followed by analysis to determine 52 trace elements using high-resolution inductively coupled plasma mass spectrometry (Finnigan Element 2; Thermo Fisher Scientific, Waltham, MA, USA) (Herner et al. 2006). We focused our analyses of exposure–response relationships on key transition metals that can generate reactive oxygen species by Fenton-type reactions: vanadium (V), chromium (Cr), iron (Fe), nickel (Ni), copper (Cu), manganese (Mn), lead (Pb), and zinc (Zn).

The second composited quarter was analyzed for WSOC using a General Electric Sievers Total Organic Carbon Analyzer (GE Analytical Instruments, Boulder, CO, USA).

The remaining composited half was analyzed for organic tracer compounds by GC/MS along with field blanks, laboratory blanks, spiked samples, and standard reference material (Urban Dust Standard Resource Material 1649a; National Institute of Standards and Technology, Gaithersburg, MD, USA). Spike recovery after correction for internal standard recoveries was in the range of 96–110% for PAHs, 99–104% for hopanes, and 68–136% for *n*-alkanes. Blank concentrations of MMW PAHs, HMW PAHs, and hopanes were below analytical detection limits (~ 10 pg/m^3 air). The method detection limits for remaining compounds were limited by field and laboratory blanks. Uncertainties for each measurement were estimated based on analytical uncertainties and uncertainties from the blank correction and were used to determine if each measurement was statistically different from zero. The precision of the spike and standard reference material analyses was used to estimate method precision (> 20% for all PAHs, hopanes, and *n*-alkanes).

Statistical analysis. We analyzed relations of repeated (within-subject) measures of biomarkers to air pollutant exposures with linear mixed effects models. Random effects were estimated at the subject level, nested within seasonal phase and community, to account for correlated within-individual repeated measures. To focus estimates of associations at the subject level, we adjusted for between-community and between-phase exposure effects as proposed by Janes et al. (2008) by using exposures that were mean-centered across community and phase [see Supplemental Material, Regression Model, Mean Centering Method (doi:10.1289/ehp.0901407)]. We decided *a priori* to adjust for 5-day average temperature. Magnitudes of association from the mixed models are expressed at pollutant interquartile ranges (IQRs; 25th–75th percentile) to allow strengths of association for different pollutants to be compared by limiting differences due to units of measurement or concentration range.

We evaluated the covariance structure using empirical variograms and found models were best fit as an autoregressive-1 correlation structure. We performed residual analyses to examine deviations from standard linear

Table 3. Exposure correlation matrix for outdoor $PM_{0.25}$ mass and organic components.

Pollutant	WSOC	PAH Total	PAH LMW	PAH MMW	PAH HMW	Hopanes	*n*-Alkanes	Organic acids
$PM_{0.25}$ mass	0.25	0.45	0.44	0.38	0.39	0.31	0.17	–0.18
WSOC	1.00	0.39	0.41	0.29	0.40	0.31	0.15	0.09
PAHs								
Total		1.00	0.89	0.93	0.81	0.54	0.15	–0.19
LMW			1.00	0.79	0.66	0.63	0.24	–0.24
MMW				1.00	0.67	0.51	0.12	–0.33
HMW					1.00	0.41	0.20	–0.03
Hopanes						1.00	0.08	–0.26
n-Alkanes							1.00	–0.06

All exposures are mean centered by study community and seasonal phase, and results are Spearman rank correlations.

Table 4. Exposure correlation matrix for outdoor PAH and source apportioned mass.

PAH	Vehicular emissions	Biomass burning	Ship emissions	SOAs	RS dust	NSS sulfate	Sea salt	Unknown
Total	0.71	0.22	0.10	0.19	0.24	0.06	0.33	0.33
LMW	0.70	0.14	0.17	0.27	0.39	0.10	0.34	0.31
MMW	0.66	0.36	–0.01	0.04	0.19	–0.06	0.27	0.30
HMW	0.66	0.08	0.09	0.27	0.13	0.13	0.19	0.14

Abbreviations: RS, resuspended; NSS, non-sea salt. All exposures are mean centered by study community and seasonal phase, and results are Spearman rank correlations. Source apportioned mass data come from Arhami et al. (2010).

Table 2. Descriptive statistics of outdoor measurements and indoor/outdoor (I/O) ratios of $PM_{0.25}$ organic components and transition metals from 47 weeks of 5-day filter composites.

Exposure	Warm season Mean ± SD	Warm IQR	Warm Min/max	Warm I/O ratio	Cool season Mean ± SD	Cool IQR	Cool Min/max	Cool I/O ratio	IQR overall[a]
Organic components									
$PM_{0.25}$ mass (μg/m^3)	9.51 ± 3.46	7.24	4.67/14.7	0.88	8.65 ± 4.51	6.07	3.31/19.3	0.94	7.37
WSOC (μg/m^3)[b]	0.52 ± 0.23	0.31	0.08/1.01	0.95	0.38 ± 0.23	0.39	0.06/0.94	0.94	0.37
PAHs (ng/m^3)									
Total	0.88 ± 0.37	0.47	0.40/1.75	0.84	1.04 ± 0.61	0.73	0.40/2.70	0.99	0.56
LMW	0.38 ± 0.15	0.20	0.19/0.74	0.78	0.33 ± 0.15	0.19	0.17/0.73	1.02	0.19
MMW	0.26 ± 0.12	0.18	0.09/0.50	0.85	0.35 ± 0.24	0.33	0.09/0.96	0.74	0.24
HMW	0.24 ± 0.11	0.18	0.11/0.50	0.97	0.37 ± 0.24	0.32	0.14/1.01	1.04	0.21
Hopanes (ng/m^3)	0.27 ± 0.34	0.36	0.06/1.57	1.00	0.25 ± 0.25	0.35	0.06/0.83	0.97	0.35
n-Alkanes (ng/m^3)	36.3 ± 23.5	43.2	9.9/81.2	1.39	54.8 ± 111	15.9	11.7/500	1.30	29.4
Organic acids (μg/m^3)	0.22 ± 0.17	0.30	0.06/0.54	5.05	0.26 ± 0.22	0.26	0.07/0.96	1.24	0.29
Transition metals (ng/m^3)									
V	4.83 ± 2.07	2.10	1.66/11.3	0.75	2.10 ± 1.19	2.40	0.54/4.25	0.77	2.95
Cr	10.2 ± 30.2	2.21	0.00/139	0.89	0.26 ± 0.45	0.49	0.00/1.24	1.00	1.18
Mn	3.09 ± 2.88	3.10	0.00/13.8	0.57	2.02 ± 1.43	1.76	0.27/6.19	0.70	2.24
Fe	144 ± 127	167	0.00/588	0.49	92.5 ± 64.2	74.7	9.39/287	0.74	115
Ni	7.21 ± 18.0	3.51	0.00/82.8	0.83	0.20 ± 0.61	0.816	0.00/1.44	2.27	1.64
Cu	6.45 ± 4.35	5.50	0.35/16.0	0.64	4.69 ± 3.22	4.91	0.43/11.3	0.60	4.69
Zn	6.88 ± 4.16	6.39	0.00/15.8	0.78	6.08 ± 3.51	4.81	1.75/13.0	0.93	5.77

Abbreviations: max, maximum; Min, minimum.
[a]Overall IQR used in regression models to estimate expected change in the biomarker from exposure to the air pollutant. [b]WSOC (μg C/m^3) was multiplied by 1.8 to yield mass of organic components (μg/m^3) according to Turpin and Lim (2001).

mixed model assumptions and the presence of influential observations. We found four influential high outliers for IL-6 > 10 pg/mL that were reset to 10 pg/mL (upper limit of its standard curve) to obtain more representative estimates of association. In a model for 5-day average $PM_{0.25}$, including the outliers resulted in an association of 0.41 pg/mL [95% confidence interval (CI), 0.00–0.82] per interquartile change in $PM_{0.25}$ of 7.37 $\mu g/m^3$, whereas resetting them to 10 pg/mL resulted in an association of 0.26 pg/mL (95% CI, –0.06 to 0.57). It is important that in the previous analysis of $PM_{0.25}$ mass (Delfino et al. 2009), the associations with 1-day and 3-day average $PM_{0.25}$ were stronger and had narrower 95% CIs than did the 5-day average for both IL-6 and sTNF-RII.

In exploratory analyses, we retested models for erythrocyte antioxidant enzymes (Cu,Zn-SOD and GPx-1) from our previous publication (Delfino et al. 2009). Random slopes and individual autoregressive models showed small, highly influential subject clusters (seven subjects) with positive associations between air pollutants and antioxidant enzymes, whereas most of the remaining 53 subjects showed inverse associations. Details of these clusters and their interpretation are presented elsewhere (Delfino et al. 2009). We present these data-driven results with the new air pollutant exposure data primarily in the Supplemental Material, Table 3 (doi:10.1289/ehp.0901407).

Results

Table 2 provides descriptive statistics for the measured exposures. Seasonal differences were greatest for MMW PAHs, HMW PAHs, and *n*-alkanes, which were higher in the cool season, and for WSOC, which was higher in the warm season, as expected because of photochemistry. Indoor/outdoor ratios were close to 1.0 for PAHs and hopanes, and indoor–outdoor correlations were strong (median *R* was 0.60 for PAH species and 0.74 for hopane species) (Arhami et al. 2010). This suggests high penetration of these outdoor $PM_{0.25}$ components into indoor environments and that measured indoor components were largely of outdoor origin. On the other hand, indoor/outdoor ratios were high for *n*-alkanes and *n*-alkanoic acids, with generally low indoor/outdoor correlation coefficients (Arhami et al. 2010). This suggests that indoor sources influenced the indoor levels of *n*-alkanes and *n*-alkanoic acids.

Table 3 shows a correlation matrix for measured outdoor organic components. We found moderate to strong correlations between $PM_{0.25}$ mass, PAHs, and hopanes. We also found small negative correlations of these species with organic acids and small positive correlations with WSOC, suggesting that POA and SOA concentrations are relatively independent of each other at the study sites.

To further improve our understanding of the clearly positive associations of biomarkers with summed PAH compounds presented below, we used the chemical mass balance model (CMB) source apportionment estimates from Arhami et al. (2010) to evaluate the possible sources of PAHs. We briefly summarize methods and source apportionment results in the Supplemental Material, Chemical mass balance (CMB) model (doi:10.1289/ehp.0901407). Table 4 shows a correlation matrix for the relation of PAHs to the CMB-estimated sources. Strong correlations are seen for total PAHs with vehicular emission sources, whereas the apportioned mass from other sources shows weak to null correlations.

In the mixed-model regression analyses, we found positive associations of circulating biomarkers of inflammation (IL-6 and sTNF-RII) with organic components (Table 5, Figure 1). We found the strongest associations with biomarkers for both indoor and outdoor PAHs, including LMW, MMW, and HMW PAHs. The next strongest associations were for hopanes. Indoor but not outdoor hopanes were associated with IL-6, whereas both indoor and outdoor hopanes were associated with sTNF-RII.

Outdoor WSOC (a marker of SOAs) was positively associated with sTNF-RII, but confidence limits crossed 1.0 ($p < 0.14$), and we found no other associations with SOA markers. The outdoor organic acids (another marker of SOAs) showed a pattern opposite to that of the POA markers, with largely negative regression coefficients in relation to biomarkers of inflammation. To assess whether this was due to inverse correlations with PAHs, we coregressed outdoor total PAHs with outdoor organic acids. We found that associations with PAHs and with organic acids decreased in magnitude to small degrees when coregressed, suggesting that the negative regression coefficients for organic acids with

Table 5. Associations of biomarkers of systemic effect with indoor and outdoor 5-day average $PM_{0.25}$ mass and organic components [regression coefficient (95% CI)].

Air pollutant	IL-6 (pg/mL)	sTNF-RII (pg/mL)
$PM_{0.25}$ mass		
Indoor	0.05 (–0.12 to 0.22)	18 (–61 to 97)
Outdoor	0.26 (–0.06 to 0.57)	125 (–40 to 289)
WSOC		
Indoor	–0.11 (–0.30 to 0.08)	15 (–77 to 108)
Outdoor	–0.08 (–0.27 to 0.10)	63 (–19 to 145)
PAHs		
Total		
Indoor	0.25 (0.07 to 0.43)**	119 (16 to 223)*
Outdoor	0.27 (0.10 to 0.44)**	135 (45 to 225)**
LMW		
Indoor	0.30 (0.10 to 0.50)**	115 (–2 to 233)
Outdoor	0.22 (0.05 to 0.39)*	109 (19 to 200)*
MMW		
Indoor	0.28 (0.07 to 0.48)**	138 (22 to 254)*
Outdoor	0.30 (0.12 to 0.48)**	143 (47 to 238)**
HMW		
Indoor	0.18 (0.02 to 0.35)*	91 (1 to 181)*
Outdoor	0.26 (0.07 to 0.44)**	137 (39 to 234)**
Hopanes		
Indoor	0.22 (0.04 to 0.39)*	107 (10 to 204)*
Outdoor	0.06 (–0.08 to 0.20)	89 (26 to 151)**
n-Alkanes		
Indoor	0.01 (–0.03 to 0.06)	–6 (–27 to 16)
Outdoor	0.009 (–0.03 to 0.05)	14 (–6 to 34)
Organic acids		
Indoor	–0.05 (–0.22 to 0.12)	–36 (–109 to 37)
Outdoor	–0.22 (–0.39 to –0.06)**	–82 (–164 to 1)

Regression coefficients and 95% CIs are for the expected change in the biomarker among 60 subjects associated with an IQR change in the air pollutant (see Table 2), adjusted for temperature.
*$p < 0.05$, **$p < 0.01$.

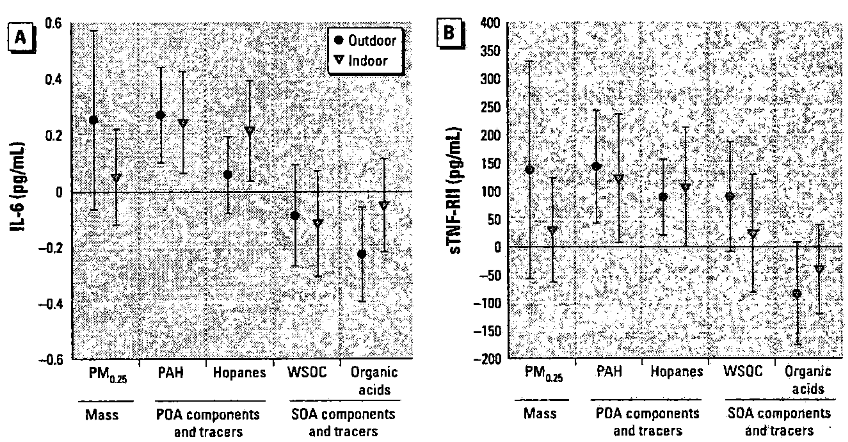

Figure 1. Associations of biomarkers with 5-day average outdoor and indoor community $PM_{0.25}$ mass, and markers of POAs and SOAs. (*A*) IL-6. (*B*) sTNF-RII. Expected change in the biomarker (adjusted coefficient and 95% CI) corresponds to an IQR increase in the air pollutant concentration (see Table 2), adjusted for temperature.

biomarkers of inflammation may be attributed to other unmeasured factors or chance.

We then tested two-pollutant regression models that included both outdoor $PM_{0.25}$ mass and total PAHs to assess whether PAHs explained the nominal association with mass. We found that IL-6 and sTNF-RII associations with mass were completely confounded by PAHs in that the regression coefficient for mass decreased to just below zero and the regression coefficient for PAHs was nearly unchanged (Figure 2A,B). We found a similar effect for hopanes, which confounded the nominal association of $PM_{0.25}$ mass with sTNF-RII (Figure 2C). The variance inflation factor was < 3.5 for exposures, thus showing little evidence of multicollinearity.

Transition metals were not associated with the biomarkers [see Supplemental Material, Table 2 (doi:10.1289/ehp.0901407)].

As previously shown (Delfino et al. 2009), the analysis of the relation of erythrocyte antioxidant enzymes (Cu,Zn-SOD and GPx-1) to air pollutants among all 60 subjects showed regression coefficients were largely negative, suggesting inverse associations, but most upper confidence limits crossed 1.0 (see Supplemental Material, Table 3 (doi:10.1289/ehp.0901407)]. The exploratory analysis showed that among seven subjects previously identified as a "positive responder group" (Delfino et al. 2009), we found largely positive associations of Cu,Zn-SOD and GPx-1 with air pollutants, and lower confidence limits were > 1.0 for outdoor $PM_{0.25}$ mass and several other exposures. In the 53 subjects previously identified as a "negative responder group," we found inverse associations of Cu,Zn-SOD and GPx-1 with indoor and outdoor total, LMW, MMW, and HMW PAHs and with hopanes (all markers of exposures linked to primary combustion). Indoor WSOC was inversely ($p < 0.07$) associated with Cu,Zn-SOD, but we found no other associations with SOA markers in the negative responder group. Confidence limits were wider for GPx-1 than for Cu,Zn-SOD.

Discussion

To our knowledge, this is the first report from a panel cohort study to show associations of circulating biomarkers of response in human subjects to specific PM organic compound classes. The measured chemicals serve as indicators and tracers for air pollutant sources and for classes of chemicals with the potential for redox activity in the body. Our prior work has focused on carbonaceous aerosols that provided some differentiation between POAs and SOAs by showing associations of biomarkers of inflammation with primary $PM_{2.5}$ organic carbon (OC) but not secondary $PM_{2.5}$ OC (a marker of SOAs) (Delfino et al. 2008, 2009). In the present analysis, we found the strongest biomarker associations with air pollutant variables for all molecular weight classes of PAHs and specific source markers of vehicular emissions (hopanes) measured in $PM_{0.25}$ with GC/MS. Furthermore, two-pollutant models of the relation between the biomarkers of systemic inflammation and both total PAHs and $PM_{0.25}$ mass showed that mass associations were completely explained by PAHs. Given the results of the chemical mass balance analysis [see Supplemental Material, Chemical mass balance (CMB) model (doi:10.1289/ehp.0901407) and Arhami et al. 2010], we infer that the confounding of nominal associations between biomarkers and $PM_{0.25}$ mass by PAHs was through a common set of sources. PAHs likely serve here as a surrogate for redox-active PM chemical components as evidenced in experimental models (Riedl and Diaz-Sanchez 2005). For example, PAHs from diesel exhaust particles and oxidized derivatives of PAHs such as quinones lead to the generation of reactive oxygen species and subsequent oxidant injury and inflammatory responses, including the expression of nuclear transcription factor-κB (NFκB) (Riedl and Diaz-Sanchez 2005). NFκB increases the transcription of cytokines and acute-phase proteins that are predictive of coronary artery disease risk (Pai et al. 2004). PAHs can induce oxidative stress responses after biotransformation to quinones by cytochrome P450 1A1 (Bonvallot et al. 2001), perhaps after delivery from the lungs to systemic targets.

In the Los Angeles Basin, most outdoor PAHs in $PM_{0.25}$ are expected to be from mobile sources (Schauer et al. 1996), and the CMB exposure correlations are consistent with this expectation. PAHs were also correlated with source markers of vehicular emissions (hopanes). Hopanes are the most unambiguous source marker of traffic emissions. However, the moderate but not strong correlation between hopanes and PAHs suggests that the measured PAHs include a different subset of mobile sources than that of hopanes. This may in part be due to the variability in PAHs relative to hopanes by combustion-related problems in the vehicle fleet (Lough et al. 2007).

Overall, the associations of biomarkers with PAHs and hopanes suggest that our previous findings of positive associations of biomarkers with $PM_{2.5}$, EC, and primary OC (Delfino et al. 2009) were due to PM of mobile-source origin. PAHs are found in greater concentrations in the quasi-UFP range compared with larger particles (Ntziachristos et al. 2007), and this has been hypothesized to explain enhanced prooxidative and proinflammatory effects of urban UFPs in the lungs and peripheral target organs of rodents (Araujo et al. 2008). The increased biological potency of UFPs may be related to the content of organic chemicals that have the capacity to reduce oxygen, such as quinones and nitro-PAHs, for which PAHs may act, in part, as a surrogate (Ntziachristos et al. 2007) or as a source after biotransformation. From the present results we infer that, although PAHs may have an effect by

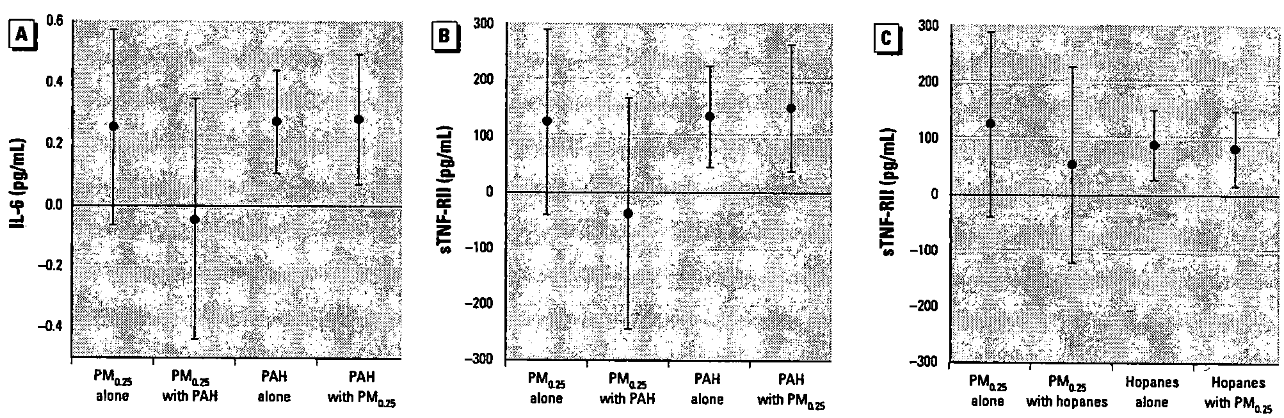

Figure 2. Associations of circulating biomarkers of inflammation with outdoor $PM_{0.25}$ mass coregressed with outdoor total PAHs and hopanes in $PM_{0.25}$. (*A*) IL-6, PAHs, and $PM_{0.25}$. (*B*) sTNF-RII, PAHs, and $PM_{0.25}$. (*C*) sTNF-RII, hopanes, and $PM_{0.25}$. Expected change in the biomarker (adjusted coefficient and 95% CI) corresponds to an IQR increase in the air pollutant concentration (see Table 2), adjusted for temperature.

themselves, they are also likely surrogates for other causal species we did not measure that are emitted from the same (traffic) sources.

We found little evidence that tracer variables for SOAs and related components (WSOC and organic acids) were associated with the circulating biomarkers in the expected direction. We have no explanation for the negative regression coefficients for organic acids with biomarkers. Although most of the SOAs are expected to be in larger PM > 0.25 μm, the present results are consistent with our finding of few biomarker associations with $PM_{2.5}$ secondary OC or accumulation mode particle mass ($PM_{0.25-2.5}$) in an earlier publication (Delfino et al. 2009). In that study, regression coefficients were also negative for IL-6 in some models with $PM_{0.25-2.5}$ and with secondary OC. We speculate that components in outdoor SOAs estimated by our methods (e.g., organic acids), are mostly water soluble and highly oxygenated, and dissolve after deposition on the airway epithelium and then quickly react with extracellular macromolecules and cell membrane constituents. Thus, these PM components may not directly interact with the vasculature, although it has been hypothesized that inhaled particles lead to airway inflammatory responses and subsequent release of activated leukocytes and cytokines into the circulation (Mills et al. 2009).

An important limitation of our characterization of SOAs is that WSOCs and organic acids do not completely characterize the SOA fraction of PM, part of which may come from the photochemical oxidation of low-volatility vapors to form hydrophilic organic components, but whose chemical identity is largely unknown. These precursor vapors include SVOCs that are largely part of POAs. SVOCs evaporate from the particle phase during the process of atmospheric dilution and subsequently react with oxidant gases to form a significant fraction of SOAs (Robinson et al. 2007).

Lipid-soluble components of PM more closely associated with primary emissions, including PAHs, may become bioavailable after deposition followed by distribution of unmetabolized chemicals to the circulation and to extrapulmonary target sites (Gerde et al. 2001). It is also possible that a small fraction of toxic components is carried via various translocation mechanisms into the circulation on UFPs (Mühlfeld et al. 2008). However, translocation may account for a potentially insignificant amount of the impact of UFPs compared with the high retention of UFPs in the lungs (Möller et al. 2008), which may lead to sustained effects through the gradual transfer of redox-active components to the circulation over many days.

Although transition metals are known to be redox active, we found no consistent associations with the biomarkers measured, possibly because of low concentrations of these trace elements in the study areas.

Finding positive associations of biomarkers with both indoor and outdoor PAHs and hopanes along with the indoor/outdoor ratios of these organic components being close to 1.0 suggests that, even though people spend most of their time indoors, indoor air quality and PM exposures are strongly influenced by PM of outdoor origin. These findings are consistent with our previous analysis for the first half of this panel showing that CMB-estimated indoor PM of outdoor origin (particle number, EC, and primary OC) were associated with the biomarkers to a similar degree as outdoor PM (Delfino et al. 2008).

Briefly, the exploratory (data-driven) findings for GPx-1 and especially Cu,Zn-SOD are consistent with our previous findings for primary OC and EC (Delfino et al. 2009) and suggest antioxidant enzyme inactivation within erythrocytes by traffic-related pollutant components, including PAHs, among a subgroup of people. This inactivation is anticipated to increase oxidative stress and thus inflammation. This is potentially important because these enzymes likely represent important intermediate end points that have been linked to the risk of developing coronary artery disease in prospective cohort and other studies (Flores-Mateo et al. 2009). Given that these findings were far less clear when including the entire 60-subject panel (because a small subgroup of seven subjects had positive associations), these results should be viewed as hypothesis generating and retested in other populations. See Delfino et al. (2009) for further details and discussion concerning potential mechanisms of antioxidant enzyme inactivation versus up-regulation that may explain group differences.

Strengths of the present study lie in exposure measurements in each subject's community microenvironment and in repeated biological marker assessments in a well-characterized patient sample. Limitations include the potential for unmeasured temporal confounding. However, we performed *a priori* adjustment for one of the largest sources of variability in inflammatory mediators that have been documented in the literature (infections), and we also accounted for temperature and for community and seasonal variability in exposures. We also acknowledge that the present study does perform multiple comparisons, although we did narrow the number of hypotheses being tested based on prior evidence of associations from the work of others and ourselves.

The results of the present study suggest that tracer components of mobile source emissions in $PM_{0.25}$ are associated with increased systemic inflammation in a potentially susceptible population of elderly individuals. The measured biomarkers likely represent important intermediate end points (systemic inflammation) that have been linked to the risk of cardiovascular diseases in prospective cohort and other studies (Kritchevsky et al. 2005; Pai et al. 2004). The positive relation between air pollution and cytokine biomarkers may also be indicative of acute risk of adverse cardiovascular outcomes related to vascular dysfunction and atherothrombosis (Mills et al. 2009). We recently reported coherent associations between hourly ambulatory systolic and diastolic blood pressure and hourly air pollutant exposures in the present panel cohort, including stronger associations with primary $PM_{2.5}$ OC compared with secondary $PM_{2.5}$ OC (Delfino et al. 2010).

We conclude that U.S. EPA–regulated ambient $PM_{2.5}$ mass measurements may not adequately represent risk to human health because they are uncharacterized by composition, source, or PM size distribution and are not necessarily representative of personal or local exposure. Confirmatory data are needed in other populations using measurements of organic components across several PM size fractions.

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Health Impacts of the Built Environment: Within-Urban Variability in Physical Inactivity, Air Pollution, and Ischemic Heart Disease Mortality

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BACKGROUND: Physical inactivity and exposure to air pollution are important risk factors for death and disease globally. The built environment may influence exposures to these risk factors in different ways and thus differentially affect the health of urban populations.

OBJECTIVE: We investigated the built environment's association with air pollution and physical inactivity, and estimated attributable health risks.

METHODS: We used a regional travel survey to estimate within-urban variability in physical inactivity and home-based air pollution exposure [particulate matter with aerodynamic diameter ≤ 2.5 μm ($PM_{2.5}$), nitrogen oxides (NO_x), and ozone (O_3)] for 30,007 individuals in southern California. We then estimated the resulting risk for ischemic heart disease (IHD) using literature-derived dose–response values. Using a cross-sectional approach, we compared estimated IHD mortality risks among neighborhoods based on "walkability" scores.

RESULTS: The proportion of physically active individuals was higher in high- versus low-walkability neighborhoods (24.9% vs. 12.5%); however, only a small proportion of the population was physically active, and between-neighborhood variability in estimated IHD mortality attributable to physical inactivity was modest (7 fewer IHD deaths/100,000/year in high- vs. low-walkability neighborhoods). Between-neighborhood differences in estimated IHD mortality from air pollution were comparable in magnitude (9 more IHD deaths/100,000/year for $PM_{2.5}$ and 3 fewer IHD deaths for O_3 in high- vs. low-walkability neighborhoods), suggesting that population health benefits from increased physical activity in high-walkability neighborhoods may be offset by adverse effects of air pollution exposure.

POLICY IMPLICATIONS: Currently, planning efforts mainly focus on increasing physical activity through neighborhood design. Our results suggest that differences in population health impacts among neighborhoods are similar in magnitude for air pollution and physical activity. Thus, physical activity and exposure to air pollution are critical aspects of planning for cleaner, health-promoting cities.

KEY WORDS: active travel, air quality, environmental planning, infill, risk assessment, urban form. *Environ Health Perspect* 120:247–253 (2012). http://dx.doi.org/10.1289/ehp.1103806 [Online 17 October 2011]

Physical inactivity is associated with increased risk of several adverse health outcomes including heart disease, type 2 diabetes, colon cancer, breast cancer, and mortality (Colditz et al. 1997; Kelley and Goodpaster 2001; Kohl 2001; Verloop et al. 2000). Active commuting, such as walking or biking to work on a daily basis, has been shown to decrease risk of all-cause mortality and cardiovascular disease (Andersen et al. 2000; Hamer and Chida 2008; Zheng et al. 2009). Various attributes of the built environment (e.g., population density, street connectivity, land use mix) have been associated with rates of physical activity at the neighborhood level (Ewing et al. 2003; Frank et al. 2005; Saelens et al. 2003a; Sallis et al. 2009). Furthermore, the type of transportation mode used (public transit vs. car) affects personal energy expenditure (Morabia et al. 2010). Thus, an important research question is whether urban planning can reduce physical inactivity and improve health.

Exposure to outdoor urban air pollution is associated with various adverse health outcomes including heart disease, respiratory disease, lung cancer, asthma, and mortality (Brunekreef and Holgate 2002; Gent et al. 2003; Pope and Dockery 2006; Pope et al. 2002). Chronic exposures vary at similar magnitudes within-cities as between-cities (Jerrett et al. 2005; Miller et al. 2007), suggesting that neighborhood location, urban design, and proximity to roads can affect exposures (Health Effects Institute 2009; Marshall et al. 2005).

Recently, the World Health Organization (WHO) cited physical inactivity (4th) and exposure to outdoor urban air pollution (14th) among the top 15 risk factors for the Global Burden of Disease (WHO 2009); for high-income countries, these ranks are 4th (physical inactivity) and 8th (outdoor air pollution). Urban planning and the built environment may differentially influence exposures to those two risk factors (Marshall et al. 2009). A small number of studies have investigated the effects of exercise while controlling for air pollution exposure (de Nazelle et al. 2009; Wong et al. 2007) or explored regional- or national-scale theoretical shifts to active travel (de Hartog et al. 2010; Grabow et al. 2011); however, accounting for health outcomes from exposure to air pollution and physical inactivity among neighborhood types is a little-studied area.

We used risk assessment to explore urban-scale spatial patterns in exposures associated with the built environment. We investigated differences in urban form that have been associated with physical inactivity and air pollution [specifically, particulate matter with aerodynamic diameter ≤ 2.5 μm ($PM_{2.5}$), nitrogen oxides (NO_x), and ozone (O_3)] to assess relationships between urban form and public health.

Methods

Our approach combined four primary sources of information: a geocoded, self-report travel diary to indicate home location and physical activity levels for a specific cohort (n = 30,007); modeled and measured estimates of outdoor air pollution concentrations and their variability in space and time; literature-derived estimates relating ischemic heart disease (IHD) rates with physical inactivity and exposure to air pollution; and geographic information system (GIS) land use variables related to walkability. Our method is descriptive (i.e., cross-sectional) and aims to explore long-term health effects of neighborhood characteristics and location. Figure 1 illustrates our risk assessment approach.

Physical inactivity and air pollution exposures. We used the year 2001 Post-Census Regional Travel Survey to estimate exposure to physical inactivity and home-based exposure to outdoor air pollution. This survey, which covers southern California communities such as Orange County and Los Angeles, included a geocoded time–activity

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Supplemental Material is available online (http://dx.doi.org/10.1289/ehp.1103806).

Research was partially conducted while S.H. and J.D.M. were visiting researchers at the Centre de Recerca en Epidemiologia Ambiental (CREAL; Center for Research in Environmental Epidemiology), Barcelona, Spain. We thank several CREAL researchers, including A. de Nazelle, M. Nieuwenhuijsen, D. Rojas-Rueda, and others in the Transportation, Air Pollution, and Physical Activities project for helpful feedback. The three anonymous reviewers provided excellent comments.

The authors declare they have no actual or potential competing financial interests.

Received 11 April 2011; accepted 17 October 2011.

diary that captured self-reported activities and travel during fall 2001 and spring 2002. The survey population consisted of a random sample of residents, recruited by telephone in six southern California counties [Imperial, Los Angeles, Orange, Riverside, San Bernardino, and Ventura; for survey details, see Southern California Association of Governments (SCAG 2003)]. To our knowledge, no other metropolitan-scale travel survey has been used to estimate physical activity and exposure to air pollution (Marshall et al. 2006); in addition, this survey represents one of the largest exposure-relevant surveys available for any urban area in the world.

Of the 40,376 survey respondents, 30,007 (74%) met our inclusion criteria: *a*) geocoded home location [2,346 respondents excluded (5.8%)], *b*) home location within the air pollution modeling domain—the South Coast Air Basin [4,491 respondents excluded (11.1%)], and *c*) complete demographic information [age, sex, and ethnicity; 3,532 respondents excluded (8.7%)]. The survey generally covered 1 weekday per participant. We multiplied each participant's 1-day physical activity record by 7 to obtain an estimate of weekly minutes of physical activity. This approach assumed that physical activity was constant across all days of the week. Population-average levels of physical activity were similar (< 15% difference) between weekdays and weekends (11 vs. 12 min/day, respectively) based on data from a small number of respondents (13%, n = 5,104) who participated in an additional weekend survey supplement (see sensitivity analysis 1, below). The survey recorded total physical activity and separately disaggregated that total into active transport (e.g., walking, bicycling) versus recreational activities (e.g., sports, working out at a gym).

Our primary estimates for air pollution exposure were based on monitoring data [U.S. Environmental Protection Agency (EPA) 2010] for $PM_{2.5}$, NO_x, and O_3 in 2001. We interpolated concentrations [inverse-distance weighted average of the nearest three monitors (Marshall et al. 2008)] to each survey participant's home location. Each pollutant had several monitoring stations ($PM_{2.5}$, 27; NO_x, 42; O_3, 52), providing good spatial coverage for the 36,000-km^2 study area. We estimated the annual average of daily 1-hr maximum concentrations for O_3 and annual-average concentrations for $PM_{2.5}$ and NO_x at each survey participant's residence to match the metrics used in the epidemiological studies that we used to estimate IHD risks. We used spatial interpolation for the base case because it can be used for all three pollutants and is easily transferable to other urban areas.

Neighborhood walkability. We calculated three built environment variables to represent neighborhood type: *a*) population density, *b*) intersection density, and *c*) land use mix. Neighborhoods that were in the upper (lower) tertile of all three built environment variables were defined as high- (low-) walkability neighborhoods. This approach classified 12% of the survey population as living in a high-walkability neighborhood and 18% as living in a low-walkability neighborhood. We used objective measurements of the built environment rather than geographical overlays to match methods commonly used in the urban planning literature. Although no standard measure of walkability exists, most indices include measures of density, connectivity, and land use mix (Ewing and Cervero 2001). As a sensitivity analysis, based on prior research (Marshall et al. 2009) we implemented a second definition that classified 33% of survey participants in high- and 33% in low-walkability neighborhoods [for methods, see Supplemental Material, p. 2 (http://dx.doi.org/10.1289/ehp.1103806)]. Results were similar for both definitions; therefore, we report results using the first definition only.

Population density. We used U.S. Census data from the year 2000 to calculate population density at the tract level for each household (U.S. Census Bureau 2000). Population density has been shown to be a predictor of per capita automobile travel (Holtzclaw et al. 2002; Marshall 2008) and trip length (Ewing and Cervero 2001), both of which are predictors of bicycling and walking (Handy et al. 2002).

Intersection density. Intersection density was calculated using road TIGER/Line data (U.S. Census Bureau 2000). A 1-km non-freeway network buffer was generated for each household using ArcGIS (version: 9.3.1, ESRI; Redlands, CA, USA). Intersections (more than two road segments) were summed within the buffer, yielding a measure of street connectivity. Previous studies show that street connectivity may reduce vehicle travel and increase walking (Ewing and Cervero 2001; Forsyth et al. 2008).

Land use mix. Following Frank et al. (2004), we calculated a land use mix index for each household location. Aerial land use data was obtained from SCAG for the year 2001 (SCAG 2010). The index [see Supplemental Material, pp. 2–3 (http://dx.doi.org/10.1289/ehp.1103806)] is a normalized ratio of the mix of four primary land uses (residential, commercial, retail, and institutional) to total land area within the 1-km network buffer. The index ranges from 0 to 1: A value of 1 represents an equal mixture of the four land uses; a value of 0 indicates 100% of land is a single land use. Impacts of land use mix on health include reducing obesity (Frank et al. 2005) and increasing physical activity (Saelens et al. 2003b).

Dose–response and relative risk estimates. For each survey participant (i.e., at the individual level), we estimated relative risks (RRs) attributable to outdoor air pollution and physical inactivity for one important health outcome: IHD. IHD is consistently associated with outdoor air pollution and physical inactivity (WHO 2009), is responsible for a large proportion of deaths in the United States (~ 18% of all deaths and 67% of heart disease deaths in 2006) [Centers for Disease Control and Prevention (CDC) 2009], and has been shown to be an important health outcome for both risk factors when considering large-scale shifts to active travel (Woodcock et al. 2009). Because our exposure estimates for air pollution are continuous, we estimated an RR for each survey participant based on a linear dose–response [see Supplemental Material, Figure S2 (http://dx.doi.org/10.1289/ehp.1103806)] for the range of observed air pollutant concentrations and the referent exposure levels described below. In contrast, WHO (2004) suggests a three-tier dose–response for physical activity: *a*) active (exercise for > 150 min/week; RR = 1), *b*) insufficiently active (exercise for 1–150 min/week; RR = 1.31), and *c*) inactive (0 min exercise per week; RR = 1.47), allowing for only three possible physical activity RRs for each survey participant. We estimated

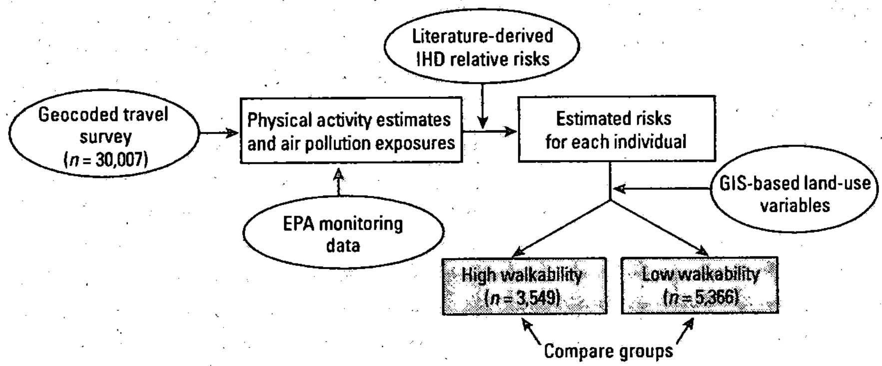

Figure 1. Conceptual framework for this risk assessment. Ovals are inputs, and boxes are midpoint calculations. Shaded boxes indicate estimated risk separated into two groups for comparison.

attributable fractions for outdoor air pollution and physical inactivity using the mean individual RR in high- or low-walkability neighborhoods.

Air pollution dose–response relationships were identified and selected as follows. We manually searched the tables of contents of four journals (*Journal of the American Medical Association, New England Journal of Medicine, British Medical Journal, Lancet*) for the years 2000–2010 for air pollution risk estimates. We also performed a search of key words in Google Scholar and ISI Knowledge, including (in various combinations) "air pollution," "$O_3/NO_x/PM_{2.5}$," "ischemic heart disease," "cardiovascular disease," "cardiopulmonary disease," "respiratory disease," "mortality," "health effects," "chronic/acute," and "dose–response." We used the "cited by" function in Google Scholar to explore subsequent studies related to each article. Through this process, we identified 62 articles. We then selected studies that focused on within-city variation and included IHD as a health outcome (Table 1).

Each RR for air pollution was estimated from cohort studies of long-term exposures; however, these estimates differed in important ways. For example, Nafstad et al. (2004) studied men 40–49 years of age, meaning our NO_x results cannot be generalized to other populations [RR = 1.08; 95% confidence interval (CI): 1.06, 1.11]. Jerrett et al. (2005) used a subset of the American Cancer Society (ACS) cohort (Los Angeles, CA, USA) to estimate a within-city RR of 1.25 per 10 μg/m³ increase in $PM_{2.5}$ (95% CI: 0.99, 1.59). Jerrett et al. (2005) did not report a significant RR for $PM_{2.5}$ in Los Angeles, but the RR estimate is roughly consistent with two between-city studies that did report statistically significant RRs: Pope et al. (2004; RR = 1.18 per 10 μg/m³ increase in $PM_{2.5}$; 95% CI: 1.14, 1.23) and Jerrett et al. (2009; RR = 1.21; 95% CI: 1.16, 1.27). The Jerrett et al. (2009) RR for a 10 μg/m³ increase in O_3 (1.008; 95% CI: 1.002, 1.013) was based on between-city variation (ACS cohort) in 96 U.S. metropolitan statistical areas generated from a one-pollutant model. However, it is important to note that Jerrett et al. (2009) reported a protective effect for O_3 based on a two-pollutant model adjusted for $PM_{2.5}$ (RR = 0.97; 95% CI: 0.96, 0.99), and overall there is less evidence in the literature for O_3 associations with IHD compared with those for $PM_{2.5}$. A within-city study of O_3 and IHD was not available.

The referent exposure levels used to estimate individuals' RRs were "active" for physical inactivity (> 150 min of moderate-vigorous activity per week), and the 10th percentile of exposure (survey population based; values: 13.6 μg/m³ for $PM_{2.5}$, 39.8 μg/m³ for NO_x, 80.3 μg/80.3 μg/m³ for O_3) for air pollution, consistent with exposures in a relatively clean neighborhood in the study area. Each survey participant's air pollution RR was estimated based on the difference between their home-location air pollution exposure and the referent exposure level. For example, for $PM_{2.5}$, an individual whose home-location exposure estimate was 23.6 μg/m³ (10 μg/m³ above the referent level) would be assigned an RR of 1.25.

Population-attributable fraction. We calculated population-attributable fraction (PAF) and estimated attributable IHD mortality rates for each risk factor in high- and low-walkability neighborhoods. PAF for a neighborhood was calculated based on the proportion of individuals exposed to each risk factor and average RR among all individuals in a neighborhood (Baker and Nieuwenhuijsen 2008):

$$\mathrm{PAF} = \frac{p \times (\mathrm{RR} - 1)}{[p \times (\mathrm{RR} - 1)] + 1}. \qquad [1]$$

Here, RR is the mean individual RR in each group (high- and low-walkability neighborhoods) and risk factor, and p is the proportion of individuals exposed in each group (defined by our referent exposure levels). We used the 2000–2001 age-adjusted IHD mortality rate in California (191.2 IHD deaths/100,000/year; CDC 2011) to estimate deaths within each group and subsequent attributable IHD mortality rates (except for NO_x where we used the IHD mortality rate for men in California 45–54 years of age: 81.9 IHD deaths/100,000/year). Attributable mortality due to physical inactivity, $PM_{2.5}$, NO_x, and O_3 cannot be summed because of confounding among the risk factors and overlap of at-risk populations. Therefore, we report attributable mortality due to the different factors separately.

We separately calculated PAF using a method with multiple exposure levels instead of the dichotomous exposure levels implicit in Equation 1, as described in the Supplemental Material [pp. 5–6 (http://dx.doi.org/10.1289/ehp.1103806)] Results based on this alternative method were similar to those reported below.

Sensitivity analyses. To explore the robustness of our estimates, we used three sensitivity analyses to assess *a*) different methods of scaling minutes of physical activity, *b*) alternate modeling approaches for air pollution, and *c*) stepwise versus linear dose–response for physical activity.

Sensitivity analysis 1: scaling method for minutes of physical activity. Our approach requires extrapolating weekly exercise rates based on the 1-day travel diary because most physical activity epidemiological literature employs the metric "minutes of physical activity per week." To test the limitations of this extrapolation for our analysis, we developed a Monte Carlo simulation that relaxes our base-case assumption (i.e., that individuals' physical activity rates are constant by day), by employing two alternative assumptions: that people who are nonsedentary are physically active *a*) every other day or *b*) every third day. The Monte Carlo simulation distributes total minutes of physical activity accordingly, stratifying by age, sex, and ethnicity. The resulting distributions of physical activity better approximate national estimates on the prevalence of physical inactivity (WHO 2004).

Sensitivity analysis 2: air pollution model. Our base-case analysis used spatial interpolation of U.S. EPA monitoring data, which are readily available for all three pollutants for many urban areas. We compared results using a Eulerian dispersion model [Comprehensive Air Quality Model with Extensions (CAMx); http://www.camx.com; nitrous oxide (NO), nitrogen dioxide (NO_2), O_3] and land-use regression (LUR; NO_2; Novotny et al. 2011). CAMx and LUR provide greater spatial precision than inverse-distance weighting but may or may not be available in other urban areas.

Sensitivity analysis 3: physical activity dose–response. We tested the sensitivity of our results to the dose–response curve for physical inactivity. Our base case used the stepwise dose–response from WHO (2004) (Table 1). For this sensitivity analysis, we generated three linear dose–response curves (low, medium, and high slopes) based on the same WHO values.

Results

Annual-average air pollution exposure for the survey population averaged 49 μg/m³ for NO_2 [interquartile range (IQR), 41–60 μg/m³), 99 μg/m³ for O_3

Table 1. Summary of RR estimates used for IHD.

Study	Risk factor	Study details	RR (95% CI)
Nafstad et al. 2004	NO_x	Within-city; men 40–49 years of age in Oslo, Norway (n = 16,209)	1.08[a] (1.06, 1.11) per 10 μg/m³
Jerrett et al. 2005	$PM_{2.5}$	Within-city; subset (Los Angeles, CA) of the ACS cohort (n = 22,905)	1.25[a] (0.99, 1.59) per 10 μg/m³
Jerrett et al. 2009	O_3	Between-cities; ACS cohort (n = 448,850)	1.008[a] (1.002, 1.013) per 10 μg/m³
WHO 2004	Physical inactivity	Meta-analysis of 20 studies from two continents (Western Europe, 8; North America, 12; total n = 327,004)	Insufficiently active:[b] 1.31 (1.21, 1.41) Inactive:[b] 1.47 (1.39, 1.56)

[a]Air pollution risk estimates used here were based on long-term cohort studies and chronic health effects. [b]Referent, > 150 min/week; insufficiently active, 1–150 min/week; inactive, 0 min/week.

(86–112 μg/m³; annual average of 1-hr daily maximums), and 22 μg/m³ for $PM_{2.5}$ (20–24 μg/m³; Table 2). Mean NO_2 exposures were below current ambient-air standards [U.S. EPA and California Environmental Protection Agency (CalEPA) standards, respectively: 100 and 57 μg/m³]. $PM_{2.5}$ exposures were approximately 1.5 and 2 times higher than U.S. EPA (15 μg/m³) and CalEPA (12 μg/m³) long-term standards (annual arithmetic mean), respectively (California Air Resources Board 2010).

Table 2. Descriptive statistics by neighborhood type [mean (IQR)].

Variable	All (n = 30,007)	Low walkability (n = 5,366)	High walkability (n = 3,549)
Age (years)	38 (21–54)	41 (23–58)	34 (20–47)
Nonwhite (%)	40	23	65
Male (%)	50	49	50
Income > $50,000 per year (%)	48	57	31
College or more (%)	46	52	40
NO_x (μg/m³)[a]	85 (68–103)	67 (50–88)	106 (89–130)
O_3 (μg/m³)[b]	99 (86–112)	111 (97–124)	86 (82–92)
$PM_{2.5}$ (μg/m³)[a]	22 (20–24)	20 (14–25)	23 (22–24)
Physical activity (min/week)	77 (0–0)	68 (0–0)	102 (0–0)
Population density in Census tract (people/km²)[c]	22,400 (7,800–28,400)	3,100 (600–5,200)	53,500 (31,900–61,600)
Intersection density (1-km network buffer)[c]	57 (27–82)	11 (2–20)	109 (86–114)
Land use mix (1-km network buffer)[c]	0.37 (0.25–0.49)	0.13 (0–0.23)	0.59 (0.50–0.66)

All continuous variables in high-walkability neighborhoods have statistically significant differences (for all variables $p < 0.001$) compared with low-walkability neighborhoods (two-tailed t-test).
[a]Home-location annual-average concentrations. [b]Home-location annual average of daily 1-hr maximum concentrations. [c]This land use variable was used to define walkability.

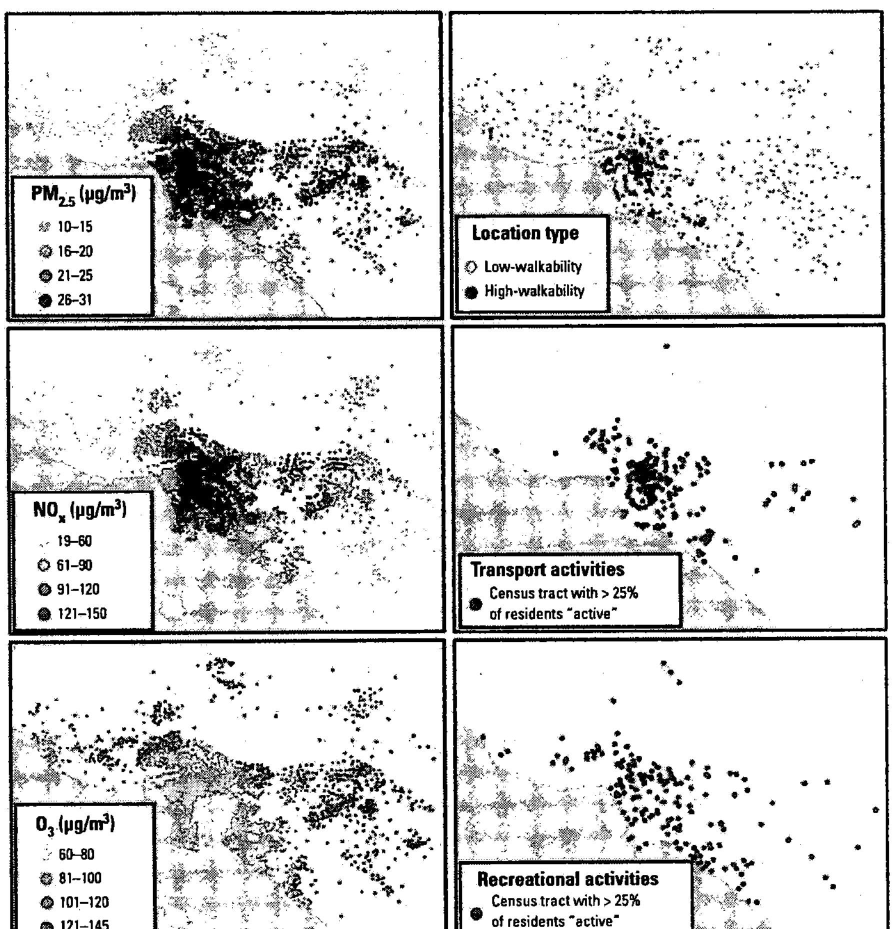

Figure 2. Spatial variation of air pollution exposure and physical inactivity. Physical activity estimates were derived from time–activity diaries, air pollution exposures were calculated from U.S. EPA monitoring data, and walkability was defined using publicly available land use variables. Icons for transport and recreational activities represent census tracts where > 25% of the survey respondents reported > 150 min/week of that activity type.

Self-reported physical activity levels averaged 77 min/week (IQR, 0–0 min/week; i.e., the 25th and 75th values are 0 min/week; Table 2). Most (83.5%) of the survey participants reported being inactive (0 min/week), 5.6% reported being insufficiently active (1–150 min/week), and 10.9% reported being active (> 150 min/week; physical activity recommendations; U.S. Department of Health and Human Services 1996). Activity levels were notably lower than national averages (U.S. averages: inactive, 29%; insufficiently active, 45%; active, 26%; WHO 2004). Sensitivity analysis 1 addresses this difference in activity levels.

NO_x and $PM_{2.5}$ concentrations were highest near the city center and major roadways, whereas O_3 concentrations were higher in the outer-lying areas (Figure 2). Because of this spatial pattern, few locations experienced low exposure to all three pollutants. Spatial patterns for physical activity were dependent on the purpose of the activity; there was no discernable spatial pattern for recreational activities, but active transport was clustered near high-walkability neighborhoods (Figure 2).

Average per capita physical activity was 50% higher in high- than in low-walkability neighborhoods (102 vs. 68 min/week; Figure 3). The number of nonsedentary individuals (people with > 0 min/week physical activity) was two times higher in high- versus low-walkability neighborhoods (24.9% and 12.5%, respectively; $p < 0.001$). However, considering nonsedentary individuals only, average physical activity was 24% lower in high- than in low-walkability neighborhoods (410 vs. 543 min/week). This finding suggests that neighborhood type may have differing impacts on the number of people participating in physical activities, average physical activity among all individuals, and average physical activity among nonsedentary individuals.

The self-reported purpose of physical activity differs by neighborhood (Figure 3). For example, active transport accounts for about half of physical activity in the high-walkability neighborhoods but only 20% in low-walkability neighborhoods. Active transport is 3.6 times higher in high- versus low-walkability neighborhoods (a finding that partially corroborates our GIS estimates of walkability), whereas nontravel activity is similar (< 10% difference) in low- versus high-walkability neighborhoods. Activity level and purpose exhibited greater weekend/weekday differences in low-walkability areas than in high-walkability areas [see Supplemental Material, Table S2, Figure S4 (http://dx.doi.org/10.1289/ehp.1103806)].

Figure 4 shows estimated attributable IHD mortality rates for each neighborhood type and risk factor. Physical inactivity was more strongly associated with IHD mortality (51 additional deaths/100,000/year overall) than were the other exposures, but IHD mortality attributable to physical inactivity was only slightly different between high- and low-walkability neighborhoods (7 fewer IHD deaths/100,000/year in high- vs. low-walkability). Conversely, overall estimated attributable IHD mortality due to exposure to $PM_{2.5}$ was smaller (30 deaths/100,000/year), but the difference between neighborhoods was slightly larger than for physical inactivity (9 more IHD deaths/100,000/year in high- vs. low-walkability). O_3 shows the reverse spatial pattern as $PM_{2.5}$ (i.e., O_3 exposure is higher in low-walkability neighborhoods, whereas $PM_{2.5}$ is lower) but a smaller difference in mortality between neighborhoods (3 fewer IHD deaths/100,000/year in high- vs. low-walkability). Attributable IHD mortality rates for NO_x (represented by risk estimates for men 40–49 years of age; not shown in Figure 4) were 13 (28) IHD deaths/100,000/year for low- (high-) walkability neighborhoods. Attributable risk estimates for physical inactivity, $PM_{2.5}$, and O_3 showed similar patterns when neighborhoods were classified according to deciles of walkability scores [Supplemental Material, Figure S5 (http://dx.doi.org/10.1289/ehp.1103806)].

Sensitivity analysis 1: scaling method for minutes of physical activity. Results [see Supplemental Material, pp. 8–9 (http://dx.doi.org/10.1289/ehp.1103806)] indicate that our alternative assumptions reduce the variability in physical activity among neighborhoods. Specifically, the Monte Carlo simulation increases the share of nonsedentary individuals (subsequently reducing average risks from physical inactivity) but also yields reductions in estimated IHD mortality differences among neighborhoods. Our core conclusions are similar among the Monte Carlo simulations.

Sensitivity analysis 2: air pollution model. Central tendencies varied by pollutant and model; however, trends in the core conclusions (i.e., shifts in exposure and risk by neighborhood type) were similar where it was possible to compare [see Supplemental Material, pp. 9–10 (http://dx.doi.org/10.1289/ehp.1103806)]. In general, differences in estimated IHD mortality rates between high- and low-walkability neighborhoods were larger when using the alternate models; therefore, base-case results reported above may be conservative estimates (i.e., underestimates) of air pollution spatial variability.

Sensitivity analysis 3: physical activity dose–response. Our results did not change appreciably when using the linear dose–response curves [see Supplemental Material, pp. 10–11 (http://dx.doi.org/10.1289/ehp.1103806)].

We also estimated RRs according to neighborhood type (high- or low-walkability) within strata of age (0–25 years, 26–50 years, > 50 years) and according to income and ethnicity [high income (> $75,000) and white vs. low income (< $35,000) and nonwhite]. The results reveal similar trends in risk differences between neighborhoods for each strata, suggesting that our results are robust to accounting for differences in income, ethnicity, and age. Details are in the Supplemental Material [pp. 11–14, Table S6 (http://dx.doi.org/10.1289/ehp.1103806)]. Prior literature further explores socioeconomic aspects of this topic (e.g., Ewing 2005; Frank et al. 2007; Sallis et al. 2009).

Discussion

Our analysis summarizes between-neighborhood variations in two risk factors (exposure to air pollution, physical inactivity) using a time–activity travel diary for one region. We found risks were differential when stratified by neighborhood walkability. Specifically, when comparing estimated IHD mortality rates among neighborhoods, differences attributable to physical inactivity were modest and comparable to differences attributable to individual air pollutants. Because of spatial patterns associated with each pollutant, urban residents were often highly exposed to at least one but not all pollutants (e.g., high exposure to O_3 in low-walkability neighborhoods or high exposure to $PM_{2.5}$ in high-walkability neighborhoods). This trade-off suggests that the net health impact of neighborhoods may depend in part on spatial patterns of air pollution.

Recent health comparisons between air pollution and exercise (Carlisle and Sharp 2001; de Hartog et al. 2010) emphasize the greater health importance of exercise relative to air pollution. This prior research considered only people who exercise (Carlisle and Sharp 2001; de Hartog et al. 2010); here, we consider the entire population—nonsedentary plus sedentary individuals. Only a subset of a given population is physically active, and only a subset of that physical activity is influenced by neighborhood design; here, the net result is that spatial differences in attributable IHD mortality risks are of similar magnitude for physical inactivity as for air pollution. Our results indicate a doubling in the share of nonsedentary people in high- versus low-walkability neighborhoods (24.9% vs. 12.5%); however, all individuals—inactive and active—experience changes in air pollution exposures. For this study population, physical activity rates were higher (and exercise-attributable IHD mortality rates lower) in high- than in low-walkability neighborhoods. However, because variations in air pollution risk are similar to variations in physical inactivity risks, when comparing high- versus low-walkability neighborhoods, health benefits from increased physical activity may be offset by health risks from air pollution exposure.

Our study uses self-reported rather than objectively measured physical activity. Previous studies that have used objectively-measured physical activity to investigate effects of urban form on physical activity (Table 3) have reported mixed results: two studies reported

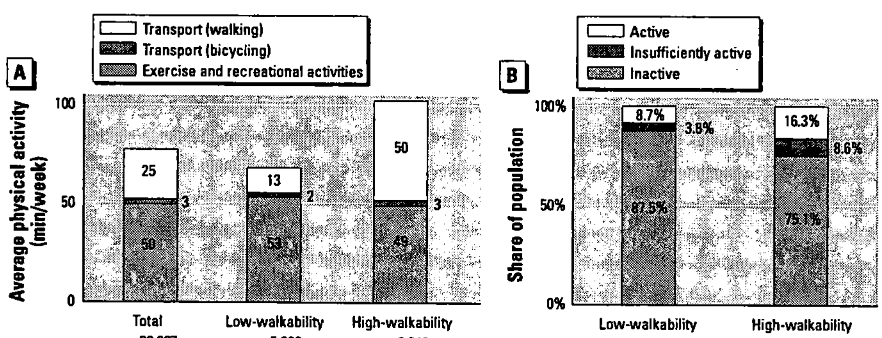

Figure 3. Differences among neighborhoods. (*A*) Average active transport (minutes walking and bicycling per person) and recreational activities. (*B*) Physical activity levels. The between-neighborhood difference in total physical activity is statistically significant ($p < 0.001$, two-tailed t-test).

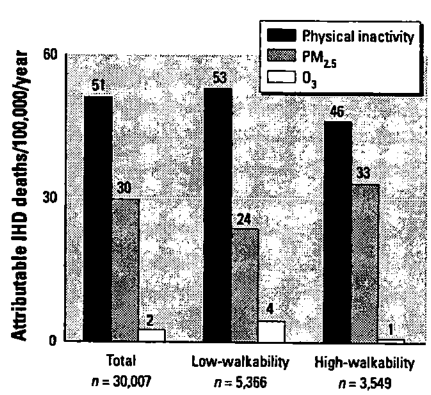

Figure 4. Estimated attributable IHD mortality rates for each risk factor and neighborhood type. Rates were calculated using means of individual RRs and prevalence of exposure within neighborhood type [referent, > 150 min/week of physical activity; 10th percentile of air pollution exposure (13.6 μg/m³ for $PM_{2.5}$, 39.8 μg/m³ for NO_x, and 80.3 μg/m³ for O_3)]. The overall incidence of IHD mortality in California is 191 deaths/100,000/year (CDC 2011).

Table 3. Comparison of results from studies using objective measures of physical activity with results from the present study.

Study	Location	Measure of physical activity	Measure of urban form	Core result
Sallis et al. 2009	Seattle, WA, and Baltimore, MD	Objective: 7-day accelerometer	Walkability (net residential density, intersection density, land use mix, retail floor area ratio)	41 min/week increase in physical activity between high- vs. low-walkability neighborhoods
Frank et al. 2005	Atlanta, GA	Objective: 2-day accelerometer	Walkability (net residential density, intersection density, land use mix)	Two-fold increase in meeting physical activity recommendations in high- vs. low-walkability neighborhoods
Forsyth et al. 2008	St. Paul, MN	Objective: 7-day accelerometer	Population density, block size (street pattern)	Significant increase in transport-related physical activity (high- vs. low-walkability neighborhoods) but no difference in total physical activity
Present study	South Coast Air Basin, CA	Self-report: one-day time activity diary	Walkability (population density, intersection density, land use mix)	34 min/week increase in physical activity between high- vs. low-walkability neighborhoods (2-fold increase in meeting physical activity recommendations)

differences in physical activity by neighborhood type (Frank et al. 2005; Sallis et al. 2009), and one indicated shifts in the purpose (transport vs. fitness) but not the amount of physical activity (Forsyth et al. 2008). These findings suggest that urban-scale differences in physical activity rates are similar between objectively measured physical activity and our self-reported measures of activity. For example, differences in per capita physical activity between high- and low-walkability neighborhoods in Seattle, Washington, and Baltimore, Maryland, were similar to differences in our southern California population [41 min/week (Seattle, Baltimore) versus 34 min/week (southern California) (Sallis et al. 2009)].

Our study limitations include those associated with travel surveys and self-reported information in general. For example, travel surveys typically undercount trips by all modes (Bricka and Bhat 2006), affecting estimates of travel time (Wolf et al. 2003). The SCAG survey suggests that vehicle undercount rates may approach 20–25% but gives little information regarding nonmotorized trips (SCAG 2004). Undercount rates may be differential by trip length (SCAG 2004), mode, or neighborhood. Comparisons with studies using objectively measured physical activity (see preceding paragraph) suggest that our core findings are robust to trip undercounting and other problems with self-reported travel data.

Our work is motivated by the goal of understanding and designing clean, healthy, sustainable cities (Giles et al. 2011). Our investigation explores only one location (Los Angeles), one health outcome (IHD), one cohort, a small number of pollutants (NO_x, $PM_{2.5}$, O_3), and physical inactivity. Clearly, further analyses incorporating other risk factors (e.g., noise, transport injury) linked to the built environment are warranted. Interaction between physical activity and air pollution may vary on an even smaller scale than we have investigated in the present study (i.e., within neighborhoods). Future analyses could use age-specific risks of IHD mortality for air pollution and physical inactivity. Our analysis is descriptive (i.e., cross-sectional) in nature; more research is needed to explore causality between urban form and health risks (especially for physical activity, because ambient air pollution exposure is largely determined by geographical location).

Despite these limitations, our results are relevant to health officials, sustainability scientists, and urban planners. To our knowledge, ours is the first analysis that directly compares health risks for both air pollution and physical inactivity among neighborhoods based on activity patterns for a random sample of residents in an urban area, and thus is the first to quantify relationships between urban form and the health impacts of physical activity and air pollution. We found that attributes of the built environment were associated with both air pollution exposure and physical inactivity. These results emphasize that to be health protective, neighborhoods designed to decrease risks from one factor must avoid unintentionally increasing risks from other factors.

Conclusion

We compared the health impacts attributable to air pollution and physical inactivity among neighborhoods for one cohort (~ 30,000 individuals in Southern California). A larger proportion of our Southern California study population was classified as nonsedentary in high- versus low-walkability neighborhoods (25% vs. 13%). However, because only a small share of the total population was classified as physically active, we estimated only moderate differences in IHD mortality rates attributable to physical inactivity between neighborhood types. Spatial patterns of estimated attributable IHD mortality rates varied by pollutant: estimated mortality due to increased $PM_{2.5}$ and NO_x were greater in high- than in low-walkability neighborhoods, whereas estimated IHD mortality due to increased O_3 was greater in low- than in high-walkability neighborhoods. In general, differences in estimated IHD mortality between neighborhoods were comparable for exposure to air pollutants and physical inactivity. Our results suggest complex within-urban spatial trade-offs in health risks associated with air pollution and physical inactivity. Efforts to design healthy neighborhoods should account for many factors, including air pollution and physical inactivity, and not address one concern at the expense of others.

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Attachment G

Brugge, Doug et al.
Near Highway Pollutants in Motor Vehicle Exhaust: A Review
of Epidemiologic Evidence of Cardiac and Pulmonary Health Risks
Environmental Health
August 9, 2007

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Environmental Health

Review

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Near-highway pollutants in motor vehicle exhaust: A review of epidemiologic evidence of cardiac and pulmonary health risks

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Published: 9 August 2007

Environmental Health 2007, **6**:23 doi:10.1186/1476-069X-6-23

Received: 2 January 2007

Accepted: 9 August 2007

This article is available from: http://www.ehjournal.net/content/6/1/23

Abstract

There is growing evidence of a distinct set of freshly-emitted air pollutants downwind from major highways, motorways, and freeways that include elevated levels of ultrafine particulates (UFP), black carbon (BC), oxides of nitrogen (NOx), and carbon monoxide (CO). People living or otherwise spending substantial time within about 200 m of highways are exposed to these pollutants more so than persons living at a greater distance, even compared to living on busy urban streets. Evidence of the health hazards of these pollutants arises from studies that assess proximity to highways, actual exposure to the pollutants, or both. Taken as a whole, the health studies show elevated risk for development of asthma and reduced lung function in children who live near major highways. Studies of particulate matter (PM) that show associations with cardiac and pulmonary mortality also appear to indicate increasing risk as smaller geographic areas are studied, suggesting localized sources that likely include major highways. Although less work has tested the association between lung cancer and highways, the existing studies suggest an association as well. While the evidence is substantial for a link between near-highway exposures and adverse health outcomes, considerable work remains to understand the exact nature and magnitude of the risks.

Background

Approximately 11% of US households are located within 100 meters of 4-lane highways [estimated using: [1,2]]. While it is clear that automobiles are significant sources of air pollution, the exposure of near-highway residents to pollutants in automobile exhaust has only recently begun to be characterized. There are two main reasons for this: (A) federal and state air monitoring programs are typically set up to measure pollutants at the regional, not local scale; and (B) regional monitoring stations typically do not measure all of the types of pollutants that are elevated next to highways. It is, therefore, critical to ask what is known about near-highway exposures and their possible health consequences.

Here we review studies describing measurement of near-highway air pollutants, and epidemiologic studies of cardiac and pulmonary outcomes as they relate to exposure to these pollutants and/or proximity to highways. Although some studies suggest that other health impacts are also important (e.g., birth outcomes), we feel that the case for these health effects are less well developed scientifically and do not have the same potential to drive public policy at this time. We did not seek to fully integrate the relevant cellular biology and toxicological literature, except for a few key references, because they are so vast by themselves.

We started with studies that we knew well and also searched the engineering and health literature on Medline. We were able to find some earlier epidemiologic studies based on citations in more recent articles. We include some studies that assessed motor vehicle-related pollutants at central site monitors (i.e., that did not measure highway proximity or traffic) because we feel that they add to the plausibility of the associations seen in other studies. The relative emphasis given to studies was based on our appraisal of the rigor of their methodology and the significance of their findings. We conclude with a summary and with recommendations for policy and further research.

Motor vehicle pollution

It is well known that motor vehicle exhaust is a significant source of air pollution. The most widely reported pollutants in vehicular exhaust include carbon monoxide, nitrogen and sulfur oxides, unburned hydrocarbons (from fuel and crankcase oil), particulate matter, polycyclic aromatic hydrocarbons, and other organic compounds that derive from combustion [3-5]. While much attention has focused on the transport and transformation of these pollutants in ambient air – particularly in areas where both ambient pollutant concentrations and human exposures are elevated (e.g., congested city centers, tunnels, and urban canyons created by tall buildings), less attention has been given to measuring pollutants and exposures near heavily-trafficked highways. Several lines of evidence now suggest that steep gradients of certain pollutants exist next to heavily traveled highways and that living within these elevated pollution zones can have detrimental effects on human health.

It should be noted that many different types of highways have been studied, ranging from California "freeways" (defined as multi-lane, high-speed roadways with restricted access) to four-lane (two in each direction), variable-speed roadways with unrestricted access. There is considerable variation in the literature in defining highways and we choose to include studies in our review that used a broad range of definitions (see Table 1).

It should also be noted that there may be significant heterogeneity in the types and amounts of vehicles using highways. The typical vehicle fleet in the US is composed of passenger cars, sports utility vehicles, motorcycles, pickup trucks, vans, buses, and small, medium, and large trucks. The composition and size of a fleet on a given highway may vary depending on the time of day, day of the week, and use restrictions for certain classes of vehicles. Fleets may also vary in the average age and state of repair of vehicles, the fractions of vehicles that burn diesel and gasoline, and the fraction of vehicles that have catalytic converters. These factors will influence the kinds and amounts of pollutants in tailpipe emissions. Similarly, driving conditions, fuel chemistry, and meteorology can also significantly impact emissions rates as well as the kinds and concentrations of pollutants present in the near-highway environment. These factors have rarely been taken into consideration in health outcome studies of near-highway exposure.

Based on our review of the literature, the pollutants that have most consistently been reported at elevated levels near highways include ultrafine particles (UFP), black carbon (BC), nitrogen oxides (NOx), and carbon monoxide (CO). In addition, $PM_{2.5}$, and PM_{10} were measured in many of the epidemiologic studies we reviewed. UFP are defined as particles having an aerodynamic diameter in the range of 0.005 to 0.1 microns (um). UFP form by condensation of hot vapors in tailpipe emissions, and can grow in size by coagulation. $PM_{2.5}$ and PM_{10} refer to particulate matter with aerodynamic diameters of 2.5 and 10 um, respectively. BC (or "soot carbon") is an impure form of elemental carbon that has a graphite-like structure. It is the major light-absorbing component of combustion aerosols. These various constituents can be measured in real time or near-real time using particle counters (UFP) and analyzers that measure light absorption (BC and CO), chemiluminescence (NOx), and weight ($PM_{2.5}$ and PM_{10}). Because UFP, NO_x, BC, and CO derive from a common source – vehicular emissions – they are typically highly inter-correlated.

Air pollutant gradients near highways

Several recent studies have shown that sharp pollutant gradients exist near highways. Shi et al. [6] measured UFP number concentration and size distribution along a roadway-to-urban-background transect in Birmingham (UK), and found that particle number concentrations decreased nearly 5-fold within 30 m of a major roadway (>30,000 veh/d). Similar observations were made by Zhu et al. [7,8] in Los Angeles. Zhu et al. measured wind speed and direction, traffic volume, UFP number concentration and size distribution as well as BC and CO along transects downwind of a highway that is dominated by gasoline vehicles (Freeway 405; 13,900 vehicles per hour; veh/h) and a highway that carries a high percentage of diesel vehicles (Freeway 710; 12,180 veh/h). Relative concentrations of CO, BC, and total particle number concentration decreased exponentially between 17 and 150 m downwind from the highways, while at 300 m UFP number concentrations were the same as at upwind sites. An increase in the relative concentrations of larger particles and concomitant decrease in smaller particles was also observed along the transects (see Figure 1). Similar observations were made by Zhang et al. [9] who demonstrated "road-to-ambient" evolution of particle number distributions near highways 405 and 710 in both winter and sum-

Table 1: Summary of near-highway pollution gradients

Citation	Location	Highway traffic intensity[a]	Pollutants measured[b]	Observed Pollution Gradients
Shi et al. 1999 (6)	Birmingham, UK	30,000 veh/d	UFP + FP (10-10^4 nm)	2–100 m [c]
Zhu et al. 2002 (8)	Los Angeles; Freeway 710	12,180 veh/h	UFP, CO, BC	17–300 m [c]
Zhu et al. 2002 (7)	Los Angeles; Freeway 405	13,900 veh/h	UFP, CO, BC	30–300 m [c]
Hitchins et al. 2002 (11)	Brisbane (Austr.)	2,130–3,400 veh/h	UFP + FP (15-2 × 10^4 nm), $PM_{2.5}$	15–375 m [c]
Fischer et al. 2000 (13)	Amsterdam	<3,000–30,974 veh/d	$PM_{2.5}$, PM_{10}, PPAH, VOCs	NA
Roorda-Knape et al. 1998 (14)	Netherlands	80,000–152,000 veh/d	$PM_{2.5}$, PM_{10}, BC, VOCs, NO_2	15–330 m [c]
Janssen et al. 2001 (15)	Netherlands	40,000–170,000 veh/d	$PM_{2.5}$, VOCs, NO_2	< 400 m [c]
Morawska et al. 1999 (12)	Brisbane (Austr.)	NA	UFP	10–210 m [c]

[a]As defined in article cited (veh/d = vehicles per day; veh/h = vehicles per hour).
[b]UFP = ultrafine particles; FP = fine particles; $PM_{2.5}$ = particles with aerodynamic diameter ≤ 2.5 um; PM_{10} = particles with aerodynamic diameter ≤ 10 um; BC = black carbon; PPAH = particle-bound polycyclic aromatic hydrocarbons; VOCs = volatile organic compounds
[c]Pollutant measurements were made along a transect away from the highway
NA = not applicable; measurements were not made.

mer. Zhang et al. observed that between 30–90 m downwind of the highways, particles grew larger than 0.01 um due to condensation, while at distances >90 m, there was both continued particle growth (to >0.1 um) as well as particle shrinkage to <0.01 um due to evaporation. Because condensation, evaporation, and dilution alter size distribution and particle composition, freshly-emitted UFP near highways may differ in chemical composition from UFP that has undergone atmospheric transformation during transport to downwind locations [10].

Two studies in Brisbane (Australia) highlight the importance of wind speed and direction as well as contributions of pollutants from nearby roadways in tracking highway-generated pollutant gradients. Hitchins et al. [11] measured the mass concentrations of 0.1–10 um particles as well as total particle number concentration and size distribution for 0.015–0.7 um particles near highways (2,130–3,400 veh/h). Hitchens et al. observed that the distance from highways at which number and mass concentrations decreased by 50% varied from 100 to 375 m depending on the wind speed and direction. Morawska et al. [12] measured the changes in UFP number concentrations along horizontal and vertical transects near highways to distinguish highway and normal street traffic contributions. It was observed that UFP number concentrations were highest <15 m from highways, while 15–200 m from highways there was no significant difference in UFP number concentrations along either horizontal or vertical transects – presumably due to mixing of highway pollutants with emissions from traffic on nearby, local roadways.

In addition to UFP, other pollutants – such as $PM_{2.5}$, PM_{10}, NO_2 (nitrogen dioxide), VOCs (volatile organic compounds), and particle-bound polycyclic aromatic hydrocarbons (PPAH) – have been studied in relation to heavily-trafficked roadways. Fischer et al. [13] measured $PM_{2.5}$, PM_{10}, PPAH, and VOC concentrations outside and inside homes on streets with high and low traffic volumes in Amsterdam (<3,000–30,974 veh/d). In this study, PPAH and VOCs were measured using methods based on gas chromatography. Fischer et al. found that while $PM_{2.5}$ and PM_{10} mass concentrations were not specific indicators of traffic-related air pollution, PPAH and VOC levels were ~2-fold higher both indoor and outdoor in high traffic areas compared to low traffic areas. Roorda-Knape et al [14] measured $PM_{2.5}$, PM_{10}, black smoke (which is similar to BC), NO_2, and benzene in residential areas <300 m from highways (80,000–152,000 veh/d) in the Netherlands. Black smoke was measured by a reflectance-based method using filtered particles; benzene was measured using a method based on gas chromatography. Roorda-Knape et al reported that outdoor concentrations of black smoke and NO_2 decreased with distance from highways, while $PM_{2.5}$, PM_{10}, and benzene concentrations did not change with distance. In addition, Roorda-Knape et al. found that indoor black smoke concentrations were correlated with truck traffic, and NO_2 was correlated with both traffic volume and distance from highways. Janssen et al. [15] studied $PM_{2.5}$, PM_{10}, benzene, and black smoke in 24 schools in the Netherlands and found that $PM_{2.5}$ and black smoke increased with truck traffic and decreased with distance from highways (40,000–170,000 veh/d).

In summary, the literature shows that UFP, BC, CO and NOx are elevated near highways (>30,000 veh/d), and that other pollutants including VOCs and PPAHs may also be elevated. Thus, people living within about 30 m of highways are likely to receive much higher exposure to

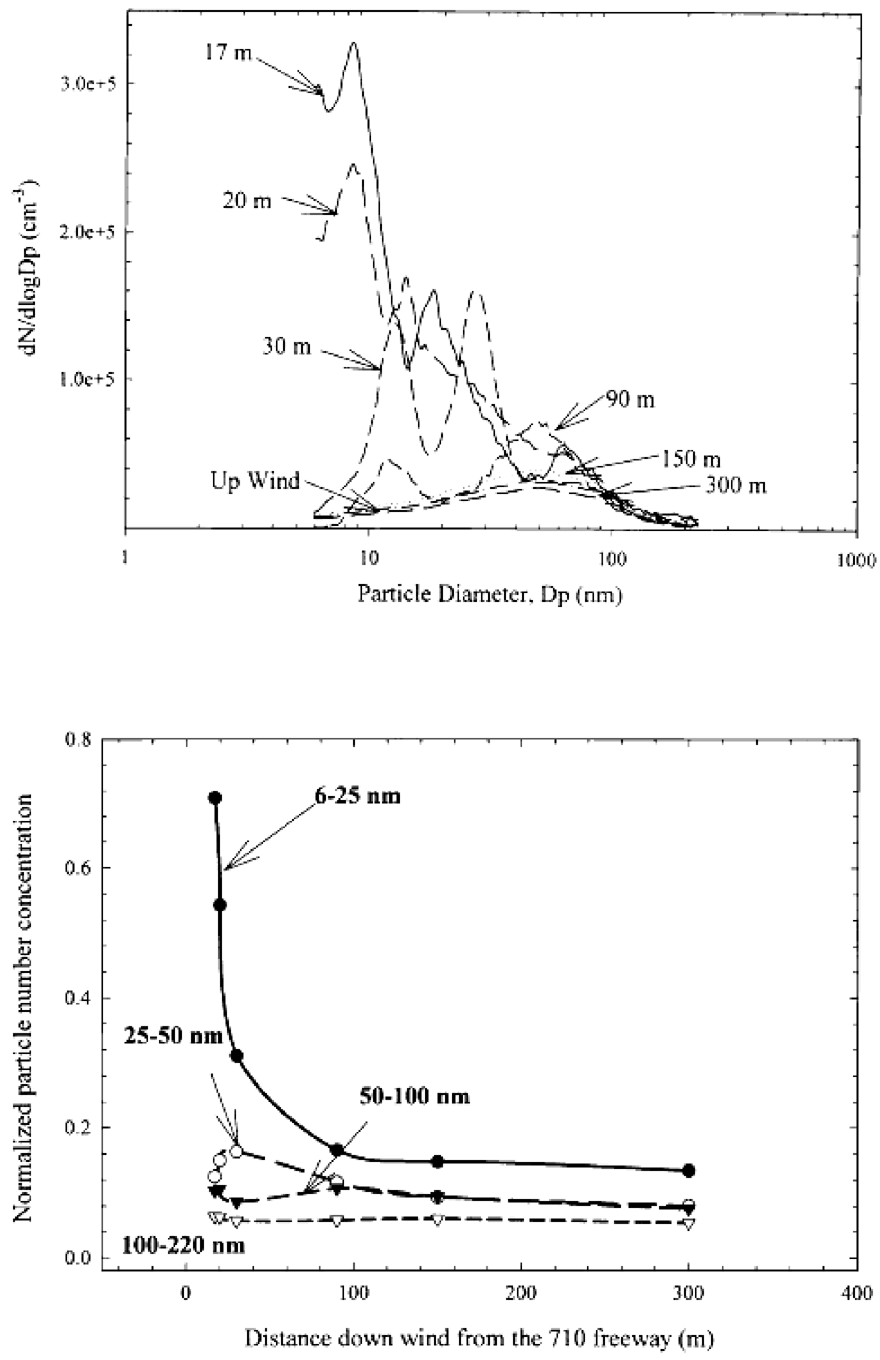

Figure 1

Ultrafine particle size distribution (top panel) and normalized particle number concentration for different size ranges (bottom panel) as a function of distance from a highway in Los Angeles. From Zhu et al. (8). Reprinted with permission from Elsevier.

traffic-related air pollutants compared to residents living >200 m (+/- 50 m) from highways.

Cardiovascular health and traffic-related pollution

Results from clinical, epidemiological, and animal studies are converging to indicate that short-term and long-term exposures to traffic-related pollution, especially particulates, have adverse cardiovascular effects [16-18]. Most of these studies have focused on, and/or demonstrated the strongest associations between cardiovascular health outcomes and particulates by weight or number concentrations [19-21] though CO, SO_2, NO_2, and BC have also been examined. BC has been shown to be associated with decreases in heart rate variability (HRV) [22,23] and black smoke and NO_2 shown to be associated with cardiopulmonary mortality [24].

Short-term exposure to fine particulate pollution exacerbates existing pulmonary and cardiovascular disease and long-term repeated exposures increases the risk of cardiovascular disease and death [25,26].

Though not focused on near-highway pollution, two large prospective cohort studies, the Six-Cities Study [27] and the American Cancer Society (ACS) Study [28] provided the groundwork for later research on fine particulates and cardiovascular disease. Both of these studies found associations between increased levels of exposure to ambient PM and sulfate air pollution recorded at central city monitors and annual average mortality from cardiopulmonary disease, which at the time combined cardiovascular and pulmonary disease other than lung cancer. The Six-Cities Study examined $PM_{2.5}$ and $PM_{10/15}$. The ACS study examined PM $_{2.5}$. Relative risk ratios of mortality from cardiopulmonary disease comparing locations with the highest and lowest fine particle concentrations (which had differences of 24.5 and 18.6 ug/m^3 respectively) were 1.37 (1.11, 1.68) and 1.31 (1.17, 1.46) in the Six Cities and ACS studies, respectively. These analyses controlled for many confounders, including smoking and gas stoves but not other housing conditions or time spent at home. The studies were subject to intensive replication, validation, and reanalysis that confirmed the original findings. $PM_{2.5}$ generally declined following implementation of new US Environmental Protection Agency standards in 1997 [17,29], yet since that time studies have shown elevated health risks due to long-term exposures to the 1997 PM threshold concentrations [29,30].

Much of the epidemiological research has focused on assessing the early physiological responses to short-term fluctuations in air pollution in order to understand how these exposures may alter cardiovascular risk profiles and exacerbate cardiovascular disease [31]. Heart rate variability, a risk factor for future cardiovascular outcomes, is altered by traffic-related pollutants particularly in older people and people with heart disease [22,23,32]. With decreased heart rate variability as the adverse outcome, negative associations between HRV and particulates were strongest for the smallest size fraction studied [33] (PM0.3–1.0); [34] (PM0.02–1). In two studies that included other pollutants, black carbon, an indicator of traffic particles, also elicited a strong association with both time and frequency domain HRV variables; associations were also strong for PM2.5 for both time and frequency HRV variables in the Adar et al study [[23]; this and subsequent near highway studies are summarized in Table 2], however, PM2.5 was not associated with frequency domain variables in the Schwartz et al. study [22].

Several studies show that exposure to PM varies spatially within a city [35-37], and finer spatial analyses show higher risks to individuals living in close proximity to heavily trafficked roads [18,37]. A 2007 paper from the Woman's' Health Initiative used data from 573 $PM_{2.5}$ monitors to follow over 65,000 women prospectively. They reported very high hazard ratios for cardiovascular events (1.76; 95% CI, 1.25 to 2.47) possibly due to the fine grain of exposure monitoring [18]. In contrast, studies that relied on central monitors [27,28] or interpolations from central monitors to highways are prone to exposure misclassification because individuals living close to highways will have a higher exposure than the general area. A possible concern with this interpretation is that social gradients may also situate poorer neighborhoods with potentially more susceptible populations closer to highways [38-40].

At a finer grain, Hoek et al. [24] estimated home exposure to nitrogen dioxide (NO_2) and black smoke for about 5,000 participants in the Netherlands Cohort Study on Diet and Cancer. Modeled exposure took into consideration proximity to freeways and main roads (100 m and 50 m, respectively). Cardiopulmonary mortality was associated with both modeled levels of pollutants and living near a major road with associations less strong for background levels of both pollutants. A case-control study [41], found a 5% increase in acute myocardial infarction associated with living within 100 m of major roadways. A recent analysis of cohort data found that traffic density was a predictor of mortality more so than was ambient air pollution [42]. There is a need for studies that assess exposure at these scales, e.g., immediate vicinity of highways, to test whether cardiac risk increases still more at even smaller scales.

Although we cannot review it in full here, we note that evidence beyond the epidemiological literature support the contention that $PM_{2.5}$ and UFP (a sub-fraction of $PM_{2.5}$) have adverse cardiovascular effects [16,17]. $PM_{2.5}$ appears

Table 2: Summary of near-highway health effects studies

Citation	Location	Highway traffic intensity[a]	Pollutants measured[b]	Distance from highway	Health Outcomes	Statistical association[e]
Schwartz et al. 2005 (22)	Boston	NA	$PM_{2.5}$, BC, CO	NA	Heart rate variability	Decreases in measures of heart rate variability
Adar et al. 2007 (23)	St. Louis, Missouri	NA	$PM_{2.5}$, BC, UFP	On highway in busses	Heart rate variability	Decreases in measures of heart rate variability
Hoek et al. 2002 (24)	Netherlands	NA	BC, NO_2	Continuous [d]	Cardio-pulmonary mortality, lung cancer	1.41 OR for living near road
Tonne et al. 2007 (41)	Worchester, Mass.	NA	$PM_{2.5}$	Continuous [d]	Acute myocardial infarction (AMI)	5% increase in odds of AMI
Venn et al. 2001 (49)	Nottingham, UK	NA	NA	Continuous [d]	Wheezing in children	1.08 OR for living w/ in 150 m of road
Nicolai et al. 2003 (58)	Munich, Germany	>30,000 veh/d	Soot, benzene, NO_2	Traffic counts within 50 m of house	Asthma, respiratory symptoms, allergy	1.79 OR for asthma and high traffic volume
Gauderman et al. 2005 (65)	Southern California		NO_2	Continuous [d]	Asthma, respiratory symptoms	Increased asthma closer to freeways
McConnell et al. 2006 (57)	Southern California	NA	NA	Continuous [d]	Asthma	Large risk for children living w/in 75 m of road
Ryan, et al. 2007 (59)	Cincinnati, Ohio	> 1,000 trucks/d	PM2.5	400 m	Wheezing in children	NA
Kim et al. 2004 (60)	San Francisco	90,000 – 210,000 veh/d	PM, BC, NO_x	School sites	Childhood asthma	1.07 OR for high levels of NO_x
Wjst et al. 1993 (68)	Munich, Germany	7,000–125,000 veh/d	NO_x, CO	School sites	Asthma, bronchitis	Several statistical associations found
Brunekreef et al. 1997 (69)	Netherlands	80,000 – 152,000 veh/d	PM_{10}, NO_2	Continuous[d]	Lung function	Decreased FEV with proximity to high truck traffic
Janssen et al. 2003 (74)	Netherlands	30,000–155,000 veh/d	$PM_{2.5}$, NO_2, benzene	< 400 m [c]	Lung function, respiratory symptoms	No association with lung function
Peters et al. 1999 (82)	Southern California	NA	PM_{10}, NO_2	NA	Asthma, bronchitis, cough, wheeze	1.54 OR of wheeze for boys with exposure to NO_2
Brauer et al. 2007 (67)	Netherlands	Highways and streets	$PM_{2.5}$, NO_2, soot	Modeled exposure	Asthma, allergy, bronchitis, respiratory symptoms	Strongest association was with food allergies
Visser et al. 2004 (91)	Amsterdam	> 10,000 veh/d	NA	NA	Cancer	Multiple associations
Vineis et al. 2006 (87)	10 Eurpoean countries	NA	PM_{10}, NO_2, SO_2	NA	Cancer	1.46 OR near heavy traffic, 1.30 OR for high exposure to NO_2
Gauderman et al. 2007 (73)	Southern California	NA	PM_{10}, NO_2	Continuous[d]	Lung Function	Decreased FEV for those living near freeway

[a]As defined in article cited (veh/d = vehicles per day; veh/h = vehicles per hour).
[b]UFP = ultrafine particles; FP = fine particles; $PM_{2.5}$ = particles with aerodynamic diameter ≤ 2.5 um; PM_{10} = particles with aerodynamic diameter ≤ 10 um; BC = black carbon; PPAH = particle-bound polycyclic aromatic hydrocarbons; VOCs = volatile organic compounds
[c]Pollutant measurements were made along a transect away from the highway
[d]Proximity of each participant to a major road was calculated using GIS software
[e]Statistical association between proximity to highway or exposure to traffic-generated pollutants and measured health outcomes
NA = not applicable; measurements were not made.

to be a risk factor for cardiovascular disease via mechanisms that likely include pulmonary and systemic inflammation, accelerated atherosclerosis and altered cardiac autonomic function [17,22,43-46]. Uptake of particles or particle constituents in the blood can affect the autonomic control of the heart and circulatory system. Black smoke, a large proportion of which is derived from mobile source emissions [30], has a high pulmonary deposition efficiency, and due to their surface area-to-volume ratios can carry relatively more adsorbed and condensed toxic air pollutants (e.g., PPAH) compared to larger particles [17,47,48]. Based on high particle numbers, high lung deposition efficiency and surface chemistry, UFP may provide a greater potential than $PM_{2.5}$ for inducing inflammation [10]. UFPs have high cytotoxic reactive oxygen species (ROS) activity, through which numerous inflammatory responses are induced, compared to other particles [10]. Chronically elevated UFP levels such as those to which residents living near heavily trafficked roadways are likely exposed can lead to long-term or repeated increases in systemic inflammation that promote arteriosclerosis [18,29,34,37].

Asthma and highway exposures

Evidence that near highway exposures present elevated risk is relatively well developed with respect to child asthma studies. These studies have evolved over time with the use of different methodologies. Studies that used larger geographic frames and/or overall traffic in the vicinity of the home or school [49-52] or that used self-report of traffic intensity [53] found no association with asthma prevalence. Most recent child asthma studies have, instead, used increasingly narrow definitions of proximity to traffic, including air monitoring or modeling) and have focused on major highways instead of street traffic [54-59]. All of these studies have found statistically significant associations between the prevalence of asthma or wheezing and living very close to high volume vehicle roadways. Confounders considered included housing conditions (pests, pets, gas stoves, water damage), exposure to tobacco smoke, various measures of socioeconomic status (SES), age, sex, and atopy, albeit self-reported and not all in a single study.

Multiple studies have found girls to be at greater risk than boys for asthma resulting from highway exposure [55,57,60]. A recent study also reports elevated risk only for children who moved next to the highway before they were 2 years of age, suggesting that early childhood exposure may be key [57]. The combined evidence suggests that living within 100 meters of major highways is a risk factor, although smaller distances may also result in graded increases in risk. The neglect of wind direction and the absence of air monitoring from some studies are notable missing factors. Additionally, recent concerns have been raised that geocoding (attaching a physical location to addresses) could introduce bias due to inaccuracy in locations [61].

Studies that rely on general area monitoring of ambient pollution and assess regional pollution on a scale orders of magnitude greater than the near-roadway gradients have also found associations between traffic generated pollution (CO and NOx) and prevalence of asthma [62] or hospital admission for asthma [63]. Lweguga-Mukasa et al. [64] monitored air up and down wind of a major motor vehicle bridge complex in Buffalo, NY and found that UFP were higher downwind, dropping off with distance. Their statistical models did not, however, support an association of UFP with asthma. A study in the San Francisco Bay Area measured $PM_{2.5}$, BC and NO_X over several months next to schools and found both higher pollution levels downwind from highways and a linear association of BC with asthma in long-term residents [60].

Gauderman et al. [65] measured NO_2 next to homes of 208 children. They found an odds ratio (OR) of 1.83 (confidence interval (CI): 1.04–3.22) for outdoor NO_2 (probably a surrogate for total highway pollution) and lifetime diagnosis of asthma. They also found a similar association with distance from residence to freeway. Self-report was used to control for numerous confounders, including tobacco smoke, SES, gas stoves, mildew, water damage, cockroaches and pets which did not substantially affect the association. Gauderman's study suggests that ambient air monitoring at the residence substantially increases statistical power to detect association of asthma with highway exposures.

Modeling of elemental carbon attributable to traffic near roadways based on ambient air monitoring of $PM_{2.5}$ has recently emerged as a viable approach and a study using this method found an association with infant wheezing. The modeled values appear to be better predictors than proximity. Elevation of the residence relative to traffic was also an important factor in this study [66]. A 2007 paper reported on modeled NO_2, $PM_{2.5}$ and soot and the association of these values with asthma and various respiratory symptoms in the Netherlands [67]. While finding modest statistically significant associations for asthma and symptoms, it is somewhat surprising that they found stronger associations for development of sensitization to food allergens.

Pediatric lung function and traffic-related air pollution

Studies of association of children's lung function with traffic pollutants have used a variety of measures of exposure, including: traffic density, distance to roadways, area (city) monitors, monitoring at the home or school and personal monitoring. Studies have assessed both chronic effects on lung development and acute effects and have been both cross-sectional and longitudinal. The wide range of approaches somewhat complicates evaluation of the literature.

Traffic density in school districts in Munich was associated with decreases in forced vital capacity (FVC), forced expiratory volume in 1 second (FEV_1), FEV1/FVC and other measures, although the 2-kilometer (km) areas, the use of sitting position for spirometry and problems with translation for non-German children were limitations [68]. Brunekreef et al. [69] used distance from major roadways, considered wind direction and measured black smoke and NO2 inside schools. They found the largest decrements in lung function in girls living within 300 m of the roadways.

A longitudinal study of children (average age at start = 10 years) in Southern California reported results at 4 [70] and 8 years [71]. Multiple air pollutants were measured at sites in 12 communities. Due to substantial attrition, only 42% of children enrolled at the start were available for the 8-year follow-up. Substantially lower growth in FEV_1 was associated with PM_{10}, NO_2, $PM_{2.5}$, acid vapor and elemental carbon at 4 and at 8 years. The analysis could not indicate whether the effects seen were reversible or not [72]. In 2007, it was reported from this same cohort that living within 500 m of a freeway was reported to be associated with reduced lung function [73].

A Dutch study [74] measured $PM_{2.5}$, NO_2, benzene and EC for one year at 24 schools located within 400 m of major roadways. While associations were seen between symptoms and truck traffic and measured pollutants, there was no significant association between any of the environmental measures and FVC < 85% or FEV_1 < 85%. Restricting the analysis to children living within 500 m of highways generally increased ORs.

Personal exposure monitoring of NO_2 as a surrogate for total traffic pollutants with 298 Korean college students found statistically significant associations with FEV_1, FEV_1/FVC, and forced expiratory volume between 25 and 75% (FEV_{25-75}), but not with FVC. The multivariate regression model presented suggests that FEV_{25-75} was the outcome measure that most clearly showed an effect [75]. Cross-sectional studies of children in Korea [76] and France [77] also indicate that lung function is diminished in association with area pollutants that largely derive from traffic.

Time series studies suggest there are also acute effects. A study of 19 asthmatic children measured PM via personally carried monitors, at homes and at central site monitors. The study found deficits in FEV_1 that were associated with PM, although many sources besides traffic contributed to exposure. In addition, the results suggest that ability to see associations with health outcomes improves at finer scale of monitoring [78]. PM was associated with reduced FEV_1 and FVC in only the asthmatic subset of children in a Seattle study [79]. Studies have also seen associations between PM and self reported peak flow measurements [80,81] and asthmatic symptoms [82].

Cancer and near highway exposures

As noted above, both the Six-Cities Study [27] and the American Cancer Society (ACS) Study [28] found associations between PM and lung cancer. Follow-up studies using the ACS cohort [29,37] and the Six-Studies cohort [83] that controlled for smoking and other risk factors also demonstrated significant associations between PM and lung cancer. The original studies were subject to intensive replication, validation, and re-analysis which confirmed the original findings [84].

The ASHMOG study [85] was designed to look specifically at lung cancer and air pollution among Seventh-day Adventists in California, taking advantage of their low smoking rates. Air pollution was interpolated to centroids of zip codes from ambient air monitoring stations. Highway proximity was not considered. The study found associations with ozone (its primary pollutant of consideration), PM10 and SO2. Notably, these are not the pollutants that would be expected to be substantially elevated immediately adjacent to highways.

A case control study of residents of Stockholm, Sweden modeled traffic-related NO2 levels at their homes over 30 years and found that the strongest association involved a 20 year latency period [86]. Another case control study drawn from the European Prospective Investigation on Cancer and Nutrition found statistically significantly elevated ORs for lung cancer with proximity to heavy traffic (>10,000 cars per day) as well as for NO_2 and PM_{10} at nearby ambient monitoring stations [87]. Nafstad et al. [88] used modeled NO_2 and SO_2 concentrations at the homes of over 16,000 men in Oslo to test associations with lung cancer incidence. The models included traffic and point sources. The study found small, but statistically significant associations between NO_2 and lung cancer. Problems that run through all these studies are weak measures of exposure to secondhand tobacco smoke, the use of main roads rather than highways as the exposure group and modeled rather than measured air pollutants.

A study of regional pollution in Japan and a case control study of more localized pollution in a town in Italy also found associations between NO_2 and lung cancer and PM and lung cancer [89,90]. On the other hand, a study that calculated SIRs for specific cancers across lower and higher traffic intensity found little evidence of an association with a range of cancers [91].

The plausibility of near-highway pollution causing lung cancer is bolstered by the presence of known carcinogens in diesel PM. The US EPA has concluded after reviewing the literature that diesel exhaust is "likely to be carcinogenic to humans by inhalation" [92]. An interesting study of UFP and DNA damage adds credibility to an association with cancer [93]. This study had participants bicycle in traffic in Copenhagen and measured personal exposure to UFP and DNA oxidation and strand breaks in mononuclear blood cells. Bicycling in traffic increased UFP exposure and oxidative damage to DNA, thus demonstrating an association between DNA damage and UFP exposure *in vivo*.

Policy and research recommendations

Based on the literature reviewed above it is plausible that gradients of pollutants next to highways carry elevated health risks that may be larger than the risks of general area ambient pollutants. While the evidence is considerable, it is not overwhelming and is weak in some areas. The strongest evidence comes from studies of development of asthma and reduction of lung function during childhood, while the studies of cardiac health risk require extrapolation from area studies of smaller and larger geographic scales and inference from toxicology laboratory investigations. The lung cancer studies, because they include pollutants such as O_3 that are not locally concentrated, are not particularly strong in terms of the case for near-highway risk. There is a need for lung cancer research that uses major highways rather than heavily trafficked roads as the environmental exposure.

While more studies of asthma and lung function in children are needed to confirm existing findings, especially studies that integrate exposure at school, home and during commuting, to refine our knowledge about the association, we would point to the greater need for studies of cardiac health and lung cancer and their association with near highway exposures as the primary research areas needing to be developed. Many of the studies of PM and cardiac or pulmonary health have focused on mortality. Near highway mortality studies may be possible, but would be lengthy if they were initiated as prospective cohorts. Other possibilities include retrospective case control studies of mortality, cross sectional studies or prospective studies that have end points short of mortality, such as biological markers of disease. For all health end points there is a need for studies that adequately address the possible confounding of SES with proximity to highways. There is good reason to think that property values decline near highways and that control for SES by, for example, income, may be inadequate.

Because of the incomplete development of the science regarding the health risks of near highway exposures and the high cost and implication of at least some possible changes in planning and development, policy decisions are complicated. The State of California has largely prohibited siting of schools within 500 feet of freeways (SB 352; approved by the governor October 2, 2003). Perhaps this is a viable model for other states or for national-level response. As it is the only such law of which we are aware, there may be other approaches that will be and should be tried. One limitation of the California approach is that it does nothing to address the population already exposed at schools currently cited near freeways and does not address residence near freeways.

Conclusion

The most susceptible (and overlooked) population in the US subject to serious health effects from air pollution may be those who live very near major regional transportation route, especially highways. Policies that have been technology based and regional in orientation do not efficiently address the very large exposure and health gradients suffered by these populations. This is problematic because even regions that EPA has deemed to be in regional PM "attainment" still include very large numbers of near highway residents who currently are not protected. There is a need for more research, but also a need to begin to explore policy options that would protect the exposed population.

Abbreviations

UFP = ultra fine particles

BC = black carbon

NO_2 = nitrogen dioxide

NOx = oxides of nitrogen

CO = carbon monoxide

PM = particulate matter

$PM_{2.5}$ = particulate matter less than 2.5 um

PM_{10} = particulate matter less than 10 um

PPAH = particle bound polyaromatic hydrocarbons

EC = elemental carbon

VOC = volatile organic compounds

SO_2 = sulfur dioxide

ACS = American Cancer Society

SES = socioeconomic status

EPA = Environmental Protection Agency

OR = odds ratio

FEV_1 = forced expiratory volume in 1 second

FEV_1/FVC = ratio of FEV_1 and forced vital capacity

FEV_{25-75} = forced expiratory volume between 25 and 75

FVC = forced vital capacity

ug/m^3 = micrograms per cubic meter of air

m = meters

um = micrometers

veh/d = vehicles per day

veh/h = vehicles per hour

Competing interests

The author(s) declare that they have no competing interests.

Authors' contributions

DB took the lead on the manuscript. He co-wrote the background and wrote the sections on asthma, lung function and cancer and the conclusions. JLD wrote the section on air pollutants near roadways and contributed substantially to the background. CR wrote the section on cardiovascular health. All authors participated in editing and refining the manuscript and all read it multiple times, including the final version.

Acknowledgements

We thank Wig Zamore for useful insights into the topic. The Jonathan M Tisch College of Citizenship and Public Service partially supported the effort of Doug Brugge and Christine Rioux. Figure 1 was reproduced with permission of the publisher.

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Attachment H

Gauderman, James W. et al.
Effects of Exposure to Traffic on Lung Development from
10 to 18 Years of Age: A Cohort Study
Lancet, Vol. 368
2006

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Effect of exposure to traffic on lung development from 10 to 18 years of age: a cohort study

W James Gauderman, Hita Vora, Rob McConnell, Kiros Berhane, Frank Gilliland, Duncan Thomas, Fred Lurmann, Edward Avol, Nino Kunzli, Michael Jerrett, John Peters

Summary

Background **Whether local exposure to major roadways adversely affects lung-function growth during the period of rapid lung development that takes place between 10 and 18 years of age is unknown. This study investigated the association between residential exposure to traffic and 8-year lung-function growth.**

Methods **In this prospective study, 3677 children (mean age 10 years [SD 0·44]) participated from 12 southern California communities that represent a wide range in regional air quality. Children were followed up for 8 years, with yearly lung-function measurements recorded. For each child, we identified several indicators of residential exposure to traffic from large roads. Regression analysis was used to establish whether 8-year growth in lung function was associated with local traffic exposure, and whether local traffic effects were independent of regional air quality.**

Findings **Children who lived within 500 m of a freeway (motorway) had substantial deficits in 8-year growth of forced expiratory volume in 1 s (FEV_1, –81 mL, p=0·01 [95% CI -143 to -18]) and maximum midexpiratory flow rate (MMEF, –127 mL/s, p=0·03 [-243 to -11]), compared with children who lived at least 1500 m from a freeway. Joint models showed that both local exposure to freeways and regional air pollution had detrimental, and independent, effects on lung-function growth. Pronounced deficits in attained lung function at age 18 years were recorded for those living within 500 m of a freeway, with mean percent-predicted 97·0% for FEV_1 (p=0·013, relative to >1500m [95% CI 94·6–99·4) and 93·4% for MMEF (p=0·006 [95% CI 89·1–97.7]).**

Interpretation **Local exposure to traffic on a freeway has adverse effects on children's lung development, which are independent of regional air quality, and which could result in important deficits in attained lung function in later life.**

Lancet 2006; 368:

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Introduction

Both cross-sectional[1–9] and longitudinal[10–15] studies have shown that lung function in children is adversely affected by exposure to urban, regional air pollution. Evidence has emerged that local exposure to traffic is related to adverse respiratory effects in children, including increased rates of asthma and other respiratory diseases.[16–28] Cross-sectional studies in Europe have shown that deficits in lung function are related to residential exposure to traffic.[27,29–32] However, does traffic exposure have an adverse effect on lung-function development in children? The answer to this question is important in view of the extent of traffic exposure in urban environments and the established relation between diminished lung function in adulthood and morbidity and mortality.[33-39]

We investigated the association between residential exposure to traffic and 8-year lung-function development on the basis of cohort data from the Children's Health Study. We also studied the joint effects of local traffic exposure and regional air quality on children's lung development.

Methods

Participants

The Children's Health Study recruited two cohorts of fourth-grade children (mean age 10 years [SD 0·44], one in 1993 (cohort 1, n=1718) and the other in 1996 (cohort 2, n=1959). All children were recruited from schools in 12 southern California communities as part of an investigation into the long-term effects of air pollution on children's respiratory health.[7,14,40] A consistent protocol was used in all communities to identify schools, and all students targeted for study were invited to participate.[40] Overall, 82% (3677) of available students agreed to participate. Pulmonary-function data were obtained yearly by trained field technicians, who travelled to study schools to undertake maximum effort spirometry on the children, using the same equipment and testing protocol used throughout the study period. Details of the testing protocol have been previously reported.[7,15] Children in both cohorts were followed up for 8 years.

A baseline questionnaire, completed at study entry by each child's parent or legal guardian, was used to obtain information on race, Hispanic ethnic origin, parental income and education, history of doctor-diagnosed asthma, in-utero exposure to maternal smoking, and household exposure to gas stoves, pets, and environmental tobacco smoke.[40] A yearly questionnaire, with similar structure to that of the baseline questionnaire, was used to update information on asthma status, personal smoking, and exposure to environmental tobacco smoke. For statistical modelling, a three-category socioeconomic status variable was created on the basis of total household income and education of the parent or guardian that completed the questionnaire. High socioeconomic status (23% of children, n=823**)** was defined as a parental income greater than US$100 000 per year, or an income over US$15 000 per year and at least 4 years of college education. The middle category (36%, n=1283) included children with a parental income between US$15 000 and US$100 000 and some (less than 4 years) college or technical school education, and low socioeconomic status (41%, n=1483) included all remaining children.

The study protocol was approved by the institutional review board for human studies at the University of Southern California, and written consent was provided by a parent or legal guardian for every study participant.

Exposure Data

We characterised exposure of every study participant to traffic-related pollutants by two types of measures—proximity of the child's residence to the nearest freeway or to the nearest major non-freeway road, and model-based estimates of traffic-related air pollution at the residence, derived from dispersion models that incorporated distance to roadways, vehicle counts, vehicle emission rates, and meteorological conditions.[41] Regional air pollution was continuously monitored at one central site location within each study community over the course of the investigation. Further details of exposure assessment are available in the webappendix.

See Online for wepappendix

Statistical methods

The outcome data consisted of 22 686 pulmonary-function tests recorded from 3677 participants during 8 years in both cohorts. We focused on three pulmonary-function measures: forced vital capacity (FVC), forced expiratory volume in 1 s (FEV_1), and maximum midexpiratory flow rate (MMEF, also known as $FEF_{25\text{-}75}$). The exposures of primary interest were the traffic measures described above.

We used a hierarchical mixed-effects model to relate 8-year growth in each lung-function measure to traffic exposure, with basic structure that has been previously described.[42] To account for the growth pattern in lung function during this period, we used a linear spline model,[43] constructed so that 8-year growth in lung function was estimated jointly with other model parameters. We estimated and tested the effect of traffic exposure on 8-year growth, and in some analyses on mean values at 10 and 18 years of age. The model allowed for separate growth curves for each sex, race, ethnic origin, cohort, and baseline-asthma subgroup. The model also included adjustments for height, height squared, body-mass index (BMI), BMI squared, present asthma status, exercise or respiratory illness on the day of the test, any tobacco smoking by the child in the previous year, and indicator variables for field technician. Random effects for the intercept and 8-year growth parameters were included at the level of participant and community.

To keep the potential effect of outliers to a minimum and to examine possible non-linear exposure-response relations, we used categorical forms of each traffic indicator in our models. For distance to the freeway, we formed four categories—less than 500 m, 500–1000 m, 1000–1500 m, and more than 1500 m. Distances to non-freeway major roads were similarly categorised based on distances of 75 m, 150 m, and 300 m. Model-based estimates of pollution from freeways and non-freeways were categorised into quartiles on the basis of their respective distributions (see webappendix). The categorisation distances for all traffic indicators were fixed before any health analyses were done. Traffic effects are reported as the difference in 8-year growth for each category relative to the least exposed category, so that negative estimates signify reduced lung-function growth or values with increased exposure.

We also considered joint estimation of traffic effects within the community and pollution between communities, which was based on the long-term average pollutant concentrations measured at the central sites (see webappendix). Pollutant effects are reported as the difference in 8-year growth in lung function from the least to the most polluted community, with negative differences indicating growth deficits with increased exposure. Possible modification of a traffic effect by community-average ambient pollutant concentration was tested by inclusion of the appropriate interaction term in the model.

To examine attained lung function, we computed percent-predicted lung function for participants who were measured in 12th grade, our last year of follow-up (n=1497, mean age 17·9 years, [SD=0·41]). To estimate predicted FEV_1 values, we first fitted a regression model for observed FEV_1 (log transformed) with predictors log height, BMI, BMI squared, sex, asthma status, race or ethnic origin, field technician, and sex-by-log height, sex-by-BMI, sex-by-BMI squared, sex-by-asthma, and sex-by-race or ethnic origin interactions. We calculated predicted FEV_1 on the basis of this model and percent-predicted as observed divided by predicted FEV_1. We used a regression model to calculate the mean percent-predicted value for each category of distance to the freeway, with adjustment for community. To aid in interpretation, we scaled percent-predicted values so that children who lived furthest (>1500 m) from a freeway had a mean of 100%, and we give means for the remaining distance groups relative to this benchmark. Analogous calculations were used to obtain the percent-predicted mean for FVC and MMEF.

Regression procedures in SAS (version 9·0) were used to fit all models. Associations denoted as significant were those with a p value less than 0·05, assuming a two-sided alternative hypothesis.

Role of the funding source

The funding sources of this study had no role in the study design, collection, analysis, or interpretation of data, in the writing of the report, or in the decision to submit the paper for publication. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

An average of 6·2 pulmonary function tests were done per child. There were equal proportions of male and female participants (webtable 1). Most children were of non-Hispanic white or Hispanic ethnic origin. 440 (12%) children lived within 500 m of a freeway, with most of these children residing in six of the 12 communities (webtable 2 and webfigure). Model-based estimates of pollution from a freeway were skewed toward either high or low values within most study communities.

8-year growth in FVC, FEV_1, and MMEF averaged 1512 mL, 1316 mL, and 1402 mL/s, respectively, in girls, and 2808 ml, 2406 ml, and 2476 ml/s, respectively, in boys. Closer residential distance to a freeway was associated with reduced growth in lung function (table 1). In children who lived within 500 m of a freeway, 8-year growth was significantly reduced compared with those who lived at least 1500 m from a freeway. Large deficits in FEV_1 and MMEF growth were also estimated for the two highest-exposure quartiles of model-based pollution from a freeway, although neither deficit was statistically significant. Indicators of traffic from non-freeway roads, including both distance and model-based pollution estimates, were not associated with reduced growth.

The association between FEV_1 growth and distance to a freeway was significant in various sensitivity analyses (table 2). Compared with the results shown in table 1 (base model), distance-effect estimates were larger with additional adjustment for socio-economic status. Further investigation showed that low socioeconomic status was associated with increased traffic exposure, with mean residential distance to freeways of 1·8 km (SD 1·32), 2·0 km (1·65), and 2·5 km (1·91) for low, middle, and high groups respectively. However, socioeconomic status was not significantly associated with FEV_1 growth, and therefore adjustment for this variable induced only a modest change. Adjustment for indoor sources of air pollution including gas stoves, pets, and exposure to environmental tobacco smoke also resulted in little change in the estimated freeway-distance effects.

Significant distance effects were seen in the subset of children who reported never having had asthma, and in the subset of children who reported no active tobacco smoking. The relation between FEV_1 growth and distance was noticeably larger in boys than in girls, although a test of effect modification by sex was non-significant (p=0·10). Only six of the 12 communities had substantial numbers of children living within 500 m of a freeway. The estimated effects of freeway distance on lung development were more pronounced in these six higher-traffic communities than in the other communities. There was no significant evidence of heterogeneity in the local distance effects between these six communities (data not shown). Furthermore, around 34% (1267) of children moved from their baseline residence during follow-up but remained in one of the 12 study communities and thus continued to participate. If we omitted post-move lung-function measurements from the analysis, the estimated effects of freeway-distance on FEV_1 growth were more pronounced.

	FVC (mL) difference (95% CI)	FEV1 (mL) difference (95% CI)	MMEF (mL/sec) difference (95% CI)
Freeway distance*			
<500 m	−63 (−131 to 5)	−81 (−143 to −18)	−127 (−243 to −11)
500–1000 m	−31 (−93 to 32)	−41 (−99 to 17)	−35 (−142 to 73)
1000–1500 m	−19 (−84 to 46)	−33 (−93 to 26)	−94 (−204 to 16)
Model-based pollution from freeway†			
4th quartile (high)	−66 (−186 to 54)	−69 (−179 to 42)	−147 (−352 to 58)
3rd quartile	−61 (−151 to 29)	−78 (−161 to 5)	−144 (−298 to 9)
2nd quartile	−27 (−90 to 36)	−22 (−80 to 36)	−37 (−144 to 71)
Non-freeway distance‡			
<75 m	5 (−63 to 72)	−35 (−97 to 27)	−66 (−181 to 49)
75–150 m	4 (−59 to 68)	22 (−37 to 80)	35 (−74 to 144)
150–300 m	−10 (−63 to 42)	−8 (−56 to 40)	−16 (−105 to 73)
Model-based pollution from non-freeway†			
4th quartile (high)	13 (−70 to 96)	3 (−74 to 80)	2 (−140 to 144)
3rd quartile	42 (−27 to 111)	16 (−47 to 80)	−23 (−141 to 95)
2nd quartile	6 (−54 to 66)	2 (−53 to 57)	11 (−91 to 113)

*Difference in 8-year lung-function growth relative to children living at least 1500 m from a freeway. †Difference in 8-year lung-function growth relative to children in the first (lowest) quartile of exposure. ‡Difference in 8-year lung-function growth relative to children living at least 300 m from a non-freeway road.

Table 1: **Association between 8-year lung-function growth and several indicators of residential traffic exposure**

	Freeway Distance (m)					
	<500	p	500–1000	p	1000–1500	p
Base model*	−81	0·012	−41	0·165	−33	0·275
Additional covariates						
Base+socioeconomic status	−92	0·005	−50	0·092	−37	0·228
Base+gas stove in the home	−86	0·008	−42	0·160	−33	0·281
Base+pets in the home	−80	0·013	−41	0·165	−33	0·275
Base+in-utero exposure to maternal smoking	−83	0·011	−33	0·269	−36	0·245
Base+second-hand smoke exposure	−86	0·008	−41	0·163	−37	0·230
Subgroups						
Non-asthmatics only	−83	0·025	−70	0·042	−61	0·091
Non-smokers only	−99	0·006	−49	0·154	−48	0·182
Boys only	−158	0·003	−54	0·264	−77	0·123
Girls only	−12	0·750	−39	0·254	3	0·932
Six communities with closest freeway proximity†	−105	0·003	−56	0·101	−40	0·260
Deleting observations after a residence change‡	−86	0·030	−73	0·042	−53	0·148

*Base model results are the same as those in table 1. All models include adjustment for the covariates listed in the Methods section. Values are the difference in 8–year FEV_1 growth relative to those living >1500 m from a freeway. †Including only children from the six communities with the largest number of children living near a freeway (Riverside, Atascadero, Alpine, San Dimas, Long Beach, and Santa Maria). ‡Censoring any pulmonary function tests recorded after a participant left his or her baseline address.

Table 2: **Sensitivity analysis of freeway-distance effects on 8-year FEV_1 growth**

See Online for webtables 1 and 2 and webfigure

	Regional pollutant effect*	p	Local freeway distance (m)						
			<500	p	500–1000	p	1000–1500	p	p for interaction†
1000–1800 ozone	–13	0·821	–81	0·012	–41	0·165	–33	0·275	0.51
Nitrogen dioxide	–109	0·003	–80	0·012	–41	0·166	–33	0·279	0.81
Acid	–111	0·002	–80	0·013	–41	0·164	–33	0·285	0.54
PM_{10}	–111	0·013	–81	0·012	–42	0·158	–32	0·287	0.24
$PM_{2·5}$	–110	0·009	–80	0·012	–41	0·160	–33	0·285	0.40
Elemental carbon	–101	0·001	–80	0·012	–42	0·156	–33	0·282	0.63

*Pollutant effects are the difference in 8–year FEV_1 growth from lowest to highest observed community–average concentration of the pollutant, specifically: per increase of 37·5 ppb ozone (1000–1800), 34·6 ppb of nitrogen dioxide, 9·6 ppb of acid vapour, 51·4 µg/m³ of PM10, 22·8 µg/m³ of PM2.5 and 1·2 µg/m³ elemental carbon. Distance effects are the difference in 8–year growth relative to those living >1500 m from a freeway. † A test of whether freeway–distance effect is modified by regional concentration of the pollutant. PM_{10} =particulate matter <10 µm aerodynamic diameter, $PM_{2·5}$=particulate matter <2·5 µm aerodynamic diameter.

Table 3: **Joint effect of regional pollution and local distance to a freeway on 8-year FEV_1 growth**

Reduced lung-function growth was independently associated with both freeway distance and with regional air pollution (table 3). Statistically significant joint models of regional pollution with distance to freeway were seen for nitrogen dioxide , acid vapour, elemental carbon, and particulate matter with aerodynamic diameter less than 10 µm and less than 2·5 µm. Ozone was not associated with reduced lung-function growth. There was no significant evidence of effect modification (interaction) of local traffic effects with any of the regional pollutants.

A subset of 1445 children were observed over the full 8 years of the study, from age 10 to 18 years. In this group, we noted significant deficits in 8-year FEV_1 growth and MMEF growth for those who lived within 500 m of a freeway (table 4). At 10 years of age, there was some evidence of reduced lung function for those who lived closer to a freeway than those who did not, although none of the differences between distance categories was statistically significant. However, by 18 years of age, participants who lived closest to a freeway had substantially lower attained FEV_1 and MMEF than those who lived at least 1500 m from a freeway.

		Lung function		8-year growth
		Age 10 years	Age 18 years	Difference* (95% CI)
		Difference* (95% CI)	Difference* (95% CI)	
FVC	Freeway distance			
	<500 m	–17 (–70 to 37)	–85 (–192 to 22)	–69 (–160 to 22)
	500–1,000 m	–12 (–61 to 37)	–54 (–151 to 43)	–42 (–125 to 41)
	1000–1500 m	–30 (–80 to 21)	–81 (–181 to 19)	–52 (–137 to 33)
FEV_1	Freeway distance			
	<500 m	–23 (–73 to 28)	–121 (–219 to –23)	–98 (–182 to –15)
	500–1000 m	–32 (–78 to 14)	–93 (–183 to –4)	–61 (–137 to 15)
	1000–1500 m	–34 (–81 to 14)	–78 (–170 to 14)	–44 (–122 to 34)
MMEF	Freeway distance			
	<500 m	–57 (–169 to 56)	–230 (–432 to –28)	–173 (–327 to –19)
	500–1000 m	–92 (–195 to 10)	–105 (–289 to 79)	–12 (–152 to 128)
	1000–1500 m	–45 (–150 to 60)	–151 (–340 to 38)	–106 (–250 to 38)

*Difference in 8–year lung function or growth relative to children living >1500 m from a freeway.

Table 4: **Cumulative effect of residential distance in the 1445 children with full 8-year of follow-up**

These deficits in average FEV_1 and MMEF translated into pronounced deficits in percent-predicted lung function at 18 years of age (figure). There was a trend of lower percent-predicted lung function for children who lived closer to a freeway than for those who lived further away. The effect was most pronounced for those who lived less than 500 m from a freeway, with average percent predicted values of 97·0% (95% CI 94·6–99·4) for FEV_1 (p=0·013 relative to >1500 m) and 93·4% (89·1–97·7) for MMEF (p=0·006).

Discussion

This study shows that residential proximity to freeway traffic is associated with substantial deficits in lung-function development in children. 8-year increases in both FEV_1 and MMEF were smaller for children who lived within 500 m of a freeway, than for those who lived at least 1500 m from a freeway. Freeway effects were seen in subsets of non-asthmatic and non-smoking participants, which is an indication that traffic exposure has adverse effects on otherwise healthy children. Deficits in 8-year growth resulted in lower attained FEV_1 and MMEF at 18 years of age for participants who lived within 500 m of a freeway than for those who lived further away. Since lung development is nearly complete by age 18 years, an individual with a deficit at this time will probably continue to have less than healthy lung function for the remainder of his or her life.

We previously reported an association between community-average pollutant concentrations and 8-year lung-function growth.[15] That result relied on comparisons in communities that had different concentrations of regional air pollution, and implicated many pollutants such as nitrogen dioxide, acid vapour, particulate matter with aerodynamic diameter less than 10 µm and 2·5 µm, and elemental carbon. Our present study builds on that result, and shows that in addition to regional pollution, local exposure to large roadways are associated with diminished lung-function development in children. We did not find any evidence that traffic effects varied depending on background air quality, which suggests that even in an area with low regional pollution, children living near a major roadway are at increased risk of health effects. Our results also suggest that children who live close to a freeway in a high pollution area experience a combination of adverse developmental effects because of both local and regional pollution.

We noted a larger freeway effect in boys than in girls, although the difference between sexes was not significant. By contrast, a cross-sectional European study[29] reported larger traffic effects on lung function in girls than in boys.[29] Several factors could explain this discrepancy in sex-specific effects between studies, from differences in specific air pollution mixtures and underlying population susceptibilities, to the general difficulty of comparisons between longitudinal and cross-sectional study effect estimates. In general, however, both studies show that lung function in children is adversely affected by exposure to traffic.

The concentrations of several pollutants are raised near major freeways. Daytime concentrations of black carbon, ultrafine particulate, and other exhaust pollutants have been reported to be high, but decline exponentially, within 500 m of a freeway,[44,45] although night-time concentrations of ultrafine particulate remain above background concentrations for distances greater than 500 m from a freeway.[46] Some studies have reported increased traffic pollution, particularly nitrogen dioxide, at distances over 1000 m from a freeway.[16,47–49] Elemental carbon, an indicator of pollution from diesel exhaust, varies with nearby high-traffic roads[47,50,51] but can also be transported across large distances.[52] Diesel exhaust is one of the primary contributors to particulate-matter concentrations in those communities most affected by traffic.[53] A pollutant such as elemental carbon could explain our reported health effects both locally and regionally.

Both regional ambient and ultrafine particulate matter present in high concentration in close proximity to roadways can elicit oxidative and nitrosative stress in the airways, which results in inflammation.[54,55] Kulkarni and co-workers[32] reported that traffic-related particulate matter was correlated with the amount of carbon in the airway macrophages of children, which in turn was associated with reductions in FEV_1, MMEF, and FVC. Chronic airway inflammation could produce our reported deficits in increased MMEF and FEV_1. Additional research is needed to identify the specific traffic pollutants that bring about health effects, and to elucidate the contribution of each pollutant to regional and local associations.

A strength of this study was the long-term, prospective follow-up of two large cohorts of children, with exposure and outcome data obtained consistently. However, as in any epidemiological study, our results could be confounded by one or more other factors related to both traffic and lung-function growth. Our results were robust to adjustment for several factors, including socioeconomic status and indoor sources of air pollution, but the possibility of confounding by other factors still exists. Throughout the 8-year follow-up, we noted around an 11% loss of study participants per year. Participant attrition is a potential source of bias in cohort studies. We analysed the subset of children who were followed up for the full 8-year duration of the study and also noted significant traffic-effect estimates, which make participant loss an unlikely explanation for our results. We did not note a significant association between growth and model-based pollution from a freeway, despite large estimated deficits in the highest-exposure quartiles (table 1). However, we were restricted in detection of an association with model-based pollution from freeways because there was little variation in this measure within most of our study communities (webtable 2).

We have shown that residential distance from a freeway is associated with significant deficits in 8-year respiratory growth, which result in important deficits in lung function at age 18 years. This study adds to evidence that the present regulatory emphasis on regional air quality might need to be modified to include consideration of local variation in air pollution. In many urban areas, population growth is forcing the construction of housing tracts and schools near to busy roadways, with the result that many children live and attend school in close proximity to major sources of air pollution. In view of the magnitude of the reported effects and the importance of lung function as a determinant of adult morbidity and mortality, reduction of exposure to traffic-related air pollutants could lead to substantial public-health benefits.

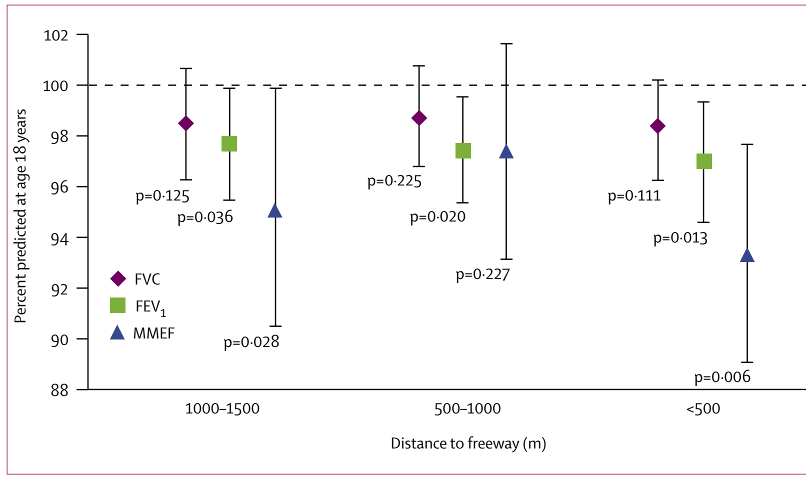

Figure: **Percent-predicted lung function at age 18 years versus residential distance from a freeway**
The horizontal line at 100% corresponds to the referent group, children living >1500 m from a freeway.

Contributors
W J Gauderman, R McConnell, F Gilliland, E Avol, J Peters, M Jerrett and N Kunzil participated in the writing of the manuscript. W J Gauderman, H Vora, K Berhane, D Thomas, and F Lurmann participated in the analysis of the data. All named authors took part in the interpretation of results, and approved the final version of the manuscript.

Conflict of interest statement
We declare that we have no conflict of interest.

Acknowledgments
This study was supported in part by the California Air Resources Board (contract A033-186), the National Institute of Environmental Health Sciences (P01ES11627 and P30ES07048), and the Hastings Foundation. We thank Cheryl Faucett for helpful discussions, members of our external advisory committee (Jonathan Samet, Nan Laird, Steve Rich, Petros Koutrakis, Gerhardt Coetzee) for important input, the school principals, teachers, students, and parents in each of the 12 study communities for their cooperation and the health testing field team.

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Effect of exposure to traffic on lung development from 10 to 18 years of age: a cohort study

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	n	Mean number of PTFs	Children with								
			8-years' follow-up				Race/Ethnic origin (%)				
			n	(%)	Female (%)	Asthma (%)	NHW	HW	AA	Asian	Other
Riverside	329	6·0	123	37·4	50·5	14·6	36·5	42·0	12·5	2·4	6·7
Atascadero	278	6·8	117	42·1	48·9	22·3	75·2	14·8	1·1	1·1	7·9
Alpine	308	6·2	121	39·3	50·1	12·9	75·0	18·8	0·0	0·3	5·8
Long Beach	320	6·1	141	44·1	47·5	13·9	32·2	24·7	18·4	15·3	9·4
San Dimas	293	6·4	117	39·9	50·2	15·3	50·2	32·4	3·1	9·2	5·1
Santa Maria	310	5·7	100	32·3	49·4	14·6	25·2	62·9	1·0	4·5	6·5
Lake Elsinore	306	6·0	104	34·0	50·0	12·5	64·3	25·8	2·3	2·0	5·6
Mira Loma	319	5·9	118	37·0	50·2	12·3	51·7	42·3	1·6	0·9	3·5
Upland	283	6·9	150	53·0	52·7	13·7	66·4	17·3	4·3	8·5	3·5
Lancaster	315	5·5	110	34·9	52·1	14·7	52·1	29·8	9·2	2·2	6·7
Lompoc	281	6·3	113	40·2	47·0	10·3	55·2	28·1	5·7	5·3	5·7
Lake Arrowhead	335	6·2	131	39·1	51·3	14·6	73·1	20·0	0·3	0·9	5·7
Overall	3677	6·2	1445	39·3	49·9	14·3	54·4	30·2	5·0	4·4	6·0

NHW=Non-Hispanic whites. HW=Hispanic whites. AA=African American. PFT=pulmonary-function test.

Webtable 1: **Participants' characteristics by community**

Effect of exposure to traffic on lung development from 10 to 18 years of age: a cohort study

	n	Residential distance to dearest								Model–based pollution from							
		Freeway (m)				Major non-freeway road (m)				Freeways (quartile*)				Major non-freeway roads (quartile*)			
		<500	500–1000	1000–1500	>1500	<75	75–150	150–300	>300	4th	3rd	2nd	1st	4th	3rd	2nd	1st
Riverside	329	103	66	61	99	46	45	90	148	190	123	14	2	149	138	41	1
Atascadero	278	83	60	46	89	11	8	15	244	0	70	155	53	4	17	58	199
Alpine	308	81	54	42	131	41	9	31	227	14	135	141	18	21	43	73	171
Long Beach	320	54	64	54	148	55	79	78	108	264	54	2	0	311	9	0	0
San Dimas	293	47	145	83	18	45	47	62	139	282	8	1	2	169	114	9	1
Santa Maria	310	44	74	58	134	25	47	104	134	0	7	73	230	18	191	64	37
Lake Elsinore	306	12	17	7	270	32	33	50	191	1	41	184	80	17	27	103	159
Mira Loma	319	9	30	45	235	20	37	57	205	11	304	2	2	12	43	212	52
Upland	283	4	0	0	279	53	52	62	116	4	2	85	192	83	100	60	40
Lancaster	315	3	35	31	246	52	24	91	148	0	21	108	186	48	127	128	12
Lompoc	281	0	0	0	281	5	21	33	222	..	..	..	..	4	26	88	163
Lake Arrowhead	335	0	0	0	335	0	0	0	335	..	..	..	..	..	..	..	..
Total	3677	440	545	427	2265	385	402	673	2217	766	765	765	765	836	835	836	835

* There is no major freeway within Lompoc or Lake Arrowhead, and no major non-freeway road within Lake Arrowhead.

Webtable 2: **Number of study participants within categories of four traffic indicators**

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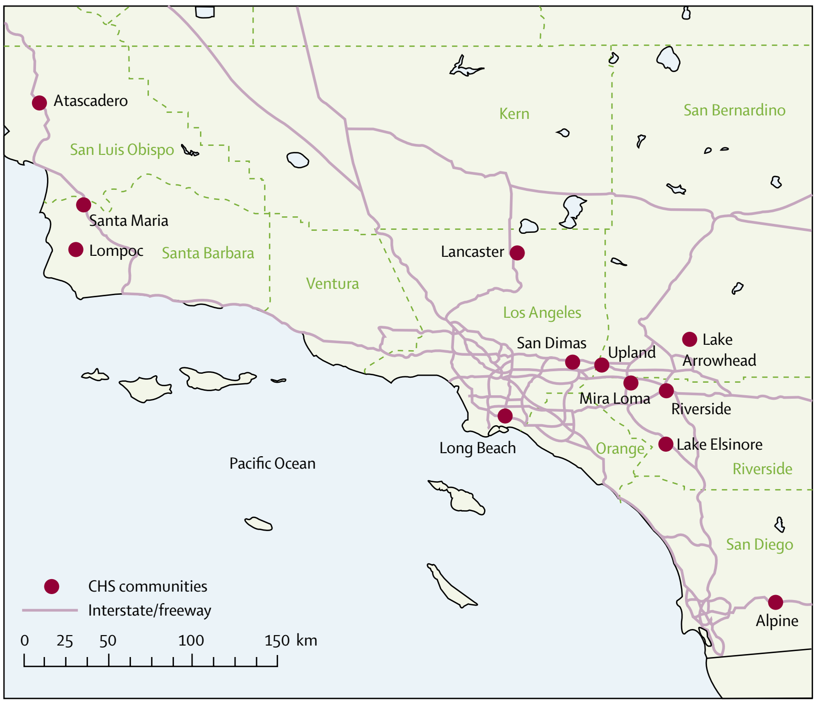

Webfigure: **Location of the 12 Children's Health Study communities and the major freeways (purple lines) in southern California.**

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Details of exposure assessment

Traffic exposures were assigned to each child on the basis of the residence at study entry. Residence addresses were standardised and their locations geocoded by use of the TeleAtlas database and software (Tele Atlas Inc., Menlo Park, CA, www.na.teleatlas.com). We used ERSI ArcGIS version 8.3 (ESRI, Redland, CA www.esri.com) software to calculate the distance from each residence to the nearest freeway, defined as an interstate freeway, US highway, or restricted-access highway, and to the nearest major non-freeway road, which included other types of highways and large roads. Yearly average daily traffic volumes were obtained from the California Department of Transportation Highway Performance Monitoring System for the year 2000. To obtain model-based estimates of traffic-related pollution exposure, we used the CALINE4 line-source air-quality dispersion model, separately for freeways and non-freeway roads.[1] The main model inputs included roadway geometry, traffic volumes, meteorological conditions (wind speed and direction, atmospheric stability, and mixing heights), and vehicle emission rates. We used the CALINE4 model to predict nitrogen dioxide concentrations derived from freeways and non-freeways at each child's home. Categories of exposure were then formed on the basis of quartiles of the within-community distribution of child-specific predictions, specifically based on cutpoints 0·6, 1·9, and 7·1 parts per billion (ppb) from freeways, and 1·5, 2·6, and 5·3 ppb from non-freeway roads. We also used the CALINE4 model to predict concentrations of other traffic-related pollutants, including oxides of nitrogen, elemental carbon, and carbon monoxide. However, predictions for each of these pollutants were almost perfectly correlated (around 0·99) with predictions of nitrogen dioxide. Thus, our model-based concentrations should be viewed as general measures of traffic-related pollution rather than this pollutant specifically. For both distance and model-based traffic indicators, within-community deviations from the corresponding community mean of the indicator were used in the health models to assess local (rather than between-community) effects.

Air-pollution monitoring stations were established in each of the 12 study communities and provided continuous monitoring data from 1994 to 2003. Each station measured average hourly concentrations of ozone, nitrogen dioxide, and particulate matter with aerodynamic diameter less than 10 μm (PM_{10}). Stations also collected 2-week integrated filter samples for measuring acid vapour and $PM_{2.5}$ mass and chemistry. Acid vapour included both inorganic (nitric, hydrochloric) and organic (formic, acetic) acids. For statistical analysis, we used total acid calculated as the sum of nitric, formic, and acetic acid concentrations. Hydrochloric acid was excluded from this sum, because concentrations were very low and close to the detection limit. In addition to measurement of $PM_{2.5}$ mass, we measured concentrations of elemental carbon and organic carbon, using the NIOSH 5040 method.[2] We calculated yearly averages on the basis of 24 h (PM_{10}, nitrogen dioxide) or 2-week ($PM_{2.5}$, elemental carbon, organic carbon, acid) average concentrations. For ozone, we calculated the yearly average of the 1000–1800 h (8 h daytime) average. Long-term mean pollutant concentrations (between 1994 and 2000 for cohort 1 and 1996 and 2003 for cohort 2) were also calculated for use in the statistical analysis of the lung-function outcomes. The distribution and correlation structure of these pollutants across communities, and their effect on lung function development, have been previously reported.[3–5] In this paper, we used community-average pollutant concentrations in models of local traffic exposure to investigate their combined effects and to explore the possibility that traffic effects vary according to regional air quality.

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