FW: Support of LA County Metro Area Plan

Elida Luna <ELuna@planning.lacounty.gov>
Fri 9/8/2023 1:46 PM
To:Leon Freeman <lfreeman@planning.lacounty.gov>;Tina Fung <tfung@planning.lacounty.gov>;Patricia Hachiya <phachiya@planning.lacounty.gov>
Cc:**EDL-DRP BU-S Commission Services <commission@planning.lacounty.gov>;**Connie Chung <cchung@planning.lacounty.gov>

FYI - Please see below regarding Metro Area Plan.

Thank you,

ELIDA LUNA (she/her/hers)
COMMISSION SECRETARY, Operations & Major Projects (OMP)

-----Original Message-----
From: brett.hollenbeck@everyactioncustom.com <brett.hollenbeck@everyactioncustom.com>
Sent: Thursday, September 7, 2023 6:48 PM
To: EDL-DRP BU-S Commission Services <commission@planning.lacounty.gov>
Subject: Support of LA County Metro Area Plan

CAUTION: External Email. Proceed Responsibly.

Dear LA County Planning Commission,

The Metro Area Plan before you is a well-crafted multi-pronged strategy suited to the community needs of unincorporated areas in central Los Angeles County including East Los Angeles, East Rancho Dominguez, Florence-Firestone, West Athens-Westmont, West Rancho Dominguez-Victoria, Walnut Park, and Willowbrook. If approved and fully implemented, this plan has the potential to stabilize the cost of housing in these neighborhoods, advance environmental justice, bolster local businesses, and foster more livable, walkable communities. I stand with Abundant Housing LA in supporting this plan, as well as the associated zoning updates and programs.

Totaling 310,000 diverse residents across 21 square miles, the Metro Area region is, in many ways, the geographic and cultural center of our incredible County. These communities of central LA County are home to rich history and a diverse blend of cultures that help make all of Southern California more special. The Metro Area deserves a plan that’s robust—not only in its approach to building affordable, accessible and abundant housing—but also in its attention to detail about the needs and preferences of these communities.

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The Metro Area Plan also provides a number of other exciting projects and opportunities, including a change to allow more stores on corner lots, a plan for safe routes to schools, and the implementation of the County’s Green Zones Ordinance, which focuses environmental justice efforts in communities disproportionately impacted by pollution.

Please support the staff recommendation and approve the Metro Area Plan, as well as the projects and zoning changes also included.

Sincerely,
Brett Hollenbeck
4431 Purdue Ave Los Angeles, CA 90230-5155 brett.hollenbeck@gmail.com

FW: Support of LA County Metro Area Plan

Elida Luna <ELuna@planning.lacounty.gov>
Fri 9/8/2023 1:46 PM
To:Leon Freeman <lfreeman@planning.lacounty.gov>;Tina Fung <tfung@planning.lacounty.gov>;Patricia Hachiya <phachiya@planning.lacounty.gov>
Cc:**EDL-DRP BU-S Commission Services <commission@planning.lacounty.gov>;**Connie Chung <cchung@planning.lacounty.gov>

FYI - Please see below regarding Metro Area Plan.

Thank you,

ELIDA LUNA (she/her/hers)
COMMISSION SECRETARY, Operations & Major Projects (OMP)

-----Original Message-----
From: laurenborchard@everyactioncustom.com <laurenborchard@everyactioncustom.com>
Sent: Thursday, September 7, 2023 7:11 PM
To: EDL-DRP BU-S Commission Services <commission@planning.lacounty.gov>
Subject: Support of LA County Metro Area Plan

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Sincerely,
Lauren Borchard
535 1/2 N Orange Dr Los Angeles, CA 90036-2066 laurenborchard@gmail.com

FW: Support of LA County Metro Area Plan

Elida Luna <ELuna@planning.lacounty.gov>
Fri 9/8/2023 1:46 PM
To:Leon Freeman <lfreeman@planning.lacounty.gov>;Tina Fung <tfung@planning.lacounty.gov>;Patricia Hachiya <phachiya@planning.lacounty.gov>
Cc:**EDL-DRP BU-S Commission Services <commission@planning.lacounty.gov>;**Connie Chung <cchung@planning.lacounty.gov>

FYI - Please see below regarding Metro Area Plan.

Thank you,

ELIDA LUNA (she/her/hers)
COMMISSION SECRETARY, Operations & Major Projects (OMP)

-----Original Message-----
From: leherc1@everyactioncustom.com <leherc1@everyactioncustom.com>
Sent: Thursday, September 7, 2023 8:18 PM
To: EDL-DRP BU-S Commission Services <commission@planning.lacounty.gov>
Subject: Support of LA County Metro Area Plan

CAUTION: External Email. Proceed Responsibly.

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Sincerely,
Mario Hercules
630 S St Louis St Apt 307 Los Angeles, CA 90023-1297 leherc1@yahoo.com

FW: Support of LA County Metro Area Plan

Elida Luna <ELuna@planning.lacounty.gov>
Fri 9/8/2023 1:46 PM
To:Leon Freeman <lfreeman@planning.lacounty.gov>;Tina Fung <tfung@planning.lacounty.gov>;Patricia Hachiya <phachiya@planning.lacounty.gov>
Cc:**EDL-DRP BU-S Commission Services <commission@planning.lacounty.gov>;**Connie Chung <cchung@planning.lacounty.gov>

FYI - Please see below regarding Metro Area Plan.

Thank you,

ELIDA LUNA (she/her/hers)
COMMISSION SECRETARY, Operations & Major Projects (OMP)

-----Original Message-----
From: tami@everyactioncustom.com <tami@everyactioncustom.com>
Sent: Thursday, September 7, 2023 9:52 PM
To: EDL-DRP BU-S Commission Services <commission@planning.lacounty.gov>
Subject: Support of LA County Metro Area Plan

CAUTION: External Email. Proceed Responsibly.

Dear LA County Planning Commission,

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Sincerely,
Tami Kagan-Abrams
2430 Hercules Dr Los Angeles, CA 90046-1634 tami@abramsgroup.org

FW: Support of LA County Metro Area Plan

Elida Luna <ELuna@planning.lacounty.gov>
Fri 9/8/2023 1:46 PM
To:Leon Freeman <lfreeman@planning.lacounty.gov>;Tina Fung <tfung@planning.lacounty.gov>;Patricia Hachiya <phachiya@planning.lacounty.gov>
Cc:**EDL-DRP BU-S Commission Services <commission@planning.lacounty.gov>;**Connie Chung <cchung@planning.lacounty.gov>

FYI - Please see below regarding Metro Area Plan.

Thank you,

ELIDA LUNA (she/her/hers)
COMMISSION SECRETARY, Operations & Major Projects (OMP)

-----Original Message-----
From: 4margreen@everyactioncustom.com <4margreen@everyactioncustom.com>
Sent: Thursday, September 7, 2023 9:57 PM
To: EDL-DRP BU-S Commission Services <commission@planning.lacounty.gov>
Subject: Support of LA County Metro Area Plan

CAUTION: External Email. Proceed Responsibly.

Dear LA County Planning Commission,

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Sincerely,
MARILYN GREEN
29500 Heathercliff Rd Spc 266 Malibu, CA 90265-6266 4margreen@gmail.com

FW: Support of LA County Metro Area Plan

Elida Luna <ELuna@planning.lacounty.gov>
Fri 9/8/2023 1:46 PM
To:Leon Freeman <lfreeman@planning.lacounty.gov>;Tina Fung <tfung@planning.lacounty.gov>;Patricia Hachiya <phachiya@planning.lacounty.gov>
Cc:**EDL-DRP BU-S Commission Services <commission@planning.lacounty.gov>;**Connie Chung <cchung@planning.lacounty.gov>

FYI - Please see below regarding Metro Area Plan.

Thank you,

ELIDA LUNA (she/her/hers)
COMMISSION SECRETARY, Operations & Major Projects (OMP)

-----Original Message-----
From: starrison1@everyactioncustom.com <starrison1@everyactioncustom.com>
Sent: Friday, September 8, 2023 7:54 AM
To: EDL-DRP BU-S Commission Services <commission@planning.lacounty.gov>
Subject: Support of LA County Metro Area Plan

CAUTION: External Email. Proceed Responsibly.

Dear LA County Planning Commission,

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Sincerely,
Angela Vanthaneeyakul
1029 S 5th Ave Arcadia, CA 91006-4331
starrison1@gmail.com

FW: Support of LA County Metro Area Plan

Elida Luna <ELuna@planning.lacounty.gov>
Fri 9/8/2023 1:46 PM
To:Leon Freeman <lfreeman@planning.lacounty.gov>;Tina Fung <tfung@planning.lacounty.gov>;Patricia Hachiya <phachiya@planning.lacounty.gov>
Cc:**EDL-DRP BU-S Commission Services <commission@planning.lacounty.gov>;**Connie Chung <cchung@planning.lacounty.gov>

FYI - Please see below regarding Metro Area Plan.

Thank you,

ELIDA LUNA (she/her/hers)
COMMISSION SECRETARY, Operations & Major Projects (OMP)

-----Original Message-----
From: targetburns@everyactioncustom.com <targetburns@everyactioncustom.com>
Sent: Friday, September 8, 2023 10:53 AM
To: EDL-DRP BU-S Commission Services <commission@planning.lacounty.gov>
Subject: Support of LA County Metro Area Plan

CAUTION: External Email. Proceed Responsibly.

Dear LA County Planning Commission,

I urge you to approve the Metro Area Plan. It is an essential step to addressing the housing crisis in Los Angeles, as well as reducing the environmental impact of the city. If approved and fully implemented, this plan has the potential to stabilize the cost of housing, advance environmental justice, bolster local businesses, and foster more livable, walkable communities. I stand with Abundant Housing LA in supporting this plan, as well as the associated zoning updates and programs.

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Please support the staff recommendation and approve the Metro Area Plan, as well as the projects and zoning changes also included.

Sincerely,
Eric Swanson

Sincerely,
Eric Swanson
16601 Foothill Blvd Apt 308 Rancho Cascades, CA 91342-1167 targetburns@gmail.com

FW: Support of LA County Metro Area Plan

Elida Luna <ELuna@planning.lacounty.gov>
Fri 9/8/2023 1:46 PM
To:Leon Freeman <lfreeman@planning.lacounty.gov>;Tina Fung <tfung@planning.lacounty.gov>;Patricia Hachiya <phachiya@planning.lacounty.gov>
Cc:**EDL-DRP BU-S Commission Services <commission@planning.lacounty.gov>;**Connie Chung <cchung@planning.lacounty.gov>

FYI - Please see below regarding Metro Area Plan.

Thank you,

ELIDA LUNA (she/her/hers)
COMMISSION SECRETARY, Operations & Major Projects (OMP)

-----Original Message-----
From: andymay@everyactioncustom.com <andymay@everyactioncustom.com>
Sent: Friday, September 8, 2023 10:59 AM
To: EDL-DRP BU-S Commission Services <commission@planning.lacounty.gov>
Subject: Support of LA County Metro Area Plan

CAUTION: External Email. Proceed Responsibly.

Dear LA County Planning Commission,

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Sincerely,
Andrew May
1901 N New Hampshire Ave Los Angeles, CA 90027-1818 andymay@yahoo.com

FW: Support of LA County Metro Area Plan

Elida Luna <ELuna@planning.lacounty.gov>
Fri 9/8/2023 1:46 PM
To:Leon Freeman <lfreeman@planning.lacounty.gov>;Tina Fung <tfung@planning.lacounty.gov>;Patricia Hachiya <phachiya@planning.lacounty.gov>
Cc:**EDL-DRP BU-S Commission Services <commission@planning.lacounty.gov>;**Connie Chung <cchung@planning.lacounty.gov>

FYI - Please see below regarding Metro Area Plan.

Thank you,

ELIDA LUNA (she/her/hers)
COMMISSION SECRETARY, Operations & Major Projects (OMP)

-----Original Message-----
From: careyjeanbennett@everyactioncustom.com <careyjeanbennett@everyactioncustom.com>
Sent: Friday, September 8, 2023 1:09 PM
To: EDL-DRP BU-S Commission Services <commission@planning.lacounty.gov>
Subject: Support of LA County Metro Area Plan

CAUTION: External Email. Proceed Responsibly.

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Sincerely,
Carey Bennett
2929 St George St Los Angeles, CA 90027-3025 careyjeanbennett@duck.com

FW: Potential Downzoning, 12822 S Main Street

DRP Metro Area Plan <MetroAreaPlan@planning.lacounty.gov>
Mon 9/11/2023 12:08 PM
To:Tina Fung <tfung@planning.lacounty.gov>

From: Joshua Schwartz <jschwartz@la-commercial.com>
Sent: Monday, September 11, 2023 9:30 AM
To: DRP Metro Area Plan <MetroAreaPlan@planning.lacounty.gov>
Subject: Potential Downzoning, 12822 S Main Street

To whom it may concern,

Good morning. I am a broker representing the owner of the above address and was looking at zoning information regarding the site. I noticed a potential plan to change the zoning of this site and wanted to get the most up to date information. Would you please let me know where the county is in the process and where I can find the most up to date information? I found this website but don't know if it's up to date. Thank you for your help.

https://planning.lacounty.gov/long-range-planning/metro-area-plan/

Best Regards,

Joshua Schwartz | Vice President
LA Commercial, Inc.
17252 Hawthorne Blvd. #480
Torrance, CA 90504
O: 424.218.9871
C: 818.912.1364
F: 310.872.3243
DRE# 02058318

Fw: Agenda Item #8, Metro Area Plan Hearing September 13, 2023

DRP Public Comment <comment@planning.lacounty.gov>
Mon 9/11/2023 1:30 PM
To:Tina Fung <tfung@planning.lacounty.gov>;Leon Freeman <lfreeman@planning.lacounty.gov>;Patricia Hachiya <phachiya@planning.lacounty.gov>
Cc:Elida Luna <ELuna@planning.lacounty.gov>

1 attachments (25 MB)
Humphreys Sydney Eagle Neighborhood Comment Letter re Metro Area Plan and Recirculated Draft PEIR 2023 July 28 Final.pdf;

FYI - Comment letter regarding Metro Planning Area.

Regards,

Rafael

From: Clara Solis <msclara416@gmail.com>
Sent: Monday, September 11, 2023 12:54 PM
To: DRP Public Comment <comment@planning.lacounty.gov>
Cc: theresaaceves@hotmail.com <theresaaceves@hotmail.com>; juanu2@aol.com <juanu2@aol.com>; Rachelvermillion1@gmail.com <Rachelvermillion1@gmail.com>; hubcapsunlimited@yahoo.com <hubcapsunlimited@yahoo.com>; alicia_fernandez@sbcglobal.net <alicia_fernandez@sbcglobal.net>
Subject: Agenda Item #8, Metro Area Plan Hearing September 13, 2023

Regional Planning Commissioners,

Please find attached our comments re the Metro Area Plan and the EIR. Although our letter was addressed to Metro Area Plan staff, our comments were not fully or adequately responded to in the Final EIR. So, we re-submit them to you now in the hope that you will consider our concerns. Our residents are literally dying from pollution and heat, we cannot take more.

Thank you,
Humphreys, Sydney, Eagle Neighborhood group

Humphreys, Sydney, Eagle Neighborhood
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July 28, 2023

VIA E-MAIL

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Patricia Hachiya, AICP
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RE: Comments on Draft Los Angeles County Metro Area Plan (released October 31, 2022) and RECIRCULATED DRAFT PROGRAM ENVIRONMENTAL IMPACT REPORT FOR THE LOS ANGELES COUNTY METRO AREA PLAN (released June 12, 2023) (Project No. PRJ2021-004165)

Dear Ms. Tran, Ms. Hachiya and Metro Area Plan team:

Please find our comments on the Los Angeles County's Metro Area Plan ("MAP" or "the Plan"), Draft Zoning Maps, Draft Zone Change Maps and the Recirculated Draft Program Environmental Impact Report (released June 2023) ("PEIR").

Most of our comments are related to impacts on the community of East Los Angeles from the Plan.

The Metro Area Plan, Zoning and draft PEIR are deficient, violate CEQA and NEPA. The Plan, Zoning and draft PEIR should be redone with meaningful input from the communities. The plan introduces additional pollution and health impacts without mitigation to environmental justice communities that are already overburdened by pollution. These most vulnerable communities must not be seen as the County's solution to meeting its housing element goals. Rapid change in these longtime primary rental communities can cause gentrification and displacement.

Each of the Metro Area Plan communities are special with their own identities, histories and unique problems. Additionally, each of the communities been under-resourced, under-served, and heavily polluted as a result of neglectful and racist public planning policies. No reasonable and comprehensive explanation is given for lumping together each of these disparate communities into one Metro Area Plan. The impacts of lumping together these communities in one plan instead of continuing to have a separate community plan for East Los Angeles which constitutes roughly one third of the plan area and population does a disservice to each of the communities included.

East Los Angeles which has a population greater than most of the other 265 communities in Los Angeles County. Lumping its plan together with much smaller communities does it and these communities a disservice. The long- term impacts to these communities from this decision were not adequately studied in the draft PEIR. Further, the plan and draft PEIR failed to recognize and study the significant undercounts of the 2020 US Census. The report document claims using the US Census Data," Between the 2010 Census and the 2020 Census, East Los Angeles lost approximately 7,710 residents." It provides no context that this Census was taken during a pandemic and during the tenure of the twice impeached disgraced former racist President Donald J. Trump who separated immigrant families and put children in cages. It fails to consider that during this Census, the disgraced president attempted to limit participation in the Census to US Citizens in an attempt to limit participation by immigrant communities. These actions are widely believed to have limited through fear the participation of immigrant communities like East Los Angeles in the 2020 US Census. It is widely believed that the 2020 US Census represents an undercount especially in immigrant communities.

The Metro Area Plan must be rejected because it increases air and noise pollution even with mitigation. The communities included in the Plan area already are all communities severely impacted by air and noise pollution. East Los Angeles is severely impacted by the five major freeways that intersect and pass through it. These are environmental justice communities who already face increased pre-mature deaths and disease from this pollution. How the County of Los Angeles could even consider a plan that further increases pollution to these communities is incomprehensible. Is the county merely saying just kill more residents? Cause more pre-mature deaths? Permanently damage more young children's lungs? Kill more old people? The impacts from living near freeways are well-documented. To increase area pollution is merely not acceptable. This plan must be rejected, redrafted and recirculated.

DEADLINE WAS TOO SHORT AND BREAKING APART CONSIDERATION OF DIFFERENT ISSUES PUTS THE COMMUNITY AT A DISADVANTAGE WHEN UNDERSTANDING THE FULL IMPACTS OF THE PROJECT

Not enough time was given to respond to the Plan, draft PEIR and zoning map and zoning changes maps. Residents in our Metro Area Communities have faced unusual circumstances which have made it difficult to meet and prepare responses to the Metro Area Plan and the Draft PEIR associated with the Metro Area Plan.

The 45 day comment period was too short and did not provide enough time for people to respond. At a minimum the deadline should have been extended to 45 days from July 13, 2023, since the ordinance and Public Hearing Zoning maps were not released until then. The document speaks of the ordinance but not having that until July 13 means that we only really had 14 full days to comment with the ordinance and zoning maps at hand to refer to leaves commenters at a disadvantage and unable to make sense of the document. Further, the Public Hearing should have been held before the deadline for comments so residents could learn from each other before submitting comments. Additionally, releasing a document during the Summer after school has let out puts the community at a disadvantage since schools are a major point of notifying community members and families often have no childcare during summer months and therefore have little time to read more than 1200 pages of documents. Finally, this process is being done piecemeal with the industrial portion being considered later. Everything should be looked at holistically and at one time. Not considering the industrial portion means the community will not have a full understanding of the impacts of the project.

Proposition 19 and its impacts including cumulative impacts are not analyzed studied or enumerated in the Plan or the draft PEIR.

The Metro Area Plan is presenting rapid change to areas which have provided for decades housing to poor and immigrant communities. It is true that renters are rent burdened, but it is also true that they are less burdened in the Metro Plan Area than in the County as a whole. The Plan documents a housing burden in the Metro Plan Area of 53 percent, stating on page 132 in the Gentrification and Anti-displacement measures section, "The Metro Area communities are amongst the most vulnerable in the County, as 53% of households in the Metro Area experience cost burden, spending over 30% of their income on housing, and most communities have a higher percentage of renter-occupied households, which adds another layer of vulnerability." However, this housing burden of 53 percent is much less than what has been documented in the county as a whole as a housing burden of roughly 75 percent. See https://news.usc.edu/179928/los-angeles-rent-burdened-households-basic-needs-usc-research/

The project in creating more than 5687 new dwelling units and 67 new Accessory Commercial Units in East Los Angeles would have potentially significant air quality and noise impacts that cannot be mitigated. The plan draft PEIR fails to study the impacts of increased pollution to a community that has five major freeways running through it. This is a special case. Pollution in these communities is already increasing mortality rates for area residents. The actual health impacts and risks associated with increasing pollution to this environmental justice community must be included as part of the draft PEIR.

ADD a project goal: Protect current residents from displacement.

See https://www.cdc.gov/healthyplaces/healthtopics/gentrification.htm

METRO AREA PLAN AND PEIR ARE DEFICIENT, SHOULD BE WITHDRAWN AND RECIRCULATED WITH MEANINGFUL INPUT FROM THE COMMUNITY:

1. The Metro Area Plan, Zoning and draft PEIR are deficient, and violate CEQA and NEPA.

A. The Plan, Zoning Maps , Zone Change Maps and draft PEIR should be redone with meaningful input from each communities. Input from communities cannot be done without proper outreach. Additionally, the impacts of the plan to the communities was not explained at the meetings. Residents were not told the impacts from changing the zoning of commercial areas to mixed use could result in increased height and density.

B. The Plan will have significant effects on the environment. Further, the plan introduces additional pollution and health impacts without mitigation to environmental justice communities that are already overburdened by pollution. The draft PEIR acknowledges that the additional pollution and health impacts cannot be mitigated and may indeed violate clean air initiatives that are in place. These most vulnerable communities must not be seen as the County's solution to meeting its housing element goals.

The plan will increase air and noise pollution. This increased pollution is not mitigated. Increased air and noise pollution will increase premature deaths and exacerbate already existing health problems caused by pollution. It will increase permanent lung damage to small children, cause more cases of asthma, heart and lung disease will increase co-morbidities which contribute to poor outcomes

Each project taller than two stories or more than twenty units should not be granted a Class 32 CEQA exemption because it should be assumed that there are unusual circumstances that will be result in significant impacts – namely significant and cumulative impacts to air quality which remain significant and unavoidable even after mitigation measures are implemented. Additionally, there will be cumulative impacts to health and there will be increased noise pollution which can not be mitigated and which will cause unavoidable and significant impacts.

AIR QUALITY

The Executive Summary of the PEIR suggests that it will implement zoning recommendations from the recently approved General Plan Housing Element 2021-2029 (Housing Element) and "considers environmental justice and equity to set forth land uses and policies that address topics such as: strategies to reduce vehicle miles traveled and improve air quality;" However, the project does not improve air quality instead it makes air quality worse and is unable to provide mitigation.

- The project will result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard which will be significant and unavoidable even after mitigation measures are implemented.
- The project will expose sensitive receptors to substantial pollutant concentrations. The impacts to sensitive receptors will be significant and unavoidable even after mitigation
- The project will have a cumulative effect on air quality resources. The impacts will be significant and unavoidable even after mitigation measures are implemented.

This Plan will increase Air pollution. It is in violation of Clean Air policies and initiatives. It is impacting only Environmental Justice Communities. It is racist. It should be rejected. The draft PEIR assumes that there will be significant and unavoidable air quality impacts when future development does roll out on a site by site basis.

If this Plan goes through there should be a programmatic approach to the Planning Department and the LA County Department of Public Health reviewing future projects covered by MAP with impacted residents to ensure the County plays an active role in addressing the health, wellness and environmental justice impacts regarding air quality and more. Every project should be assumed to require a CEQA EIR as there will be cumulative impacts from projects past, present and future.

AIR POLLUTION

Given the anticipated increase in air pollution the Plan and draft PEIR should be rejected and a new plan that does not add pollution to this environmental justice community should be drafted with real community input from at least 1 percent of ELA residents. A project goal is to reduce pollution. This plan fails that project goal and should be rejected.

A health impact analysis and risk assessment should have been provided for East Los Angeles since the population is already severely impacted from air pollution for the four freeways that run through and intersect East Los Angeles. The draft PEIR is deficient. The draft PEIR states at Page 1129 5.1.1:

> *Future development could potentially cause significant and unavoidable air quality impacts to the following thresholds: Conflict with or obstruct implementation of the applicable air quality plan; Result in a* ***cumulatively*** *considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard (including releasing emissions which exceed quantitative thresholds for ozone*

precursors); Expose sensitive receptors to substantial pollutant future development could potentially cause significant and unavoidable air quality impacts to the following thresholds: Conflict with or obstruct implementation of the applicable air quality plan; Result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard (including releasing emissions which exceed quantitative thresholds for ozone precursors); Expose sensitive receptors to substantial pollutant.

Draft PEIR fails to address Heat Island Impacts to Air Quality

The draft PEIR is deficient in evaluating air quality impacts to the East Los Angeles environmental justice community which is the 30th most dense community out of 265 communities in Los Angeles. Draft PEIR fails to address Heat Island Impacts to Air Quality from reduced tree canopy and increased hardscape from the project.

Additionally, higher temperatures from heat island impacts increase ground-level ozone formation. See below https://www.epa.gov/heatislands which states:

In addition to their impact on energy-related emissions, elevated temperatures can directly increase the rate of ground-level ozone formation. Ground-level ozone is formed when nitrogen oxides and volatile organic compounds react in the presence of sunlight and hot weather. If all other variables are equal, such as the level of precursor emissions in the air and wind speed and direction, more ground-level ozone will form as the environment becomes sunnier and hotter.

i. The draft PEIR fails to document the increased poor health outcomes, premature deaths, increased cases of asthma, heart and lung disease and other health problems currently experienced by residents facing pollution.
ii. The draft PEIR fails to conduct a health impact risk assessment.

HEALTH IMPACT ASSESSMENT and a HUMAN HEALTH RISK ASSESSMENT

Because the project will cause air quality impacts in East Los Angeles, an environmental justice community and other communities within the Metro Plan Area that already suffer from health problems from poor air quality that is in non-attainment under an applicable federal or state ambient air quality standard, the PEIR should include a Health Risk Assessment and Health Impact Assessment to determine the general air quality, health risk, and greenhouse gas impacts from the Project. It should also include a summary overview of the results of the AQ/HRA/GHG analyses.

A human health risk assessment must also be prepared because the risk to life and health among East Los Angeles is endangered by this plan which will exacerbate air and noise pollution and increase heat island impacts. A human health risk assessment is a quantitative, analytic process to estimate the nature and risk of adverse human health effects associated with exposure to specific chemical contaminants or other hazards in the environment, now or in the future. For more information, see the U.S. Environmental Protection Agency.

Additionally, we request that the study include an analysis of the impacts on air pollution from heat island impacts which are becoming progressively worse in East Los Angeles and other communities in the Metro Plan Area. Specifically, it is noted that heat island impacts are worse in Urban areas.

We also request that the study include an analysis of health risks from heat island impacts and how this project will worsen those impacts and effect the health of East Los Angeles residents and other residents impacted by this project.

See What Extreme Heat Does to the Human Body:
https://www.washingtonpost.com/world/interactive/2021/climate-change-humidity/?itid=lk_interstitial_manual_35

See How Extreme Heat Kills, Sickens, Strains and Ages Us

https://www.nytimes.com/2022/06/13/climate/extreme-heat-wave-health.html
See below for Heat Island Impacts and impacts on health from Heat Island

HEAT ISLAND IMPACTS

From Sourav Mukherjee, et al 2021
https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2020EF001886

"Climate change has increased extreme events (e.g., drought, heatwave, and heat stress) in a warming world (Konapala et al., 2020; Matthews et al., 2017; Mukherjee & Mishra, 2021). Heat stress has led to massive human morbidity and mortality in recent years (Matthews et al., 2017). The impact of high temperatures is often compounded by high atmospheric relative humidity, which slows heat dissipation from the human body, thereby adding to heat stress (HS) (Buzan & Huber, 2020). Numerous recent studies have reported the adverse effect of heat stress on public health and labor efficiency in the United States (Fechter-Leggett et al., 2016), much of which has been exacerbated by human-caused climate change (Matthews et al., 2017). Severe recent HS events in the West and the Southeast in summer 2020 are representative of the types of conditions expected to become more common in the CONUS in future (Rastogi et al., 2020; Wu et al., 2014)."

Communities like East Los Angeles which has five major freeways (I-710,SR710, SR60, 101, I-10, I-5) running through it have a substantial amount of freeways and are park poor with little green space and trees. Some of this is due to redlining (See – How decades of Racist Housing Policy left Neighborhoods Sweltering - https://www.nytimes.com/interactive/2020/08/24/climate/racism-redlining-cities-global-warming.html) which because land in communities of color was valued cheaper were prime locations for the siting of freeways. Additionally, racism in terms of the ability to vote and choose representatives was terribly constrained until the passage of civil rights laws in the 1960's. Many of the freeways that now pass through East Los Angeles were planned before communities like East Los Angeles had representative that they chose. Indeed, it was not until 1992 that Supervisor Gloria Molina became the first Latino Supervisor elected in Los Angeles in the 20th century. That lack of representation meant that communities like East Los Angeles had little political power to fight unwanted freeway projects that other communities like South Pasadena and Beverly Hills were able to stop. Fast forward until today and the impacts of redlining and racism continue wherein communities that still provide connectivity and trees in the form of habitat are spared from projects and communities like East Los Angeles are required to take the burden of increased density for the rest of Los Angeles.

For further analysis on equity and Heat Island Impacts see:
https://www.epa.gov/heatislands

See also:

Heat and smog hit low-income communities and people of color hardest, scientists say

https://wapo.st/3Ydj5S6

It has been found by Eric M Wood, et al that, "Affluent communities harbored a unique composition of street trees, including denser and larger trees than lower-income communities," https://esajournals.onlinelibrary.wiley.com/doi/full/10.1002/eap.2149

> This disparity of tree cover between rich and poor neighborhood is prevalent throughout the US and was cited as "trees grow on money" (See Schwarz, K., et al 2015. Trees grow on money: urban tree canopy cover and environmental justice. PLoS ONE 10, e0122051, http:// dx.doi.org/10.1371/journal.pone.0122051Schwarz et al., 2015) and (https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0122051).

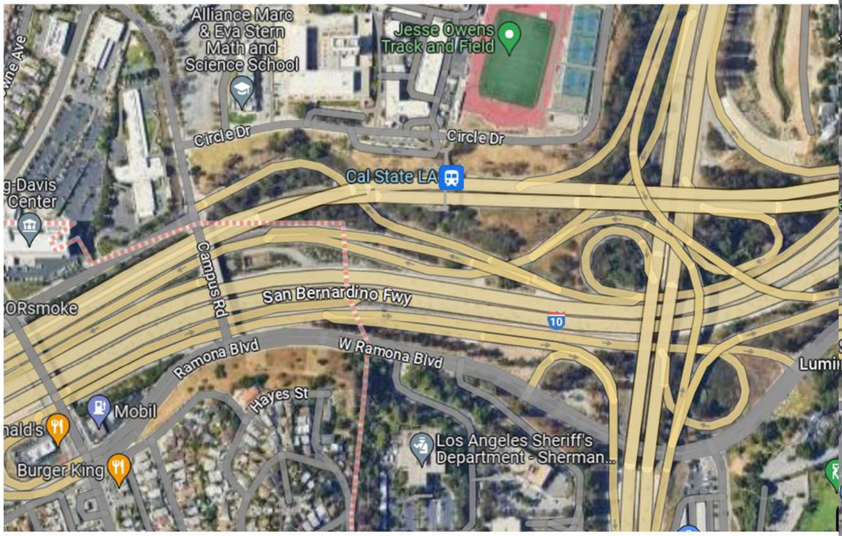
Another study in the journal Nature, finds Disproportionate exposure to urban heat island intensity across major US cities. It found that the average person of color lives in a census tract with higher SUHI intensity than non-Hispanic whites in all but 6 of the 175 largest urbanized areas in the continental United States.

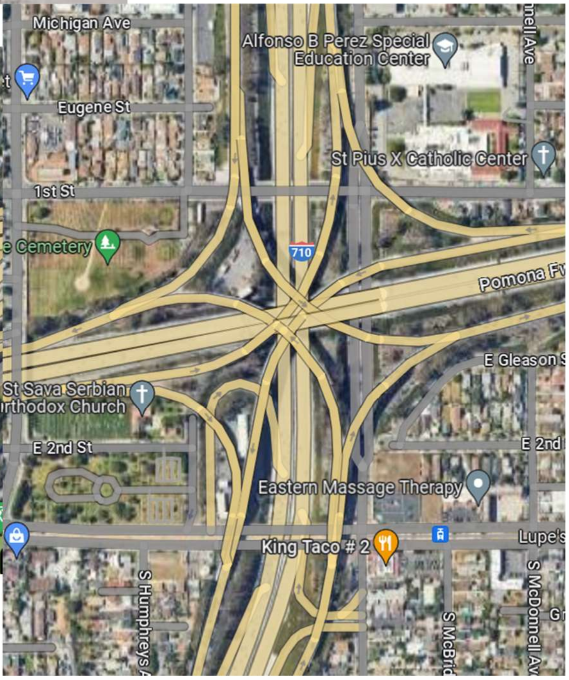
https://www.nature.com/articles/s41467-021-22799-5

As noted above, this isn't by chance or less value of trees by the community, it is because the history of redlining and racism that communities like East Los Angeles have less trees and a smaller tree canopy.

In East Los Angeles, freeways and concrete came in trees went out.

This 1932 Photo by Anton Wagner shows a neighborhood east of Eastern Avenue that was probably taken by the 710 freeway. Trees were abundant. Below the I-10 and SR60 to 710 interchanges are seen.

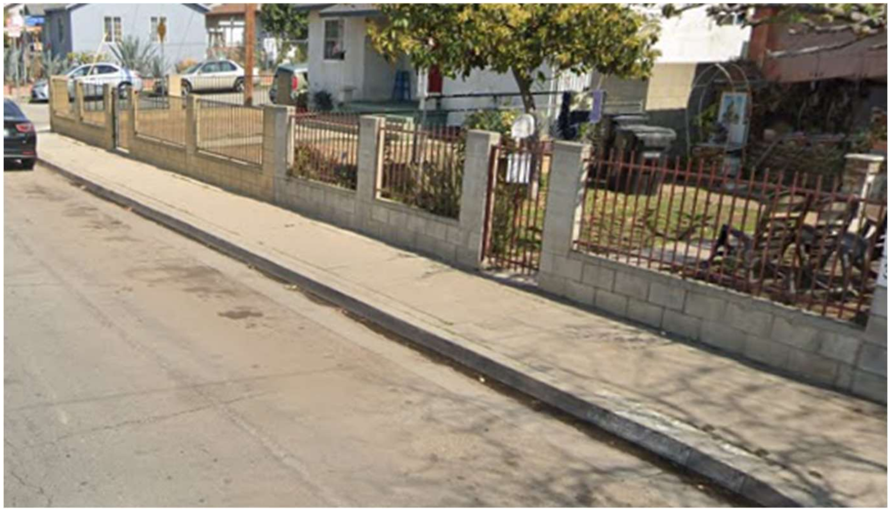




In the 1970's, streets were widened to accommodate the pass through traffic that uses East Los Angeles streets when traffic on the five freeways becomes congested. Trees were removed and replaced with non-native trees unlikely to survive like the bottle brush trees.

Below Eastern Avenue, East Los Angeles. Visible is a portion of the cemented in parkway that used to exist before the street was widened.

Below Humphreys Avenue, East Los Angeles. In the 1970's the streets were widened to accommodate traffic that exits on the I-710 freeway South at the 3rd Street exit (which actually exits on Humphreys at Eagle) Not a single parkway tree remains on Humphreys from the freeway exit to 3rd Street. Prior to the widening there were Oak trees and other shade trees. The trees were replaced with Bottle Brush trees which were dead within two years. The scrawny trees frequently broke in half or were hit by cars exiting the freeway at high speeds.



The Metro Plan Area is an area where residents already suffer from health problems from poor air quality. It is an area that is in non-attainment under an applicable federal or state ambient air quality standard. The PEIR must include a Health Risk Assessment to determine the general air quality, health risk, and greenhouse gas impacts from the Project. It should also include a summary overview of the results of the AQ/HRA/GHG analyses.

Additionally, the study should include an analysis of the impacts on air pollution from heat island impacts which are becoming progressively worse in East Los Angeles and other communities in the Metro Plan Area. Specifically, it is noted that heat island impacts are worse in Urban areas.

The study include an analysis of health risks from heat island impacts and how this project will worsen those impacts and effect the health of East Los Angeles residents and other residents impacted by this project.

The PEIR has so many deficiencies related to a lack of information on potential health impacts of the project, that we recommend that the PEIR be redone and recirculated for review and comment. Additionally, the Metro Area Plan should be re-written with meaningful public participation. The Metro Area Plan should address the health risks that it will cause to the community. It should consider a finding that its implementation will cause a danger to public health.

This important determination is based upon our identification of the following deficiencies related to public health in the PEIR:

1. Failure to include a HEALTH IMPACT ASSESSMENT and a HUMAN HEALTH RISK ASSESSMENT

2. Failure to describe, discuss or cite any of the dozens of studies from around the world, including many from Southern California, linking exposure to near roadway emissions with a wide range of health effects, including, as examples:

- Exacerbation of asthma and new cases of asthma (Gauderman et al. 2005; McConnell et al, 2006; McConnell et al, 2007; Jerrett et al, 2008; Perez L et al , 2012)
- Reduced lung function (Gauderman et al, 2007; Urman et al, 2014)
- Cardiovascular heart disease (Brook et al, 2010; Gan et al. 2010, 2011; Hoffmann et al. 2006; Kan et al. 2008)

3. Failure to describe or discuss studies and rulings that conclude that diesel exhaust and diesel particulate are carcinogens, which is critical to understanding the potential health risks of a Freeway Cap on residents who live adjacent or near to the freeway.

The Air Quality Assessment fails to mention action in California in 1998 that declared diesel as a Toxic Air Contaminant, with a unit risk value of cancer potency for cancer risk. However, California's OEHHA and the regions South Coast AQMD have, respectively, adopted quantitative risk value and an acceptable level of risk, which the Neglects to address.

TREE LOSS AND IMPACTS ON AIR QUALITY AND HEAT ISLAND IMPACTS MUST BE STUDIED AND QUANTIFIED IN THE PLAN AND PEIR.

The Metro Area Plan will make East Los Angeles into an Urban Desert by removing trees where they are now most abundant on private property. This will result in untold misery by area residents faced by future global warming and climate change. East Los Angeles cannot sustain further tree loss and increased hardscape.

The Metro Area Plan will decrease tree canopy on existing properties. Trees will be cut down to accommodate more housing. The loss of trees will increase heat island effects and reduce the amount of CO2 being removed from the community. The loss of trees will increase air pollution.

The plan does not contain this information. It is deficient and does not fully analyze the impacts to the environmental justice community of East Los Angeles and other Metro Area Plan communities.

From Su Jin Lee, et al See - https://johnwilson.usc.edu/wp-content/uploads/2018/03/Increased-home-size-and-hardscape-decreases-urban-forest-cover-in-Los-Angeles-Countys-single-family-residential-neighborhoods.pdf

> The environmental benefits of trees and other forms of green cover are many and varied and play a crucial role in improving residents' quality of life and in maintaining urban environmental amenities (Akbari et al., 1997, 2001; Dwyer et al., 1992; Dwyer and Miller, 1999; Longcore et al., 2004; Simpson and McPherson, 1996). Abundant green cover helps to maintain or boost property values and brings environmental benefits such as reduction in energy use, improvement in air quality, reduction in noise, control of stormwater runoff, provision of habitat for wildlife, and enhancement of aesthetic values. Together, the tree, shrub, and grass cover of the city can be conceptualized as an "urban forest," which meets the definition of a forest by exceeding 10% cover of trees (Rowntree, 1984).
>
> Trees provide shade and decrease energy consumption by helping to keep buildings cool in summer (Dwyer et al., 1992; Simpson and McPherson, 1996). Trees intercept sunlight before it heats buildings and reduce wind speed by as much as 50%. Approximately $10 billion is spent annually to cool residential dwellings in the U.S. so the potential impact of these savings is considerable (Akbari et al., 1990). Akbari et al. (2001) reported that the City of Los Angeles, for example, could save $270 million annually from an expanded tree cover. Vegetation cover may also help to reduce the urban heat island and thereby reduce nighttime residential energy consumption.

See also: **Peak power and cooling energy savings of shade trees – Akbari, et al**
https://www.sciencedirect.com/science/article/abs/pii/S0378778896010031

C. Housing: Further, the plan identifies the community needs in terms of housing but does not provide a way to achieve this. The PEIR is deficient in that it does not evaluate the plan's ability to meet the communities housing needs. The plan changes zoning from Commercial to Mixed Use, but does not require that the housing built be affordable. Developers can build density projects with as little as 5 percent Extremely Low Income Units. This means that the 95 percent of the housing provided will be market rate. The last housing element built market rate units but failed to build enough affordable units in the various categories.

   i. The draft PEIR fails to study and analyze whether the Plan has a possibility of meeting the goals in the various low income categories, - "extremely low income, very low income, low income, moderate."
   ii. The draft PEIR also fails to consider the impacts of building a large number of market rate units on existing area rents and the impacts of such upward pressure on area rents. It fails to analyze whether the Plan policies will lead to higher rents in East Los Angeles and other Metro Plan Areas which will increase homelessness and displacement.

D. The proposed Plan would result in significant and unavoidable impacts to Air Quality, Biological Resources, Cultural Resources, Hazards and Hazardous Materials, Mineral Resources, Noise, Population and Housing, Public Services (Parks), Recreation, Tribal Cultural Resources,
And Utilities and Service Systems.

E. The proposed Plan and PEIR fail to consider and study and mitigate for all of the impacts of increasing density in some of of the most dense communities in all of Los Angeles County. Walnut Park is the 8th densest and East Los Angeles the 30th densest communities in terms of people per square acre out of 265 communities in the County of Los Angeles.
   i. Fails to consider the socio-economic impacts of increasing density.
   ii. Fails to adequately study traffic impacts. East Los Angeles with 5 major freeways is different than many communities in that most of its traffic is from outside the community. Most of the traffic is pass through traffic and vehicles exiting the freeway when the freeways become congested. If every resident in East Los Angeles used public transportation, rode bicycles and didn't drive cars there would still be traffic and resulting pollution.
   iii. Fails to consider the impacts of not having enough parking. Fails to adequately study the impacts of not having enough parking on noise and air pollution. Fails to study the impacts of vehicles circling in search of parking. Fails to consider the parking study which was recently completed in East Los Angeles. (See attached.)
   iv. Fails to consider impacts to community health of increasing density. Does not provide a health risk assessment for increasing air and noise pollution on an environmental justice community that is already overburdened by significant air and noise pollution.
   v. Fails to document the impacts of violating air quality standards on the community.

F. It is reprehensible that any plan presented would increase air and noise pollution to a community that is already overburdened by air and noise pollution from racist government policies in the past that concentrated four major freeways in this community. At what point, is the project merely saying that it is okay to increase deaths from pollution. It is widely acknowledged that the air and noise pollution in these communities are causing premature deaths. It is not good enough to merely state that the project will increase air and noise pollution to these communities and that these increases cannot be mitigated.

   i. Because the Plan will increase air and noise pollution and these increases cannot be mitigated. The PEIR must provide a health risk assessment for each of the communities in the plan. The health risk assessment should evaluate, analyze, quantify and enumerate the number of pre-mature deaths that will be caused by this plan, the increase in emergency room visits, the increase in asthma, lung cancer, heart disease, covid 19 cases and deaths, diabetes and other illnesses attributed to increased air and noise pollution.

G. Fails to acknowledge other projects currently going forth in these communities and their combined impacts on residents living within these communities.

H. Does not adequately address cumulative impacts from the plan and other current projects past, present and future.

I. Does not assess cumulative impacts from state and local density bonus projects in conjunction with possible impacts from zoning changes from this plan.

J. Does not adequately assess impacts to historic resources within the community from plan zoning changes. Any Zoning and ordinance changes should require preservation and restoration of historic buildings and resources. Before demolition all buildings on Whittier Blvd should be assessed by a historian. Consideration of creating a Historic Preservation Overlay Zone along Whittier Blvd. is strongly advised. Historic Buildings and resources should be excluded from changes in Zoning from Commercial to Mixed Use.

   i. Does not adequately address impacts to historic resources from changing commercial zoning to mixed use zoning on location like Whittier Blvd, Atlantic Blvd. and Beverly Blvd.

   ii. Advocates for changing facades. Any such changes should include restoring historic facades and preserving historic facades. Such changes in the past may have resulted in the loss of historic resources like the façade changes made in the 1990's under the Whittier Blvd CBR Façade Project which may have removed Moderne facades and art deco structures. See 4765 Whittier Blvd. See Attachment:

   Policy LU 3.2: Facade Beautification should also include language around preserving cultural and historical elements and architecture.

   Policy LU 3.3: Architectural Elements. Require defining architectural elements and visual interest

   in new development and renovations to existing structures, including renovating long expanses of windowless walls along the street frontage.

K. **Proposition 19:** The project fails to study the impacts of recently passed Proposition 19 on the community. The project also fails to assess the cumulative impacts of this proposition:

The Metro Area Plan fails to study the impacts of Proposition 19 on the plan area. Not once is Proposition 19 mentioned in this document. Proposition 19, which will reassess property values at today's market rates when a current property owner dies and their heirs inherit the property, has the possibility of creating a great deal of upheaval in the housing and rental market. Many of the areas rentals today are single family dwellings owned by Mom and Pop landlords. Mom and Pop landlords unlike corporate interests who own rentals tend to raise rents less and evict tenants less. Heirs of current owners facing tax increases of three to four thousand dollars a year and the likelihood of a renters who will not be able to afford a $300 dollar monthly rental increases to their rent may sell. These properties will likely fall into the hands of developers who will knock down existing housing stock that is affordable and create rental housing stock where yearly rental increases are issued or create luxury housing for sale that is unaffordable to current residents. The impacts of Proposition 19 on land use, area residents ability to stay in their homes, rents, pollution from demolition and building of properties and the related pollution caused health impacts should be studied both in the plan and the draft PEIR. https://www.npr.org/2021/07/07/1013645699/economic-pressures-are-rising-on-mom-and-pop-rental-owners

The plan should include language which protects the existing populations and culture. East Los Angeles and Metro Plan Areas remain one as some of the last remaining areas near the City of Los Angeles that are not gentrified. They have remained as a resource for working class and immigrant communities. Research question that has been ignored in this proposal. "What will the impact of this plan be in terms of displacement on this community? Will it increase displacement? Each new project should ask? Will this project increase displacement.

Cumulative Impacts:

Each new project should be evaluated for cumulative impacts with other proposed projects, future and past and present with careful consideration to its impacts since 2015, as to its

1) impacts on displacing current residents.
2) Increasing Pollution
3) Increasing Heat Island Impacts

If the proposed project does any one of the above it should be rejected. This should be an ordinance included with any Metro Area Plan.

Land Use

The section below addresses concerns regarding policies included in the report focused on land use.

Regarding Policy TOD 1.1 Housing and Mixed-Use Development. Provide mixed-use, medium- to high-density in Transit Oriented Districts

The EIR shows that the plan will have air and noise pollution impacts which cannot be mitigated. East Los Angeles is too dense in terms of people per acre as noted in the plan document. The area is traversed by freeways. Transit Oriented Development will not reduce traffic or pollution because most of the traffic is pass through. Experience with housing built with little or no parking has resulted in residents from those projects parking along adjacent residential areas. This has been reported in meeting after meeting. The parking study shows in some areas 120 percent of the parking is being used. (See Attached)

Furthermore, Policy TOD 1.5 Active Ground Floor. Promote high-quality urban design and active ground floors through design standards and a variety of allowed uses on major mixed use and commercial corridors.

Policy LU 2.2: Incentivize Gathering Spaces. Incentivize the inclusion of gathering spaces in
commercial, mixed-use, and multi-family residential development through parking reductions, floor
area ratio increases, or other relevant incentives.

Parking in many community meetings throughout East Los Angeles is the number one concern. A case study could be the Alta Vista Apartments project on 3rd near Woods. Projects claiming to cater to transit such as the Alta Vista project on 3rd near Woods Street, were built with developers claiming that residents would not use street parking. Woods residents have said that residents from that project are using their street parking. Since the building of that project residents have reported that their quality of life has been reduced.

The community voices which prompted Los Angeles County to fund a parking study which is attached should be listened to. Already, state law, density bonuses and transit-oriented community laws, ordinances and zoning require less parking. The community if asked would say no to further reducing parking by giving bonuses for providing gathering spaces in their buildings. But the community was not told this was one of the considerations. Instead this policy is hidden in thousands of pages, in millions of words.

Changing Commercial areas on Whittier Blvd to Mixed use may have a negative impact on East Los Angeles Commercial Districts. Time after time we have seen mixed used building's ground floors flounder. Ultimately they are vacant and used for storage. Before making this radical change a study should be done on how successful mixed use first floor commercial uses have been in communities with similar demographics. Additionally, many residential projects touted as not needing parking have added to an already difficult parking situation in East Los Angeles. If tenants of mixed use, use available parking that could limit the ability of businesses to provide parking for their customers. At the very least, the ground floors of mixed use buildings should be devoted entirely to commercial uses. Having a Policy such as TOD 1.5

Active Ground Floor is not sufficient. An objective zoning ordinance which requires ground floors be dedicated to commercial uses.

It appears that one of the primary reasons for changing the designation from Commercial to Mixed Use is for the County to meet its housing element goals. Currently, the commercial designation generally allows for the building of up to 50 dwelling units. The change to mixed use will allow for the building of up to 150 dwelling units. In East Los Angeles, the community is already impacted by high density, air and noise pollution and pass through traffic due to its proximity to 4 major freeways. It should not be further burdened by increased density simply to allow the county to meet its housing element goals. This is an environmental justice community which will be impacted by unmitigated increases in pollution due to these plans according to the draft PEIR. See Appendix B-2 Housing Element Re-Zone Sites.

The Plan provides a Long Term Land Use Assessment. Unfortunately, the Plan fails to provide a realistic means for attaining the shortfalls. For example, the assessment presents for East Los Angeles in Table 2.1 Demand Analysis Summary (2021-2035) targets, “Target (Rounded),

Housing (Units) 5,200, Market Rate 1,500 Affordable 3,700

Retail (Square Feet) 184,800 Office (Square Feet) 109,800”

As noted, affordable units are what is needed. However, the plan does not identify a means for providing these affordable housing units. Its housing plans rely on existing programs such as the density bonus program which provides as little as 5 percent affordable housing for extremely low income units, meaning that 95 percent of the units are market rate. With no real program for creating affordable housing, it is no wonder that the county failed to meet its last housing element needs, which created much more market rate units than needed and much fewer affordable units than needed. We are concerned that by introducing so much market rate housing into Metro Area Plan through the infusion of Mixed Use units where there used to be commercial units in areas like East Los Angeles, Whittier and Atlantic Blvds., there will be upward pressure on rents throughout these communities. We ask that this be studied in a recirculated Draft PEIR.

Additionally, instead of providing solutions to the lack of retail space, the plan will probably reduce retail space by changing current commercially zoned areas to mixed use. It has been the experience in Los Angeles especially in environmental justice communities in the past decade that mixed use properties are not really built as mixed use, instead the minimum amount possible of commercial is built, usually one unit of less than 2000 square feet.

Displacement Aspects of the Metro Area Plan:

The Metro Area Plan seems to want to change the Metro Plan Areas into something different from what exists today. While these areas have remained a refuge from gentrification for the poor and for immigrant communities. The Metro Area Plan seems intent on gentrifying and displacing these communities. While the community wants less polluting industries they did not ask for gentrification. Some of the ideas presented in the plan such as a Life Science Corridor have caused problems in other communities. Residents in Boyle Heights, El Sereno, and Lincoln Heights faced with the BioScience corridor have seen land speculation driving up prices, displacement, increased rents and loss of green space.

Ghost Kitchens, these kitchens have been associated with areas around the USC campus with area residents experiencing higher rents and displacement.

Artisan units, residents have been concerned that soon after art gallery's appear gentrification follows.

Concerns that the displacement aspects of the Plan have not been addressed.

See https://www.cdc.gov/healthyplaces/healthtopics/gentrification.htm

Sociological impacts of rapid change and huge increases in density to a stable working-class community.

The Plan is considering replacing existing businesses with new businesses. These new jobs may not be available to existing residents of this community. The draft PEIR fails to study the economic impacts to the community and its members.

Will this project cause homelessness among existing community residents as rents rise? This question is not addressed.

Will this project cause area rents to rise as 95 percent market rate units are introduced in newly zoned mixed use buildings? Developers always chose the option which requires them to build the fewest affordable units…- usually the extremely low income units which require only 5 percent of the units to be reserved. See Jorge de la Roca: https://jorgedelaroca.name/p_latoc.pdf "*..the TOC program can be a tool to ramp up the production of units. However, it encourages developers to build a small number of extremely low-income units instead of a larger number of low-income units."*

Also concerning is inclusion of so-called "non-polluting science-and technology-driven research and development (R&D)" facilities. How will these technologies be regulated? There is concern that they will use, "under-researched, highly toxic substances, and/or diesel-fueled technology." Will these businesses increase increase vehicle and cargo truck traffic in our neighborhoods, increasing air emissions, traffic, and PM2.5 pollution including tire and brake fugitive dust? Will these jobs be available to residents within the community or will they bring in workers from the outside?

Any land use plans should not displace tenants and should not increase homelessness among Plan area residents. Language should be incorporated throughout the document that requires this.

Retention of existing mature trees in the community's are ignored. Yet it is mature trees that provide the most benefit. Research has shown that newly planted trees take twenty years to provide benefits and are for the first 20 years producers of carbon. So in environmental justice communities where pollution is already a problem and is actually killing people, trees should not be removed. Any new plantings should include native trees such as the drought tolerant Southern California Black Walnut, Coast Live Oaks and Western Sycamores. Many area in East Los Angeles are in areas that have historically had water running through them during rainy seasons. Trees grew here, in some cases still exist and can grow here again. Areas with water historically are near Bonnie Beach and Downey, 3rd Street between Eastern and Humphreys down to Eagle, 3rd Street between Kern and Dangler, Gratian near Dangler. Sycamores are fast growing and would be well adapted to such areas. See Gratian near Dangler. It is near here where there is still a Coast Live Oak living on private property. Money should be preserved to provide existing property owners with these protected trees with incentives to retain these trees which provide community benefits in terms of carbon uptake.

Health, Wellness, and Environmental Justice & Hazards and Hazardous Materials
The Plan and draft PEIR considerations of health, wellness and environmental justice impacts of the Metro Area Plan, places the community at a disadvantage in assessing concerns. There is no assessment of any site-specific development.

Other recommendations include:

Improve Community Engagement. Inadequate community engagement occurred. Additionally presentations did not include the most important community impacts. At least 3000 residents should have be engaged. East Los Angeles includes a third of the Plan area at least one thousand ELA residents (approximately 1 percent) should have been involved.

For many East Los Angeles residents and immigrant communities, employment has been hard to obtain. These community members historically because of racism and today have turned to self-employment and creating small businesses. Street vending is a form of this. However, it is ripe for exploitation by owners of stands and vending trucks who have employees. Street vendors should not be employees working for an owner who is avoiding paying rent, livable wages and sound working conditions including bathrooms and running water. Infrastructure should be provided to reduce pollution to neighborhoods from gas powered generators, diesel trucks running for hours a day.

Metro can also encourage and provide more assistance/resources for at-home businesses.

The report under section 3.4-1, states that Policy ED 3.2: Promote the attraction of businesses and industries that provide employment improvement opportunities and encourage professional advancement for low skill workers. How will this be done? Specific Guidelines should be provided. Local hire should be encouraged.

Commercial Development in East Los Angeles:

While the plan acknowledges, “The community appears to experience retail expenditure leakage to neighboring areas in the region or “retail leakage” due to the newer, large format retailers located in other areas of the County,” the plan fails to present options to recapture this leakage, instead presenting plans that will decimate its remaining commercial district by changing its zoning from commercial to mixed use. It appears that East Los Angeles is being planned as an area where people will live, not shop with proposals of a small number of Accessory Commercial Units (ACU’s) providing for area residents with enough opportunities for local retail.

Instead of addressing the retail leakage in a way that would benefit community members, the County of Los Angeles is seeing these communities as opportunities for solving its Housing Element goals without regard to the residents who live here and already have a strong local community identity.

Whittier Blvd. Commercial District an Opportunity Ignored and instead destroyed by the Metro Area Plan

Whittier Blvd. could have been seen as an opportunity for commercial development with large areas of parking already available behind many of the retail buildings. These parking areas could be enhanced allowing for residents to easily shop locally and provide one stop shopping. What the large format retailers have is abundant parking, and places to eat, gather and enjoy the community. Whittier Blvd is ideally placed for this, representing an opportunity for a community based commercial shopping area which will in the future be easily accessed by the Metro Station. Anchoring this hub should be a market where local area residents can purchase food at low prices. (Currently on Whittier Bl., there is an Uno market which could possibly be enhanced to better serve the community.) Care must be given to retaining historic buildings.

See attached list of historic buildings on Whittier Blvd. in which the Metro Area Plan proposes changes from Commercial to Mixed Use Zoning. The list is not complete as I ran out of time. The Plan and draft EIR should complee the list. These properties must be protected from demolition. See Attached.

Historic Preservation

- The goals should include an elimination of the LA County fees for historic landmark designation;

- The goals include a policy where LA County pauses any development/permit approval process as soon as a historic landmark nomination application is submitted for a property;
- The goals include prioritizing and preserving legacy businesses and the implementation of a Countywide Legacy Business program. (6.1.3 Preserve Legacy Businesses).

  Should consider if conversion of properties from Commercial to Mixed Use undermine the preservation of Legacy Businesses. This should be studied and evaluated in the draft EIR.

  Because there are so many historic and legacy properties on Whittier Blvd., there should not be a blanket change in zoning from Commercial to Mixed Use:

- 6.1.1 Preserve historic resources. Overall, the County has a lack of designated landmarks. Increase County Designations by:

  Collaborating with community groups to nominate properties and provide technical assistance to help them through the nomination process. Should also include community members who would like to nominate their property.

  H. Historical Context

Some items are listed in one place but omitted from others. Authors should review for completeness. Include all items in all categories.

Statement does not adequately address the impact that freeways had on the majority of East Los Angeles. The freeways make East Los Angeles different when creating Community Plans. Because of the freeways and tremendous amount of traffic and pollution generated which have concentrated the density of East Los Angeles, making it the 30th most dense community out of 265 communities special care must be given when considering the impacts of a new Metro Area Plan. For each project considered, there should be zero tolerance to adding pollution, heat island impacts and removing mature trees. Each project should be considered as adding cumulative impacts with projects past, present and future in terms of air pollution.

4.1, Pages: beginning at 257 – Timeline Incomplete Incorrect

Statement is incorrect/incomplete “1845: California becomes a U.S. territory [Agricultural]” US President Polk in 1845 sought to purchase California from Mexico. Mexican President Herrera refused.

The Mexican American war began in 1846

Treaty of Guadalupe Hidalgo 1848 ceded California to the US.

1848 Gold discovered in California

February 19, 1942: President Franklin D. Roosevelt issues Executive Order No. 9066 [Civil Rights and Social Justice] ADD “which forced the internment of Japanese citizens.”

Fails to Mention historical events that had a great impact on US residents in East Los Angeles.

Mexican Revolution 1910 – 1920 Increased Migration

Great Depression 1929 - 1939

Repatriation of US Citizens of Mexican descent to Mexico during the Great Depression 1929 to 1939. *Deportation campaigns, especially in Southern California, forced people to board Mexico-bound trains or buses. From 1930 to 1940 the census records a substantial decline (237,000) in the number of Mexican-born residents. US-born Mexican Americans were also expelled in the "repatriation" campaigns. (Source: https://depts.washington.edu/moving1/latinx_migration.shtml)

World War II **–** Need for Labor increased migration from Mexico for both agriculture and other industries. US negotiated Guest Worker programs including the Bracero program which exploited workers and discouraged unionization. From 1942 to 1964, 4.6 million contracts were signed. (Source: **https://www.labor.ucla.edu/what-we-do/research-tools/the-bracero-program/)**

The 1940s saw the population of Latinx Americans jump by more than a million, followed by still larger increases in the 1950s and 1960s. By 1970, 7.6 million people of Latin American heritage lived in the mainland states, a more than three-fold increase since 1940. (Source: https://depts.washington.edu/moving1/latinx_migration.shtml)

Fails to consider the Impact of Freeways on East Los Angeles

While the 1939 Redlining Maps severely impacted the ability of ethnic minorities to inherit intergenerational wealth, the freeways running through East Los Angeles also severely impacted property values. As more and more freeways were introduced into East Los Angeles, non-Mexican-American residents became fewer. Historically, East Los Angeles was one of the areas without deed restrictions excluding Mexican Americans from buying properties, Mexican American families developed deep roots in the community. Financial considerations and tight family ties kept many Mexican American families in East Los Angeles. From the period of the first introduction of the Ramona Parkway (now I-10) in 1943, East Los Angeles became more and more Latino as other ethnic groups left.

In 1948, the I-5 extended South from the I-10.

The I-710 Freeway opened in 1958.

The SR 60 opened in 1965.

The freeways have brought traffic, pollution and noise throughout Los Angeles. Much of the traffic in East Los Angeles can be attributed to these freeways. When accidents occur or traffic is heavy, vehicles exit and use the streets of East Los Angeles as alternative routes. There are few places in East Los Angeles where noise is not ubiquitous. If every person in East Los Angeles used public transit (not possible as many residents use their vehicles in their jobs) there would still be traffic.

East Los Angeles is the 30th most dense community out of 265 in Los Angeles County. The number of people per unit is also high. Housing density could possibly be reduced with ADU's. Current families living in overcrowded units could have intergenerational family members live in the ADU. This would not add to the parking problem experienced by area residents.

Fails to Consider East Los Angeles residents numerous attempts at Cityhood

Fails to document and consider 1976 Monterey Park annexes Bella Vista neighborhood and East Los Angeles College from unincorporated East Los Angeles. This negatively impacted East Los Angeles ability to become a city.

Fails to document other annexations of East Los Angeles including by Commerce.

Fails to consider the removal of Maravilla housing units in the early 1970's on housing in East Los Angeles.

SIGNIFICANT EVENTS TABLE

Fails to consider impact of freeways on population trends, even though the freeways were built during the period of White Flight. Freeways removed many long time residents from East Los Angeles.

EAST LOS ANGELES

Still a problem with Vietnam War.

The statement on page, 29 paragraph 3, lines 8-10, "The Chicano Moratorium March occurred on August 29,1970, when more than 20,000 Mexican-Americans marched through East Los Angeles in protest of the disproportionate number of Mexican-Americans in the Vietnam War" diminishes the valor, sacrifice and heroism of Mexican Americans during the Vietnam War. The protest was not just about the disproportionate number of Mexican Americans serving in Vietnam but the number being drafted and of casualties suffered by the community. See below:

Vietnam disproportionately affected Latinos. Though Mexican American males of military age composed about 14 percent of the population in five Southwestern states, they composed 18.2 to 19.4 percent of war casualties in those states, according to research estimates by scholars.

From: https://www.nbcnews.com/news/latino/two-fronts-vietnam-war-throughlatino-

familys-lens-n419001

Does not consider impacts of freeways on changing demographics from 1940's to 1960's.

6.3.3 Add to priority corridor list: Atlantic Blvd. which is in jeopardy due to changing zoning from Commercial to Mixed Use.

Appendix A – Historical Context – Study List

Add to important events – addition of 4 major freeways in East Los Angeles – Environmental Racism/ Environmental Justice

Amend Significant Places List:

Remove 6037 N. Figueroa (The Wall that Talks) – This is in the City of Los Angeles not in Metro Plan Area.

Add Serbian United Benevolent Society Cemetery, 2nd and Humphreys

East Los Angeles

We are also glad to see that the MAP draft recognizes the unique needs of each community and seeks to adopt subgoals and policies to meet those needs. Our comments on the East LA-specific goals and policies are as follows:

East LA Specific Goal 1: The transportation network, including bus and rail stations and corridors, is attractive, comfortable, safe, and efficient (p. 149).

Many residents in East Los Angeles have expressed safety concerns while riding Metro. Buses and trains must be clean. Routes eliminated when the Metro Gold Line was introduced should be evaluated for reintroduction. The old bus routes were near to people's homes and were accessible to seniors. There are concerns with ADA access. Metro's emphasis on trains has hurt historic connectivity.

East LA Specific Goal 2: The pedestrian and bicycle networks in East Los Angeles are comprehensive, accessible, safe, pleasant to use, clearly demarcated, and connected to activity centers such as community and recreational centers, schools, and transit centers, among others (p. 149).

Regarding Policy 2.1 and 2.4,
Native Trees should be planted. Streets with no parkways should be evaluated on how to reintroduce trees that were eliminated for Street widening projects.

2.3, which prioritizes ADA-compliant pathways, we further request that the Plan also include ensuring that basic government services, such as emergency services and/or trash collection services, have unobstructed access to serve residents as needed. We also request that the Plan drafting team consider adding City Terrace Drive as well as 3rd Street to Policies 2.4 and 2.5. Many streets are not ADA accessible. Government trash cans and mails boxes often obstruct access for those in wheelchairs. A survey should be conducted and these obstructions moved to other locations. An example is a mail box on South Humphreys Avenue between Gratian and 4th Street.

East LA Specific Goal 3: Comprehensive design. Design streets and sidewalks that meet the needs of pedestrians, bicyclists, transit users, and motorists (p. 149).

Residents need more peace on the streets in East Los Angeles. Noise is everywhere. Trees need to be planted. Bus stops should provide shade without LED advertising. LED light creates pollution that hurts nearby residents ability to sleep at night and disrupts the migratory patterns of birds.

LED billboards adjacent to Plan area housing, roadways and freeways should be prohibited. LED Billboards slow traffic. Even a second of delay adds up to traffic delays and pollution. A case in point is the billboards at the Citadel. Traffic slows. When freeway signs are activated, traffic slows to read the signs. These signs should be prohibited.

The redrafted Plan should also recommend walking tours with the community to identify ongoing needs and compensate community members for their time and expertise.

Because of the freeways, residents value their scenic vista. Preservation of the remaining scenic vistas must be preserved for the mental well-being of residents who are surrounded by overpasses, freeway structures and concrete everywhere. The unique views of both the San Gabriel mountains and Downtown Los Angeles for community residents by ensuring building heights do not exceed current levels. Similar concerns exist for the views from Ascot Hills Park.

Consider traffic increases from uses – office buildings going to bring more traffic as well to the area

Concerns re displacement and gentrification and ensuring jobs remain available to local residents and are safe and healthy jobs.

A goal should be added to address areas where industry and residential areas border one another and to ensure that nuisance, pollution and other health impacts on residents are minimized.

Existing markets and small businesses should be preserved by establishing the legacy business program, supporting smaller more vulnerable business.

A freeway cap near Humphreys Elementary and Ford Blvd Schools should be considered. Freeway caps are a good idea. As they will not be built for many years, they should not be used as mitigation for increasing pollution in the Plan.

Cumulative Impacts:

Each new project should be evaluated cumulative with other proposed projects, future and past and present with careful consideration to its impacts since 2015, as to its:

1) impacts on displacing current residents.

2) Increasing Pollution

3) Increasing Heat Island Impacts

Additional Concerns:

NOISE:

Given the increase in noise this plan should be rejected and a new plan drafted.

Recent studies on noise have shown the impacts on health of residents is significant. A health impact analysis and risk assessment should have been provided in light of the already severely impacted population in East Los Angeles. The draft PEIR is deficient in analyzing the impacts to this Environmental Justice community. The draft PEIR states,

> *With implementation of the Project, future development could potentially cause generation of a substantial temporary or permanent increase in ambient noise levels in the vicinity of the Project in excess of standards established in the in the County General Plan or noise ordinance (Los Angeles County Code, Title 12, Chapter 12.08), or applicable standards of other agencies. The establishment of an ACU, regardless of business enterprise type, would likely represent a perceptible increase in community noise level for the nearest surrounding neighbors in outdoor ambient sound environments where noise from pre-existing HVAC noise is already audible during daytime or nighttime hours, as applicable.*

Big Idea Number 4, Introduce Freeway Caps:

CAPPING OF FREEWAY

The capping of the freeway to create greenspace at first look sounds like a good idea, but the impacts, costs and timeline of doing so are not enumerated or explained. There are many questions left unanswered. Will it be a concrete bridge with dirt on top and trees? Will pollution be more concentrated at the exit points? Will homes be taken? What will be the:

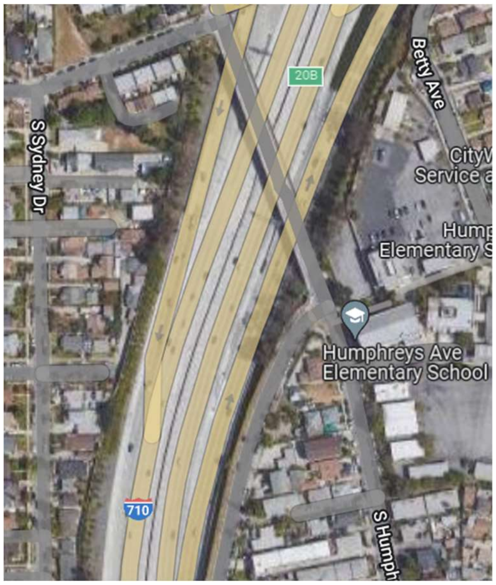
Construction costs? Greenhouse Gas Impacts. Heat Island Impacts?

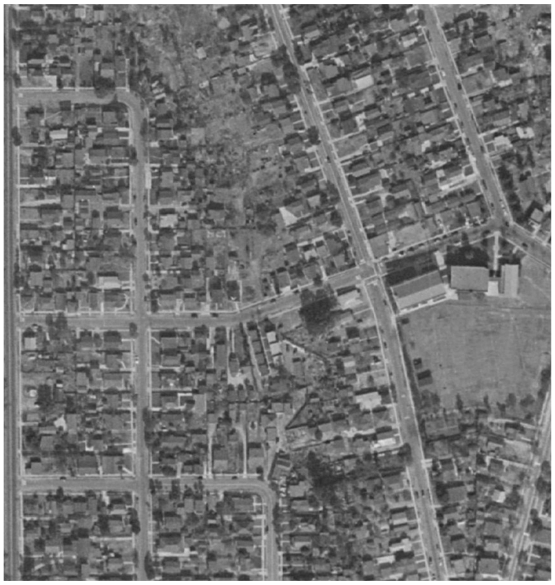
All of this should be outlined in the PEIR.

Finally, we are concerned that this is a pie in the sky proposal that is presented as a possible mitigation for the impacts to air quality in our communities. We are concerned that the proposal will remove open space and many of the last remaining trees in East Los Angeles and that this freeway cap is a way of quieting criticism of the removal of open space and trees by promising something that is not real and could actually have negative impacts on the community.

The I-710 freeway area adjacent to Humphreys Elementary School is a possible location to install a cap. However, residents should be engaged on this. Any plan arrived upon most have robust public input. The area is park poor. Residents use the perimeter of Calvary Cemetery to jog and walk around. Residents near Eagle and Sydney would like the County lot on Eagle near Sydney to be a pocket park.

Old time residents on Sydney remember when they could watch their children walk to Humphreys school from their back door. Below an undated photo shows Calvary Cemetery. The cemetery built in 1896 northern border is Third Street and Eastern border is Eastern. Parallel to Eastern the next east street is Sydney and then Humphreys Avenue.





The photo at far left shows the I-710 freeway section near the school which would be ideal for a cap because it is trenched. The third street below it is Eagle where today the Humphreys bridge crosses. The next street south is Fifth Street which used to run into Humphreys Elementary School. The 1952 Historic Aerial at right shows the area before the freeway. Another old time Sydney resident recalled. When the freeway came, my neighbors across the street were gone.

REZONING COMMERCIAL TO MIXED USE

Zoning in Commercial areas should not be changed to mixed use. This will reduce the amount of Commercial establishments in the community forcing community members to shop outside of the community. Changing zoning in East Los Angeles from Commercial to Mixed Use will allow the maximum number of units to increase from 50 to 150. Residents in East Los Angeles have let the county know that they don't want increased density as they are already suffering from pollution, traffic and parking problems. These problems will not be solved even if every person in East Los Angeles used public transportation. The freeways bring traffic and pollution to the community. The draft PEIR failed to study the impacts of changing the zoning on residents of East Los Angeles. A comprehensive study of changing the zoning from commercial to mixed use on impacts on businesses, residents and their ability to shop in their community, jobs, traffic, parking pollution, health impacts and risks should be included in the draft PEIR.

Concerns that Big Idea Number 1 to Attract Cleaner Industrial Neighbors, namely the Life Science Corridor will conflict with Big Idea Number 5, Prioritize Housing Stability.

The bioscience corridor in the City of Los Angeles has led to speculation in surrounding communities. Former rental units are being sold pushing long-time residents out and making property prices unaffordable to most. Residents in Boyle Heights, Lincoln Heights and El Sereno are seeing a new waive of gentrification. We are afraid this will happen to East Los Angeles with a Life Science Corridor.

When we went ground truthing in East Los Angeles, it wasn't to create a life science corridor, it was to create zoning and code enforcement that did not allow dirty businesses.

Throughout the United States, there has been unprecedented buying up of property by developers. In community after community, longtime residents are being displaced. Many place the number of properties being bought by developers at 30 percent. Meanwhile, over the past few decades, the wealth has been redistributed to the top one percent. Often these developers create rental property management companies which raise rents at every opportuni**ty.**

Concerns that Big idea number 2, "Define and Allow Accessory Commercial Units (ACUs)" will not solve problem with being able to purchase healthy foods economically.

East Los Angeles is a food desert. Supermarkets, Cooperatives, and farmer's markets where residents can buy affordable food are needed.

The plan seems to envision East Los Angeles's traffic problems as being solved by having "walkable communities" where residents can buy overpriced food. This is ridiculous. As long as East Los Angeles has five major freeways, the I-10, the SR 60, the I-5 and the I-710 and SR710 it will always have traffic. Unless East Los Angeles has sufficient locations where food and other amenities can be purchased, it will not be walkable. A few ACU's will not create walkable communities.

Big Idea Number 3, Well-Regulated Mobile Food Facilities

Many see street vendors as our neighbors, who are trying to make a living, the paletero with a push cart who is scraping by. Vendors who work for themselves should be treated differently than owners of trucks and facilities who owns multiple taco trucks or stands who has employees working on the truck or at the stand.

People who are employees at the local stands and trucks, often do not have a restroom or a place to wash their hands. Is this exploitation of workers? Does anyone regulate if labor laws are being broken? In addition to regulation of health laws. Labor laws should be followed to ensure that employees are not being exploited. Frequently, these workers are standing next to stands with gas generators running 12 hours a day. These generators not only pollute the local neighborhood, but also endanger the health of the employee. Additionally, there are frequently smoky open fires which also subject the surrounding residents and the employee to unhealthy conditions.

There should be areas for electricity to be plugged in so that gasoline powered generators are not used.

Add to Big Ideas, Project Goals, Objectives add questions to applications for development

All across the United States, residents are having difficulty keeping up with rent increases and the dream of owning a home is becoming more difficult. Up to 30 percent of purchases of property in the past few years have been by people not intending to live in the property. This problem is happening also in Los Angeles County. A policy discouraging speculative developers who purchase property and create luxury housing and rentals where rents are increased by the maximum allowed and residents frequently evicted should be developed.

Residents are increasingly unable to purchase properties because developers with easy money are willing to pay more. California State policies which allow developers to build multiple units on a property are allowing developers to overbid which leaves the average buyer unable to compete. Additionally, we are seeing affordable rental units sold with renters evicted where the new owner takes down the old units to build new ones. Sometimes this is done illegally, sometimes legally.

East Los Angeles has been a community where people are able to afford to purchase their first home or afford to rent a house. It is now being seen as an opportunity for developers to knock down existing housing stock. The Plan should be concerned that existing residents will be pushed out. This is a concern with the life science corridor.

Fair Housing Laws were written to limit discrimination, now that policy is being turned upside down with policies that push existing residents out. This is often called gentrification.

Goal: The current housing plan should promote ownership of properties by

1) individuals who intend to live on the properties or
2) preserve ownership of properties by Mom and Pop landlords who tend to raise rent less often,
3) or by community land trusts which seek to promote affordable housing.

Goal: Current residents should not be displaced.

Goal: Create housing that can be afforded by current residents.

Policy: TOC projects must provide no less than 15 percent of housing that is extremely low-income housing. Projects which create a higher percentage of market rate units put upward pressure on surrounding rents.

Policy: Every commercial and housing development should be subjected to the following questions:

1) Will this project tend to place upward pressure on existing rents? If yes, Project should not be approved and a CEQA exemption shall not be granted.
2) Will this project increase homeownership by current residents? If yes Project should be approved.

3) Will this project displace current residents? If yes, Project should not be approved and a CEQA exemption shall not be granted.

Thank you for the opportunity to comment.

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FESIA A. DAVENPORT
Chief Executive Officer

October 6, 2021

To: Supervisor Hilda L. Solis, Chair
Supervisor Holly J. Mitchell
Supervisor Sheila Kuehl
Supervisor Janice Hahn
Supervisor Kathryn Barger

From: Fesia A. Davenport
Chief Executive Officer

REPORT BACK ON EAST LOS ANGELES PILOT PARKING ENFORCEMENT AND BENEFIT DISTRICT STUDY (ITEM NO. 4, AGENDA OF APRIL 30, 2019)

On April 30, 2019, the Board of Supervisors (Board) adopted a motion directing the Chief Executive Office (CEO), in conjunction with the Departments of Public Works (DPW), Auditor-Controller, County Counsel, and the Sheriff (LASD) to conduct a comprehensive review of residential and business/commercial parking enforcement practices throughout East Los Angeles (East LA); research best practices utilized in other jurisdictions; and study the feasibility of establishing a localized Enforcement District and a Parking Benefit District in the unincorporated communities of East LA.

The CEO engaged Walker Consultants (Walker) to conduct a parking availability and improvement study (East LA Parking Study) for the unincorporated communities of East LA. The study encompasses an assessment of the parking needs in the East LA communities, a review of current parking restrictions and enforcement practices, research of best practices, and community outreach and engagement. Walker performed parking counts, interviewed County personnel, obtained information from the various County departments, and conducted research on best practices of other jurisdictions. In addition, the CEO held virtual meetings for the public and local community groups, and Walker conducted an online survey to reach out to the community to obtain their valued input.

The East LA Parking Study was conducted during the COVID-19 pandemic. However, based on the high parking demand numbers observed during the pandemic and the feedback gleaned from stakeholders, the high level of demand overall is the basis that the parking recommendations were formulated. The COVID-19 conditions were not considered to have materially impacted parking conditions such that they would negate the findings and recommendations of the study.

Walker's East LA Parking Study identified prominent parking issues in the East LA communities in both the residential and business/commercial areas, which include: limited availability of

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on-street parking; and limited enforcement of illegal parking blocking fire hydrants, sidewalks or driveways, red zones, overnight parking, abandoned/inoperable vehicles, illegal sidewalk vending, etc. that affirms the communities' complaints.

To address the parking issues, Walker recommends a three concurrent task approach summarized below and in Attachment A for the Board's consideration. The complete East LA Parking study, by Walker, is included as Attachment B. A major component to improve the parking in the East LA communities is to obtain community buy-in during each task of the implementation.

A. **Task 1 - Enforcement Enhancements (Immediate Implementation - within one year):** Increase enforcement by hiring a parking enforcement services company to **augment** existing LASD parking enforcement staff for an initial contract period of five years. Revenue generated from the increase in the number of citations should be used to offset the cost of the contract and County staff for the monitoring/managing of the contract. Annual evaluations of the enhanced enforcement efforts as to the effectiveness of the program would be conducted and reported to the CEO.

B. **Task 2 - Preferential Parking Districts:** Establish a preferential parking district (PPD) in the residential neighborhoods immediately surrounding the proposed Whittier Boulevard Parking Benefit District (PBD). DPW could begin community outreach to gauge the interest in creating PPD's. DPW would manage the PPD on a permanent basis (as DPW currently manages various PPD's in the County). If there is enough interest to establish a PPD, DPW would alter the current PPD's flat fee structure and implement a specific East LA PPD that would have a tiered rate structure, and require license plate credentials.

C. **Task 3 - Parking Benefit District:** If the community desires, establish a PBD along Whittier Boulevard East of the I-710. The PBD would restrict the revenue generated from the parking meters and potential parking enforcement citations, and have it reinvested into the District for community benefits, such as landscaping of common areas, improving blight areas, enhancing corridor maintenance, increasing bike/pedestrian pathways, enhancing enforcement, and potentially increasing parking infrastructure.

Improvements to the paid parking options to generate increased revenue include: (1) multi-space meters that are credit card-enabled and pay-by-license plate rather than by space, or pay-by-cellphone; (2) Use of license plate recognition (LPR) enforcement; and (3) Use of off-street parking lots (owned by the County) for additional paid parking for visitors and employees.

Public Works could begin community outreach to gauge the interest in creating PBD's. If the community is attracted by the concept of the PBD, DPW would need to initiate the steps in developing the goals and strategies, rules, funding mechanism, etc. that govern the PBD. DPW would manage the PBD for the operations and maintenance of the parking meters and would control the funds, but the net revenue (after operating expenses) will be overseen by a Department to be determined, who will authorize the expenditures of the funding based on the PBD's advisory committee comprised of community stakeholders.

The implementation of any of the recommendations from this report, including the award of a contract for the parking enforcement services, and/or the establishment of either a preferential parking district or a parking benefit district will require returning to the Board for approval. DPW should work with our office, Auditor-Controller, and County Counsel as part of their due diligence and include any budget impacts of any proposed changes. The establishment of any Special Fund, and any staffing requests will be included in the submittal to the CEO during the annual budget process, and would be fully offset by revenue generated by the paid parking options and potential enforcement fees. The enforcement fees that previously went into the General Fund from the East Los Angeles area would be diverted to the proposed Special Fund(s).

East LA's parking concerns may stem from high-population density leading to the lack of available on-street parking, but the solutions to address the issues should not only include regulatory measures such as enforcement, but also policies to allow for viable transportation options while balancing housing needs, and re-envisioning public right-of-ways and spaces. Various County/non-County departments are reviewing potential actions that complement the results of the East LA Parking Study such as DPW and the Street Ambassador Program; Department of Consumer and Business Affairs and the illegal sidewalk vending ordinance; Department of Regional Planning on policies for Accessory Dwelling Units and housing; and the Metropolitan Transportation Authority increasing transit opportunities by planning for two future rail stations in East LA.

East LA has the highest population density in the County for communities with a population over 100,000, and there are 16,000+ persons per square mile residing in this community. The median household income in East LA is $43,879 compared to $64,251 in the County. Implementing these recommendations for better parking management and innovation in the East LA area to change the parking culture will enhance the quality of life and service for the East LA communities by addressing the parking issues that have adversely affected the residents and businesses.

Should you have any questions concerning this matter, please contact me or Sheila Williams at (213) 974-1155 or swilliams@ceo.lacounty.gov.

FAD:JMN:MM
SW:CY:CF:kd

Attachments

c: Executive Office, Board of Supervisors
County Counsel
Sheriff
Auditor-Controller
Public Works
Regional Planning

Attachment A

EAST LOS ANGELES PILOT PARKING ENFORCEMENT AND BENEFIT DISTRICT STUDY

To address the parking issues, CEO recommends a three concurrent task approach summarized below for the Board's consideration.

Task 1 - Enforcement Enhancements (Immediate Implementation- within one year): Establish a parking enforcement district throughout unincorporated East LA, enforced by a professional parking enforcement services provider dedicated to this task, funded by parking citations.

To determine if a parking enforcement district is in fact necessary, CEO recommends a pilot program to increase enforcement as the first step to mitigate the parking issues where the community can see the results in a short amount of time and gain the County's trust. Due to the limited staffing of LASD, outsourcing parking enforcement services with a professional parking enforcement firm can increase enforcement capabilities and consistency, and the County can remain flexible by increasing/decreasing services depending on the need. The training and ability to shift personnel resources from the parking enforcement firm allow for consistent coverage.

In addition, the option to use LPR enforcement (vehicle-mounted license plate scanner equipment), allows the County to invest in technology to increase efficiency, and reduce liability with in-person engagement, especially when encountering aggressive members of the public.

By increasing enforcement personnel, the revenue generated could offset the cost of the contract, and the County's staff time in monitoring/managing the contract. Using a 3-year average (from Fiscal Year (FY) 2017-18 to FY 2019-20) of revenue versus expenditures for the East LA area, LASD collected approximately $3.47 million from citations, and spent approximately $1.15 million in staffing, vendor's fees, and DMV fees. The net amount of $2.32 million could be used to procure the contract services of the professional parking enforcement firm, and invest in new technology.

<u>Recommendation:</u> Hire a parking enforcement services company to **augment** existing parking enforcement staff for an initial contract period of five years as a pilot. Revenue generated from the increase in citations could be used to offset the cost of the contract and County staff for monitoring/managing of the contract.

County departments such as LASD, with their expertise, or DPW, due to their role with the road right-of-way, may service the contract with the parking enforcement services company. The services contract should be developed and managed in collaboration with LASD Parking Enforcement Detail to ensure maximum efficiency and support.

Annual evaluations of the enhanced enforcement efforts as to the effectiveness of the program would be conducted and reported to the CEO. Any modifications to the pilot program would be discussed with the Board offices.

A parking enforcement district using a professional parking enforcement firm solely or a hybrid model may be established after the pilot period ends. An operational effectiveness study should be completed evaluating the use of the contract firm, County personnel, or hybrid of both to find the balance of insourcing and outsourcing this responsibility and its budget impacts, but also meeting the needs of the communities. During this process, a comprehensive fee study should also be conducted to update the parking citation fees.

Any staffing requests and changes to the budget structure will be included in the submittal to the CEO during the annual budget process and is proposed to be fully offset by revenue generated through enforcement.

Task 2 - Preferential Parking Districts: Establish a PPD in the residential neighborhoods immediately surrounding the proposed Whittier Boulevard Parking Benefit District (PBD) (discussed below). Establishing preferential parking areas in the residential areas primarily surrounding the business/commercial corridors, may help the residential areas with parking, as parking becomes limited due to the spillover from these businesses. The purpose of the program is to limit the number of household vehicles parked along the street during business operating hours as well as to control the amount of time a visitor may park on neighborhood streets. It also encourages the use of private driveways and garages for those residents who have this option.

The preferential parking districts would be managed by issuing residential parking permits, limiting the number of permits per residence, having a tiered-rate structure, and requiring license plate credentials.

<u>Recommendation:</u> DPW could begin community outreach to gauge interest in creating PPD’s. If there is enough interest to establish a PPD, DPW would diverge from the current PPD’s flat rate permit fee structure and implement a specific East LA PPD that would have a tiered rate structure, and require license plate credentials. DPW would manage the PPD on a permanent basis (similar to current preferential parking districts in the County).

DPW currently manages permits for 14 preferential parking districts throughout the unincorporated areas of the County. Flat rate permit costs range from $14 to $120 per dwelling unit for each 3-year renewal period and generates approximately $15,000 a year towards the maintenance and operations of the permit program of the Districts. To limit the number of cars parked in the proposed preferential parking area, a specific analysis may be conducted to review the number of permits to be issued per residence, have a tiered-rate structure, and require the permits be associated with a specific license plate.

Task 3 - Parking Benefit District: Establish a PBD along Whittier Boulevard East of the I-710 (pilot), and consider other PBD locations throughout the business/commercial corridors of unincorporated East LA where low on-street parking availability has been identified as a problem (after pilot).

To further enhance the East LA community, the County may consider creating a PBD with community “buy-in” that would require improvements to the paid parking options in the business/commercial corridors to generate additional revenue that would be reinvested into the local communities. Community “buy-in” is key to the development of the PBD, due to the lengthy process of establishing a PBD. Task 3 entails extensive community outreach, developing goals and strategies, creating policy/procedures on how to allocate funding, guidelines for the stakeholders and advisory committee, and purchasing and installing meters, and analysis to review fees.

The PBD would restrict the revenue generated from the parking meters and potential citation revenue, and have it reinvested into the District for community benefits, such as landscaping of common areas, improving blight areas, increasing bike/pedestrian pathways, and enhancing enforcement.

The improvements to the paid parking options to generate increased revenue include: (1) multi-space meters that are credit card-enabled and pay-by-license plate rather than by space, or pay-by-cellphone; (2) Use of LPR enforcement; and (3) Use of off-street parking lots for additional paid parking for visitors and employees.

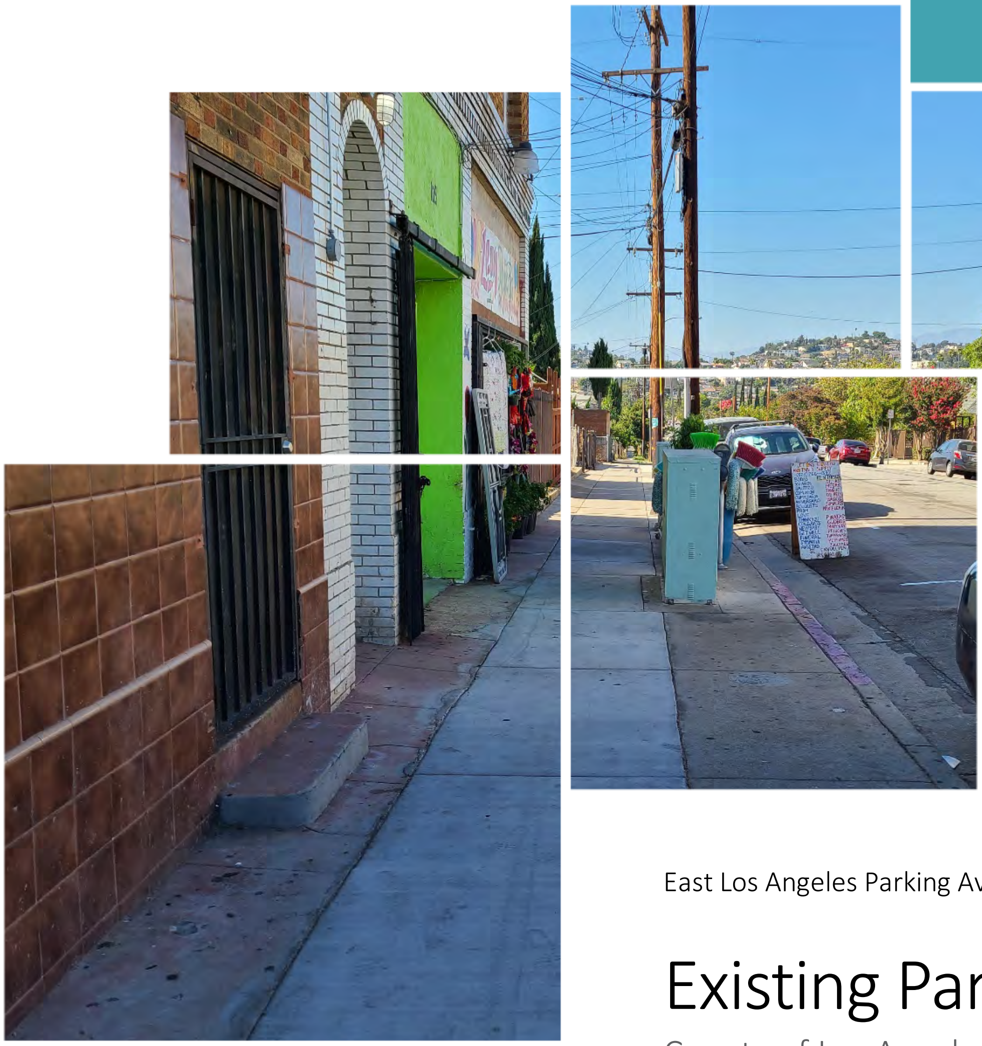
Recommendation:

DPW could begin community outreach to gauge the interest in creating PBD’s. If the community is attracted by the concept of the PBD, DPW would need to initiate the steps in developing the rules, funding mechanism, etc. that would govern the PBD. DPW would manage the PBD for the operations and maintenance of the parking meters and potential citation revenue and would control the funds, but the net revenue (after operating expenses) will be overseen by the Executive Office of the Board of Supervisors on behalf of the Supervisorial District, who will authorize the expenditures of the funding based on the PBD’s advisory committee comprised of community stakeholders.

Food Trucks/Vendors:
Walker also addresses the need to coordinate food trucks/vendors that take up parking in the business and commercial areas, mainly occupying the “One-Hour Only” parking spaces. Most violators remain in the space beyond the posted time limits because it is lucrative to continue their business even though they are violating the parking time limits. In addition to the recommendation to extend the time limits from one hour to two hours in the commercial areas, there is a need to consider how this group of business owners fit within the East LA economy. Parking regulations that prevent food trucks from operating may free up parking, but at the expense of someone’s livelihood.

Recommendation: Department of Consumer and Business Affairs in collaboration with Public Health, Regional Planning and DPW to work with local businesses and food truck and mobile kitchen vendors to create designated areas where these mobile services may be offered to the public without affecting business/commercial access and traffic conflicts.

ATTACHMENT B



East Los Angeles Parking Availability Improvement Study

Existing Parking Conditions

County of Los Angeles, CA

September 24, 2021

Prepared for:
Chief Executive Office Budget and Operations
Community Services

WALKER CONSULTANTS

Contents

Appendix

Exhibits

Introduction

The County of Los Angeles (“County”) engaged Walker Consultants (“Walker”), to conduct a parking availability and improvement study for the unincorporated community of East Los Angeles. The study encompasses an assessment of the community’s parking needs, a review of current parking restrictions and enforcement practices, research of best practices, and community outreach and engagement. In addition, the study identifies the implementation challenges and potential adverse consequences to local residents and businesses of the recommended solutions presented henceforth.

The study is divided into several tasks beginning with a review of existing parking conditions (Task 2), followed by an analysis of current restrictions and enforcement practices (Task 3), recommendations for improvement (Task 4), a feasibility study for implementing a pilot parking enforcement district (Task 5), and a feasibility study for implementing a parking benefit district (Task 6).

This report addresses the evaluation of existing parking conditions (Task 2).

Background

In 2019, the County of Los Angeles Board of Supervisors directed the Chief Executive Office to study parking conditions throughout the community of East Los Angeles, following the study conducted by the Department of Public Works in City Terrace. While this study accounts for the findings of the previous City Terrace study, it is a separate analysis. The focus in the City Terrace study of 2019 was to identify solutions to provide access for emergency vehicles through the hillside streets. This study focuses on finding solutions to address the issues of parking management and enforcement. With direction from the Chief Executive Office, this study aims to pull together all departments that have a role in parking to take a comprehensive approach at addressing the issues identified.

Executive Summary

Walker conducted an analysis of existing parking conditions in East Los Angeles (East LA). The analysis included a parking supply and demand study along residential and commercial corridors throughout the community, community engagement to hear directly from stakeholders what the parking issues, as they experienced them, are in East LA, and needs and issues identification to begin to inform the development of recommendations to improve current conditions.

Overview of Findings

The existing conditions analysis revealed that parking in East LA is made difficult by a combination of factors. There is no one single source for the parking problems that the community faces. However, by identifying the issues we can begin to develop solutions that may help ease the challenges that residents, business owners, employees, and visitors of East LA regularly face.

The following details a listing of our findings of the existing parking conditions in unincorporated East LA.

High Population Density East LA has the highest population density in the county for communities with a population over 100,000. There are 16,000+ persons per square mile residing in East LA. At the same time 84 percent of commuters drive or carpool to work, and 88 percent of East LA households have access to 1+ vehicles. There is a high concentration of non-conforming residences (more units than allowed per zone) and higher than average household size. The combination of a high population density and high vehicle reliance for mobility results in high parking demand.

Lack of Available On-Street Parking The most evident and vocalized issue in East LA is the lack of available on-street parking. On residential streets, parking occupancy levels are so high, that instances of illegal parking (e.g., parking in intersections, red curb, blocking driveways, double parking, etc.) are commonplace, thus pushing on-street occupancies above 100 percent. This issue is so broad that it can be found in most residential neighborhoods. The factors leading to the scarcity of available on-street parking include inconsistent or ineffective enforcement of current regulations, a free to park system, high automobile reliance, , high population density, and accessory dwelling unit laws for converting garage/carports without replacing parking.

In commercial areas, on-street parking utilization was also high. While it should be noted that the commercial on-street utilization data and observations were gathered during the COVID-19 pandemic, which most certainly reduced observed parking demand for commercial and commuter parking, the parking demand observed was *still* found to be high. For this reason, and the input provided by stakeholders regarding troubling, impacted parking conditions, our working assumptions that will inform our recommendations are that the parking supply for commercial spaces is impacted by high parking demand. The following table shows the on-street occupancies observed during the period of peak parking demand.

	PEAK			
	OCCUPANCY PERCENTAGE**			
	Weekday†	Weekend††		
ZONE	Residential	Residential[1]	Commercial[2]/ Industrial[3]	Total
César Chávez	99%	84%	83%	84%
1st Street	100%	87%	63%	79%
Whittier (West)	104%	89%	66%	87%
Olympic (West)	111%	94%	98%	95%
Nueva Maravilla‡	104%	--	--	--
Ford/Mednik	103%	84%	25%	77%
Telford	53%	40%	21%	37%
Whittier (East)	107%	96%	99%	97%
Olympic (East)	105%	88%	81%	86%
Atlantic	107%	89%	60%	77%
Saybrook	115%	91%	13%	90%
Whiteside	113%	96%	100%	97%
TOTALS	104%	83%	73%	81%

Notes:

** Occupancy percentage is equal to parking occupancy divided by inventory.

†† Commercial parking demand as measured during weekend peak; Industrial demand as measured during weekday peak.
‡ Each section treated as a separate block of residential parking.
1 On-street spaces on residential blocks
2 On-street spaces on commercial blocks
3 On-street spaces on industrial blocks

'Reserving' of On-Street Parking Spaces/Low Turnover Because on-street parking is sparsely available, many residents have become accustomed to holding on to their on-street spaces for as long as they can. This essentially 'locks' those spaces out from being used by anyone else, exacerbating the lack of available parking. Results from the online survey of the public's experience with parking in East LA indicate that a majority of residents worry about losing their parking space on the street, and thus the practice of 'reserving' a parking space by some begets more 'reserving' of parking by others. A similar issue occurs along commercial corridors, where merchants have voiced their concerns over catering trucks and vehicles associated with street vending posts occupying time-limited parking spaces along commercial corridors for extended periods of the day, thus limiting turnover of those spaces and the opportunity for others, particularly customers of established businesses in the area, to park.

Limited Parking Enforcement There is a general sentiment in the community that parking enforcement is not meeting the needs of the residents and businesses of East LA. Common complaints are that patrols on the street are insufficient to address illegal parking practices during evenings and weekends, they are difficult to reach to report and respond to issues, and that they do not cite enough to discourage instances of illegal parking, including occupying a parking space for more than 72 hours, among others. Walker's extensive review and analysis of the available staffing and coverage of the area validated the perception of parking enforcement inadequate to address the significant demands. A first step in addressing the parking issues experienced in East LA will be applying more effective enforcement. Results from the community outreach indicate that most people are generally in favor of increased enforcement.

Mobile Vendors Along commercial corridors, there are complaints from merchants that mobile food vendors,[1] as well as their customers, occupy short-term parking spaces intended for patrons of the corridor-lining businesses. On the other hand, some community members expressed the sentiment that mobile vendors are merely trying to make a living and that vendors should be allowed to park on the street. When it comes specifically to short-term parking, it is a best practice to make those spaces available to customers. At the same time, mobile vendors may need a place to be able to operate. A potential solution could combine active enforcement of time limits combined with the development of a zone approach to allow food vendors in zones for a specified duration of time. Once the time has expired, they must move out of the zone or a penalty may be incurred. Other jurisdictions have variations of these policies.

Parking Spillover The issue of unavailable on-street parking leads to issues of parking spillover when no accessible or acceptably convenient alternatives are available. Parking spillover generally refers to when parking demand for one land use spills over into the parking supply of an entirely different use, and those users subsequently may then suffer from insufficient parking. Residents and business owners highlighted parking spillover issues in various forms. Residents complained of automotive businesses

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[1] In the form of both food trucks and sidewalk vendors.

(repairs and sales) parking their inventory along residential streets, spillover from transit users who park on residential streets or in parking intended to serve local businesses, and non-residents (i.e., people from outside of the immediate neighborhood) parking on residential streets. In commercial areas, business owners complained that: mobile vendors occupy on and off-street parking spaces meant for their customers, spillover from transit users, and spillover from residents.

Inoperable Vehicles A common issue that residents have communicated is inoperable vehicles parked on the street and left for extended periods of time without penalty. Walker staff did observe evidence of vehicles being parked on the street for extended periods of time. A solution to address this issue will start with increased enforcement, but a more tailored approach could be more effective. For example, the City of Pico Rivera operates its inoperable vehicle program throughout the entire city. Enforcement staff have outlined the city into approximately 20 zones and approach each zone at a time. With this structured and deliberate piecemeal approach, they have seen 85-95 percent compliance rates in each zone.

Off-Street Parking Supply The impact of high parking demand to on-street parking in East LA is clear; however, the impact on the public off-street supply of parking is less so. The County own a several parking lots throughout the community, some of which are located near commercial corridors. While on-street demand along commercial corridors was high, off-street parking demand in the county-owned lots were not observed reaching capacity. We have noted that parking observations were conducted during the Covid-19 pandemic, which would have impacted demand in some if not all areas. Still, in comparing satellite imagery with what was observed, the conclusion is that county-owned off-street parking is not consistently, fully utilized. The County should review public access to the County owned lots and develop options for increased utilization.

Privately-owned off-street parking, as noted via the stakeholder outreach, is being encroached upon by mobile vendors and customers of those vendors. In areas near transit, the encroachment is coming from commuters whom do not want to pay for parking at the transit station. The options for a preferential parking district that would be mutually beneficial for property owners, business owners, customers, and the county will be explored.

In residential areas, the off-street parking capacity was also surveyed during peak periods to understand whether more vehicles can be accommodated off-street to relieve some of the pressure from on-street parking. As noted previously, on-street parking is impacted by the behavior to ‘hold onto’ on-street parking, as residents wish to maintain their off-street spaces available for guests to park in, for easily moving vehicles in and out, or storing inoperable vehicles. There are also accessory dwelling units (ADUs) that can impact parking demand on the street as well as the availability of driveway parking. Still, the results of the survey of driveways conservatively indicates that there is opportunity to accommodate more vehicles off-street than are currently being parked.

Free Parking System Enforcement is key to maintaining availability and order in the parking system. In locations that experience high parking demand, paid parking in some form (from paid street parking in commercial areas to parking permits on residential streets) is an effective enforcement tool.[2] With the exception of approximately 150 parking meters that are in operation along 1st Street, the rest of East LA has free on-street parking. With one of the highest population densities in the county, and high rates of

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[2] In basic terms, a paid space only requires one visit by an enforcement officer to ensure compliance, a free space requires at least two visits.

vehicle ownership, the free parking system makes parking enforcement of spaces and the allocation of demand between higher and lower demand locations more challenging.

Residential Parking Permits Given the impact of high parking demand on residential streets, most community stakeholders indicated that they would support a residential parking permit (RPP) district if it meant that there would be more available on-street parking as a result. Still, some community members expressed opposition, in part depending on the amount of any fee. Some of the reasons given were that East LA has many income-burdened residents, enforcement is currently lacking so an RPP would be ineffective, and many felt that unless RPPs are established everywhere, demand will spill over into neighborhoods that do not establish one. The concerns raised by the community are valid and will be taken into consideration prior to developing a program. Nonetheless, there are many ways in which a program can be structured to meet the needs of the community. For example, for the concerns about price, the first permit may be offered free of charge or at a very low rate.

Land Use and Housing Policies Many in the community expressed that land use and housing policies are adding to the parking issues that community members experience in East LA. For instance, some community members expressed concern over the approvals of affordable multi-family developments with seemingly low parking supplies, likely as a result of state policies that reduce or eliminate minimum parking requirements. In looking at a list of recent approvals, newer developments are being built to code as specified in the Third Street Specific Plan, where residential developments are required to provide at a minimum one (1) parking space per unit. The goal of the Third Street Specific Plan is to enable transit-supportive development near East LA transit stations. The vast majority of East LA is located within Southern California Association of Government's High Quality Transit Area and is already one of the most transit accessible areas in the Los Angeles Area, which allows new residential projects to request reduced parking requirements. Still, issues of high parking demand are not entirely tied to new development: existing multigenerational households, multi-vehicle ownership, and free parking all impact the demand on the street. We note that recent policy changes to allow for fewer parking spaces for residential uses have been made to increase the supply of housing, and lower the cost of housing development. For example, with respect to accessory dwelling units (ADUs), the state and county have been clear in their desire to provide as much housing as possible to address the housing crisis, thus prioritizing housing for people over housing for cars. However, we also note that arguments made for, and policies advocating, reducing minimum parking requirements typically assume actively enforced on-street parking measures, adding credence to the need for more parking enforcement on the streets of East LA.

Management of Parking Supply/Demand East LA is one of the densest communities in the county, yet it relies entirely on signage and enforcement of that signage to manage the high demand for its parking supply. Given that parking is free in most of East LA, with the exception of 150 parking spaces along 1st Street, the inconsistent likelihood of receiving a citation for an infraction, and that there are limits to the number of enforcement officers that may be working at a given time, one can understand how issues of parking congestion are so vast across the community. More active management of parking resources in East LA offer the possibility to improve parking availability on the street, potentially significantly. Currently, the fragmentation of parking management, where enforcement is handled by the Sheriff Department, and infrastructure and operations are handled by Public Works is a challenge. A central department that oversees all aspects of parking should achieve efficiencies, better customer service, execution of parking policies, and address parking issues more comprehensively than the current structure allows. Task 3 of this study explores the options for identifying the county department that is best suited to manage parking.

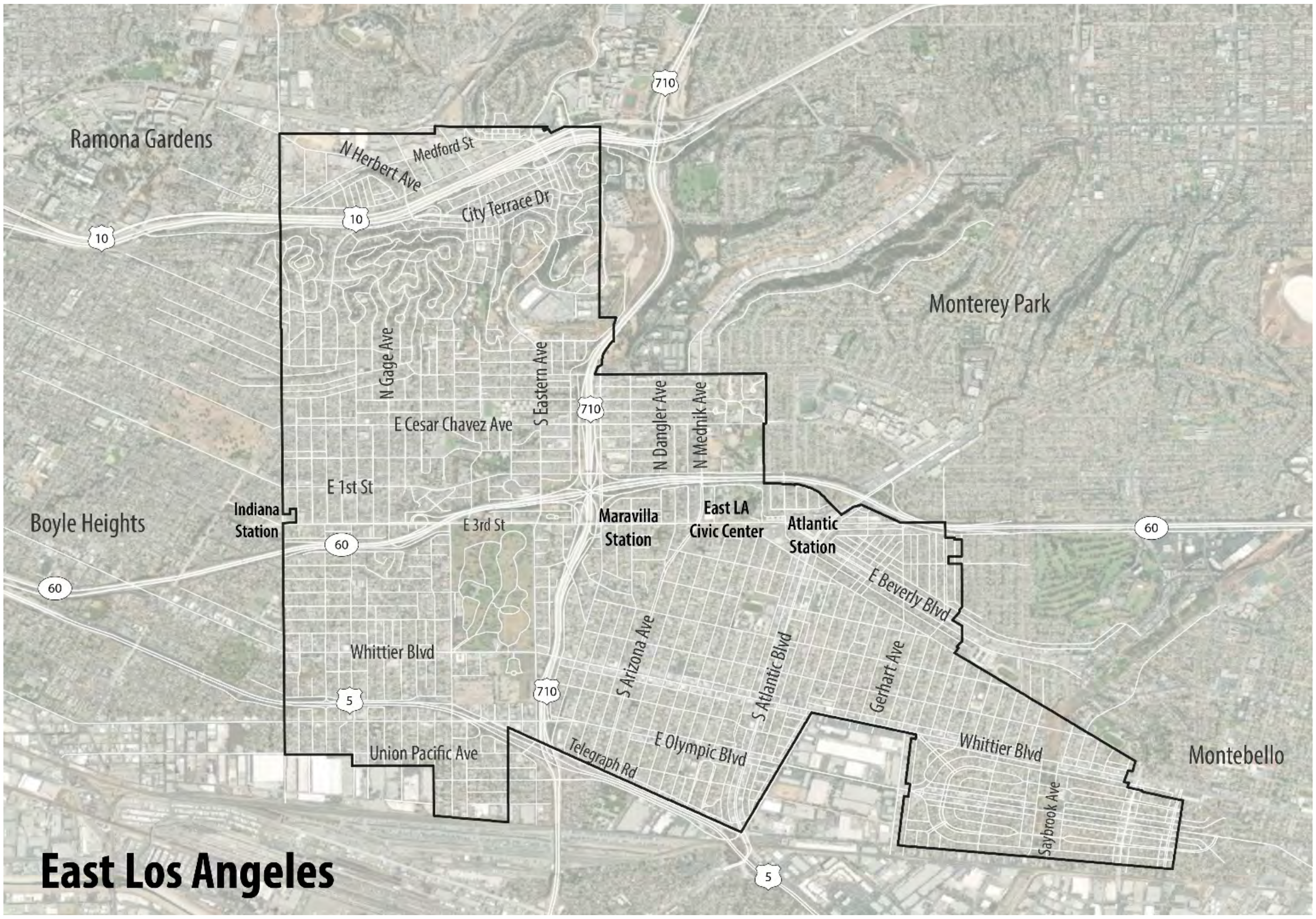
01

Geographical Boundaries and Community Characteristics

East Los Angeles Demographics and Community Characteristics

East Los Angeles ("East LA") is an approximately 7.45 square mile unincorporated community and U.S. Census "Designated Place." East LA is located immediately east of the Boyle Heights district of the City of Los Angeles, south of the El Sereno district of the City of Los Angeles, north of the City of Commerce, and west of the cities of Monterey Park and Montebello. The boundary of East LA is shown in Figure 1.

Figure 1: East Los Angeles Boundary



Source: Walker Consultants, 2020.

Population and Housing

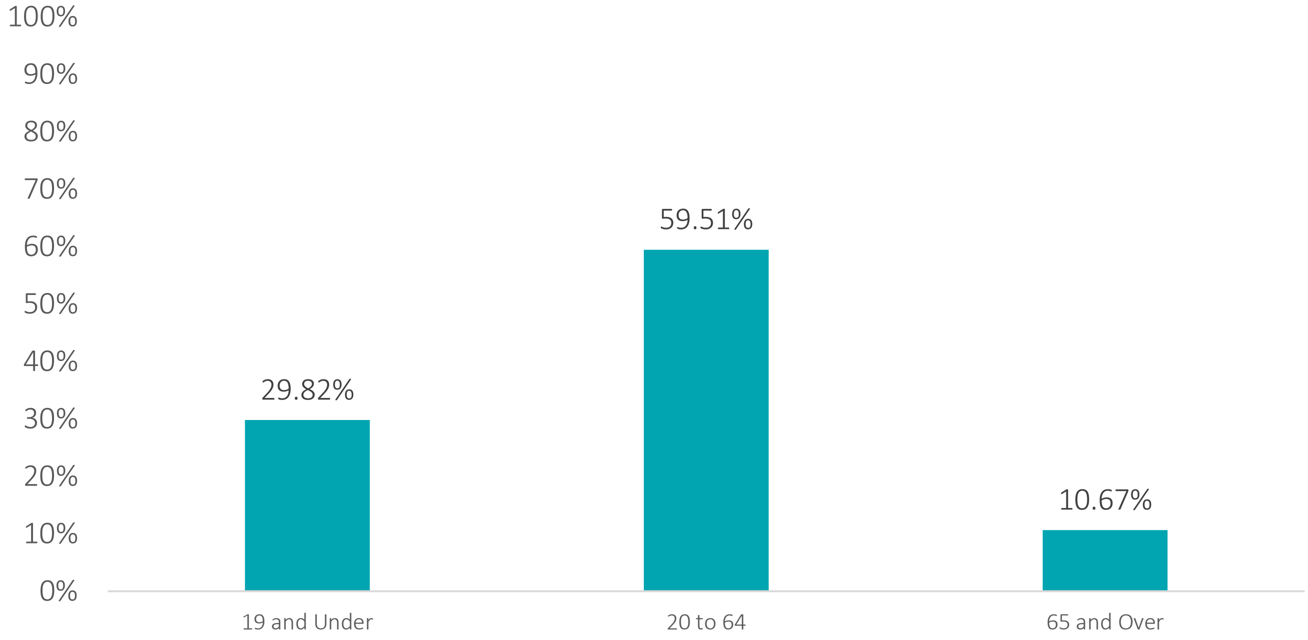
East LA has a total population of 119,827.[3] Of this total about 114,954[4] (95 percent) identify themselves as Hispanic or Latino.

In terms of age, the population in East LA skews toward working age adults as shown by Figure 2. Of the total population (119,827):

- 29.82 percent are aged 19 and under,
- 59.51 percent are between the ages of 20 and 64, and
- 10.67 percent are 65 and over.

The median age in East LA is 32, four years younger than the County-wide median of 36.

Figure 2: East Los Angeles Age of Population



Source: Data - U.S. Census Bureau (2018) American Community Survey 5-year estimates Table S0101. Graphics -Walker Consultants, 2020.

There are 33,290 total households in East LA, the majority of which are single, detached units (63 percent).

Figure 3 displays the percentage of each type of housing unit within East LA.

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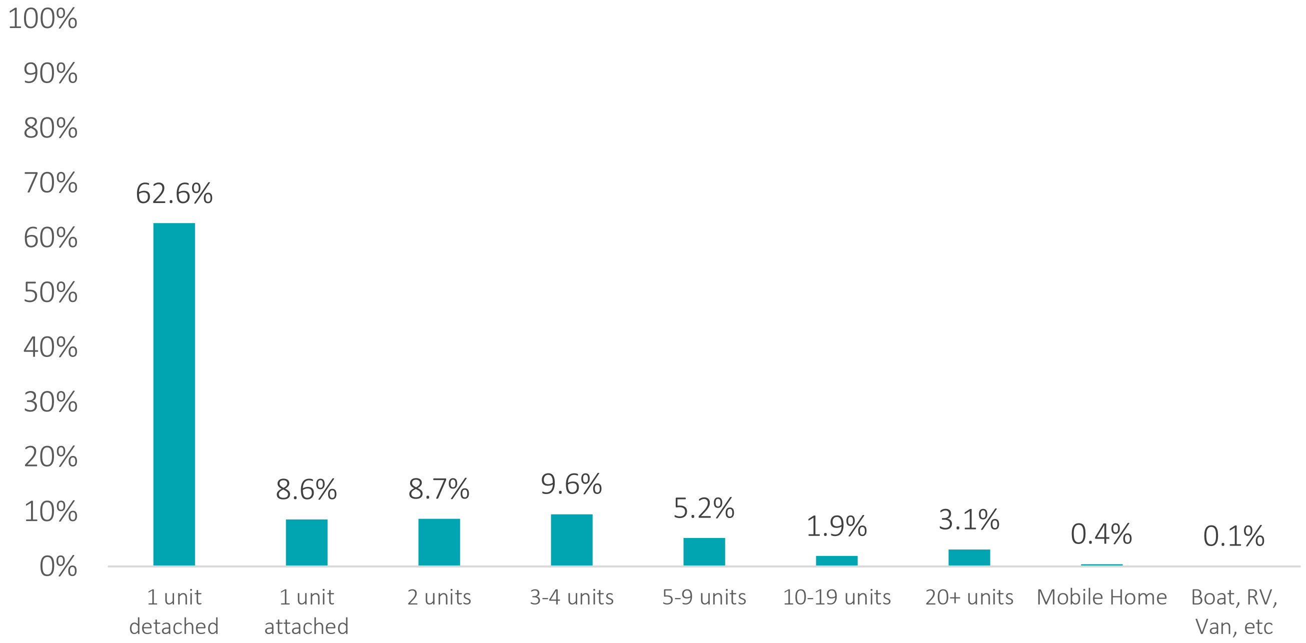
[3] U.S. Census Bureau (2018). American Community Survey 5-year estimates. Table DP05.

[4] Ibid.

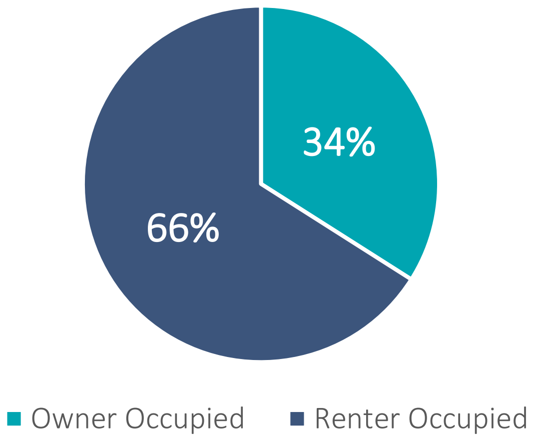
Figure 3: East Los Angeles Housing Supply Breakdown



Source: Data - U.S. Census Bureau (2018) American Community Survey 5-year estimates Table DP04. Graphics -Walker Consultants, 2020.

Figure 4 demonstrates the household tenure for East LA, meaning the conditions under which household units are held or occupied (i.e., owner or renter). As shown, there are a greater number of renter-occupied units in East LA than owner-occupied units.

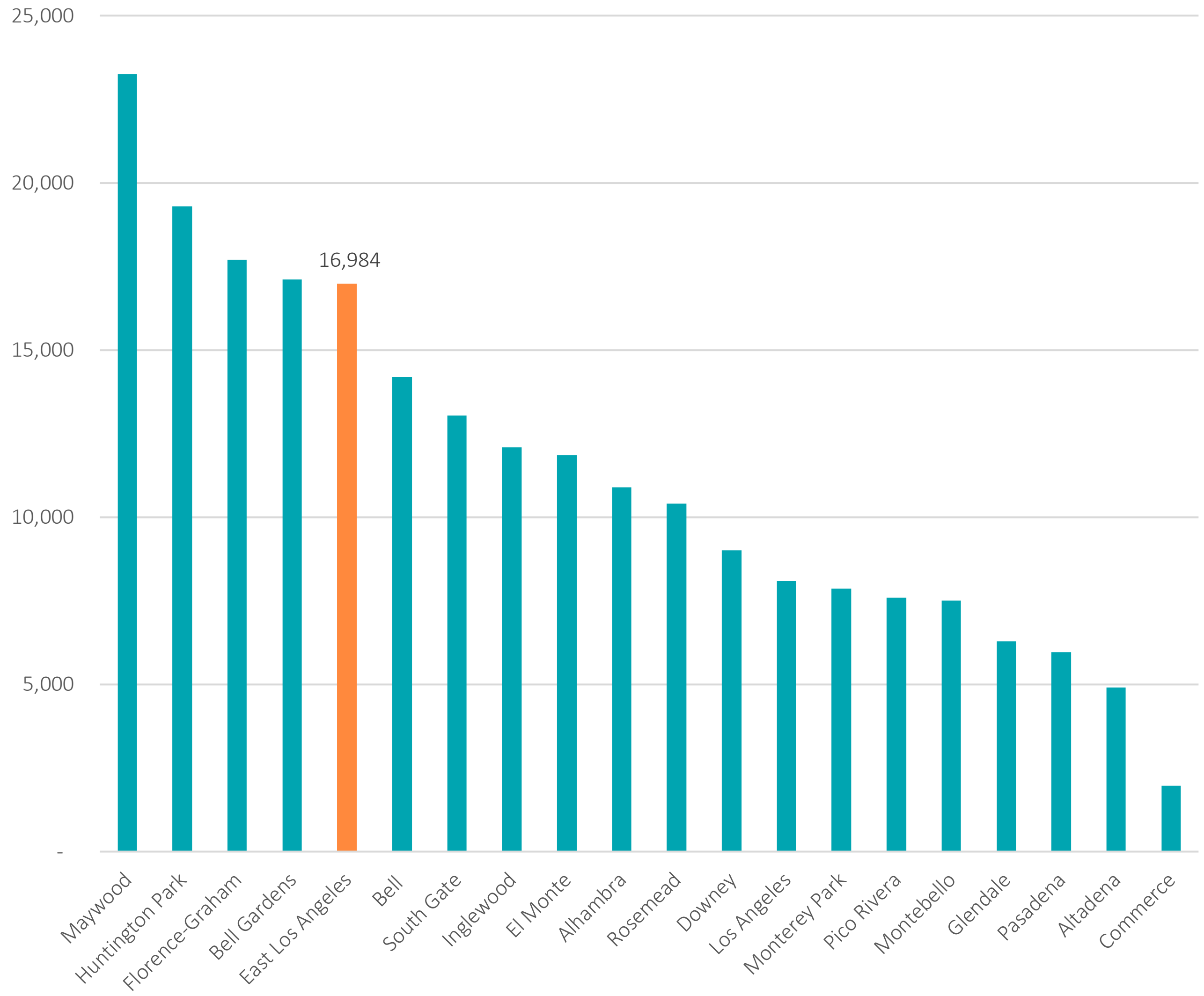
Figure 4: East Los Angeles Household Tenure



Source: Data - U.S. Census Bureau (2018) American Community Survey 5-year estimates Table S1101. Graphics -Walker Consultants, 2020.

East LA has a population density (persons per square mile) of 16,984. Figure 5 compares the population density of 20 cities located in the Greater Los Angeles region.

Figure 5: Population Density per Square Mile of Los Angeles County Cities and Census Designated Places (CDP)

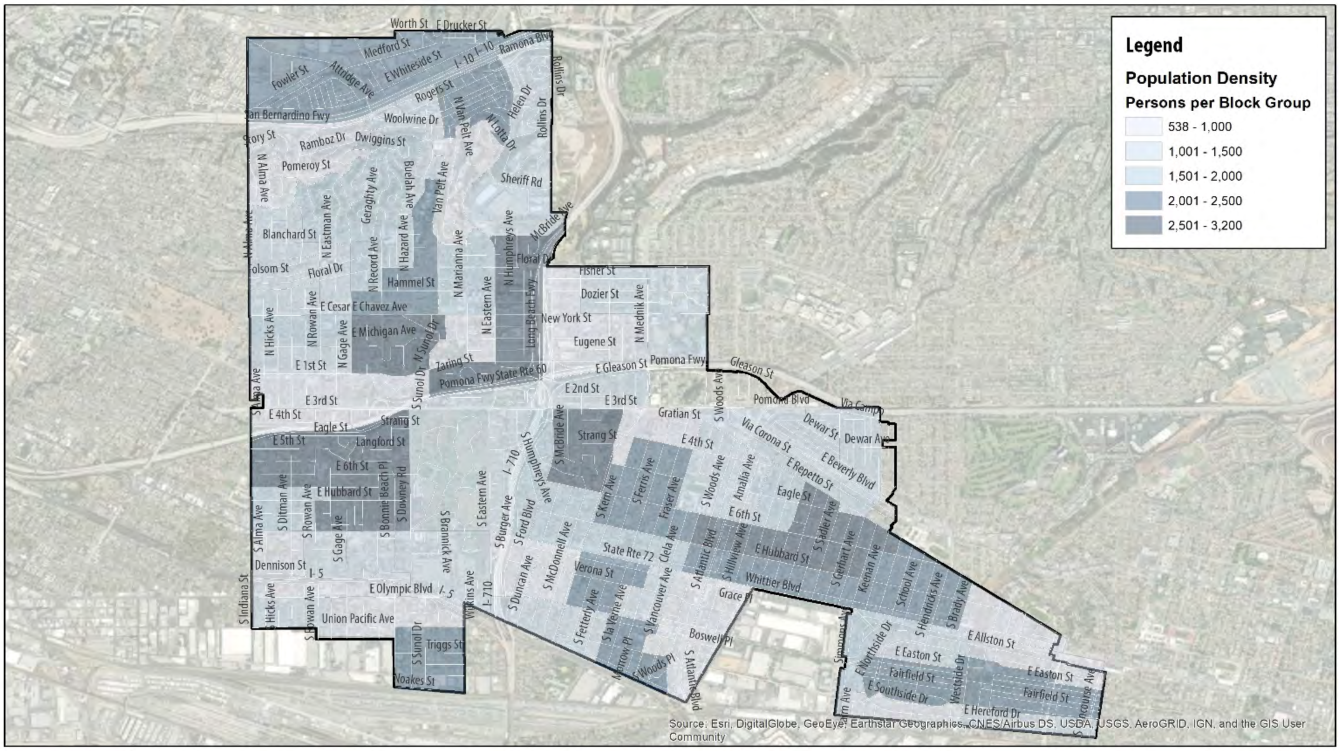


Source: Data - U.S. Census Bureau (2010) Decennial Census. Retrieved from https://www.census.gov/quickfacts/fact/table/eastlosangelescdpcalifornia/POP060210#POP060210
Graphics -Walker Consultants, 2020.

As shown in Figure 5, East LA has among the highest population densities in the region, only surpassed by Bell Gardens, Florence-Graham, Huntington Park, and Maywood. This means that there are more people residing per square mile in East LA than in most nearby communities. However, when looking at cities and communities that have populations of 100,000+, East LA is the densest in the county.

Within the boundaries of East LA, the densest neighborhoods are not concentrated in any one area, and instead are disbursed throughout the community. Figure 6 shows the population density within East LA by block group[5].

Figure 6: Population Density in East Los Angeles by Block Group



Source: Data - U.S. Census Bureau (2018) American Community Survey 5-year estimates Table B00001. Graphics - Walker Consultants, 2020.

As shown in Figure 6, the darker blue areas represent the denser block groups, and thus the areas with a higher concentration of residents.

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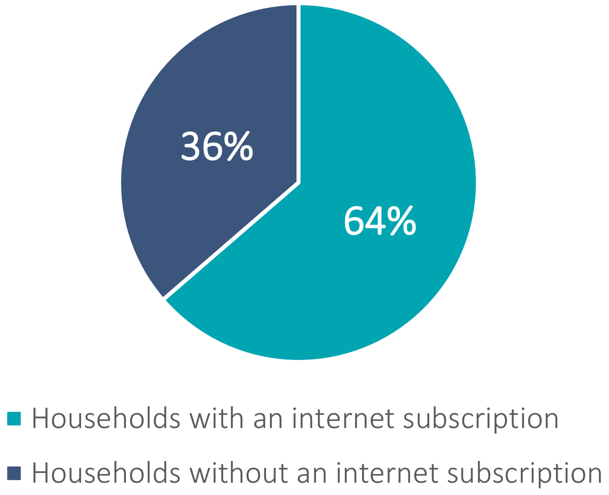
[5] Block Groups (BGs) are statistical divisions of census tracts, are generally defined to contain between 600 and 3,000 people and are used to present data.

Internet Access

Figure 7 illustrates the breakdown of East LA households with and without an internet subscription. In this data set an internet subscription includes dial-up and broadband of any type such as a cellular data plan, broadband cable, and satellite internet service.

Figure 7: East Los Angeles Household Internet Access



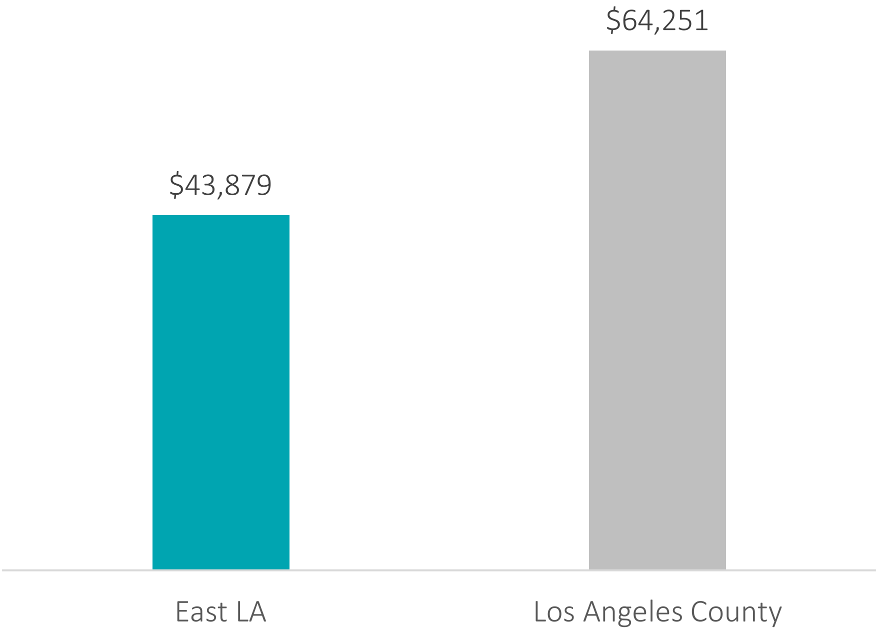
Source: Data - U.S. Census Bureau (2018) American Community Survey 5-year estimates Table S2801. Graphics -Walker Consultants, 2020.

As shown in Figure 7, 64 percent of households in East LA have an internet subscription, and 36 percent do not. The percentage of households without an internet subscription is higher than in Los Angeles County, where 82 percent of households have internet subscriptions, and 18 percent do not.

Economic Profile

Figure 8 shows that the median household income for households in East LA is less than in Los Angeles County as a whole, whereas median household income is $43,879 in East LA and $64,251 in the county.

Figure 8: East Los Angeles Median Household Income



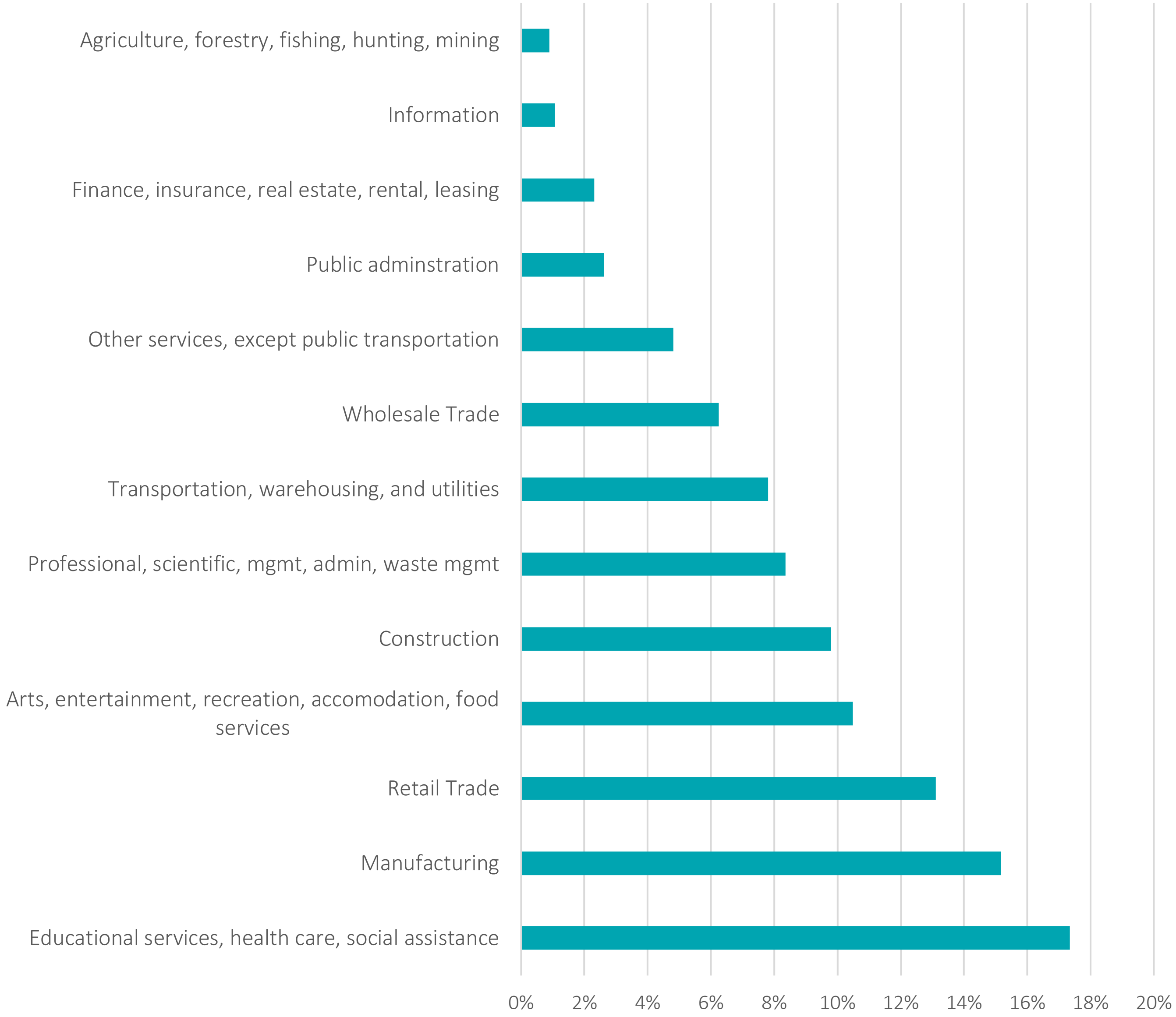
Source: Data - U.S. Census Bureau (2018). American Community Survey 5-year estimates. Table S1901. Graphics -Walker Consultants, 2020.

When looking at income per capita (i.e., per person), East LA residents average $16,281 annually. In comparison, that is about half of the county average, $32,469.

Figure 9: East Los Angeles Residents Industry Employment demonstrates employment in East LA by industry sector. The top three employment sectors are:

1. Educational services, health care, and social assistance (17 percent)
2. Manufacturing (15 percent)
3. Retail trade (13 percent)

Figure 9: East Los Angeles Residents Industry Employment

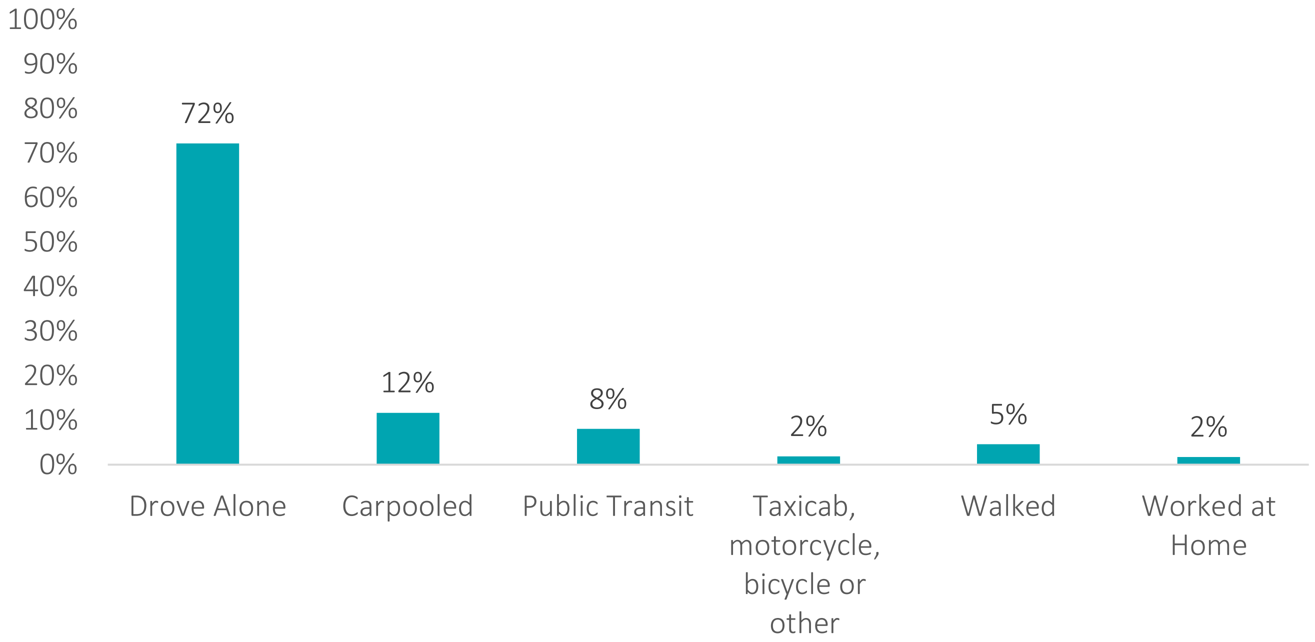


Source: Data - U.S. Census Bureau (2018) American Community Survey 5-year estimates Table S2403. Graphics -Walker Consultants, 2020.

Travel and Transportation

The majority of residents in East LA travel to work by driving alone (72 percent). Figure 10 demonstrates the travel modes for East LA workers.

Figure 10: East Los Angeles Workers Means of Transportation to Work



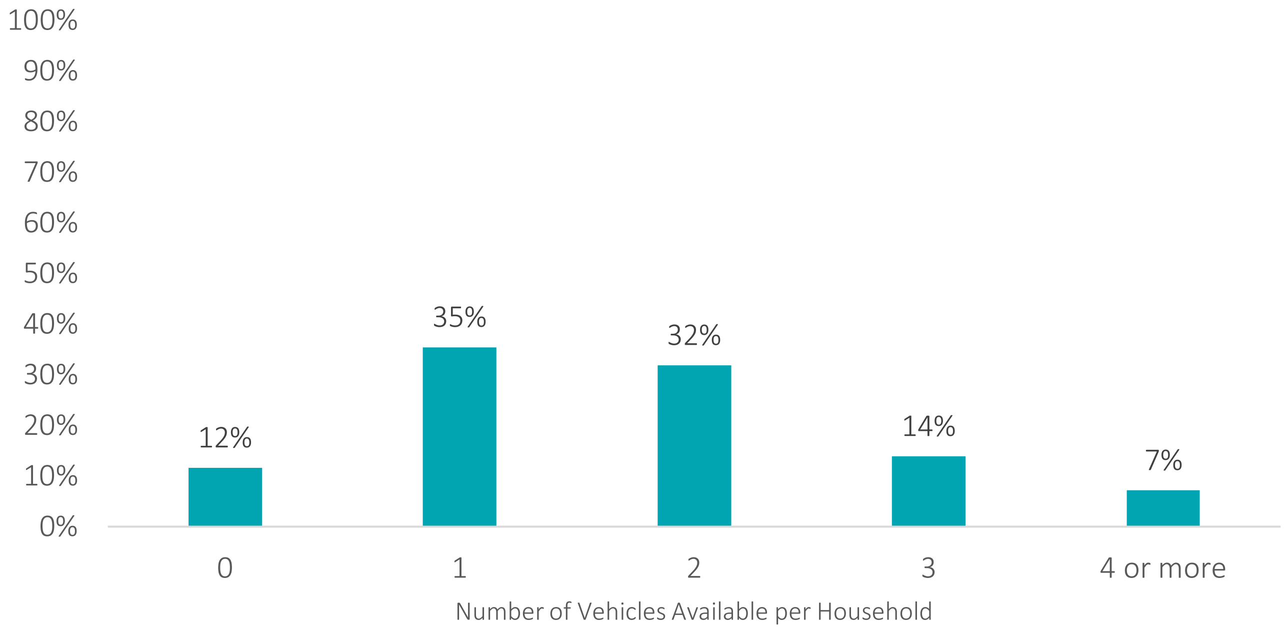
Source: Data - U.S. Census Bureau (2018) American Community Survey 5-year estimates Table B08101. Graphics -Walker Consultants, 2020.

While single-occupancy vehicle (SOV, Drove Alone) travel is the most common mode for commuters in East LA and in the County, commutes on public transit are slightly higher in East LA than in the County at large. As shown in the chart, the share of transit commuters is eight (8) percent in East LA. In comparison, the County's share of commuters is six (6) percent.

Still while the share of transit use in East LA is higher than in the County, a recent study from the Institute of Transportation Studies at the University of California Los Angeles (UCLA) has shown that transit ridership is declining in the greater Los Angeles region, with an increase in vehicle ownership as one of the main factors in the decline of transit use.[6] Thus, while East LA boasts four Gold Line Stations (Indiana, Maravilla, Civic Center, and Atlantic) the management of parking in an area like East LA is critical to addressing issues of access and quality of life.

With respect to vehicle ownership, approximately 90 percent of East LA households have at least one vehicle available. Figure 11 summarizes vehicle availability for households in East LA.

Figure 11: East Los Angeles Number of Vehicles Available per Household



Source: Data - U.S. Census Bureau (2018) American Community Survey 5-year estimates Table B08201. Graphics -Walker Consultants, 2020.

Land Use and Planning

Per data retrieved from the Los Angeles County Assessor, there are a total of 19,130 parcels in East LA. There are eight general land use categories in East LA, and they include:

1. Residential
2. Commercial
3. Industrial
4. Institutional
5. Government

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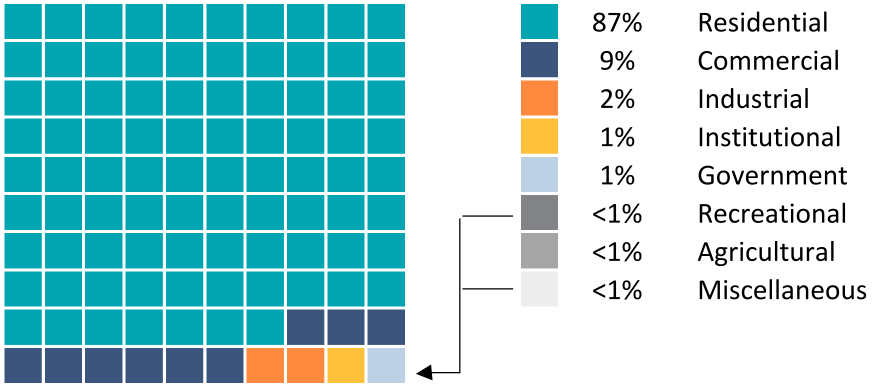
[6] https://www.its.ucla.edu/2018/01/31/new-report-its-scholars-on-the-cause-of-californias-falling-transit-ridership/

6. Recreational
7. Agricultural
8. Miscellaneous

Of that total, residential parcels account for 87 percent, commercial account for 9 percent, industrial 2 percent, institutional 1 percent, government 1 percent, and recreational, agricultural, and miscellaneous all less than 1 percent. Figure 12 shows the percentage of total parcels found in East LA by land use.

Figure 12: Parcels by Land Use Type in East Los Angeles

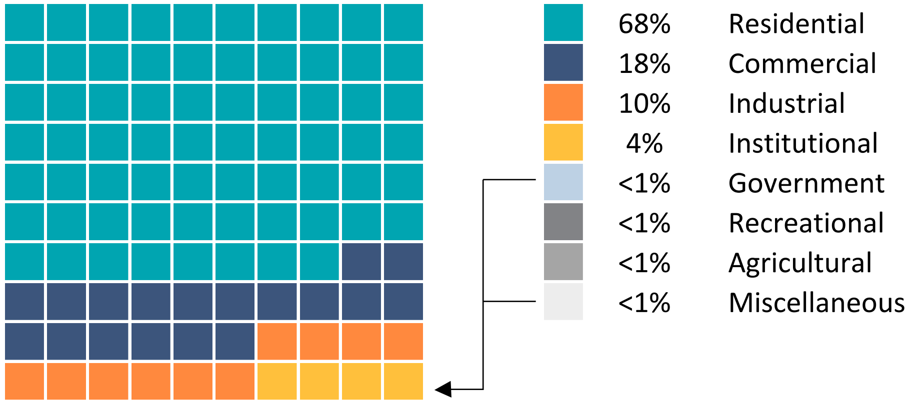


Source: Data - Los Angeles County Assessor. Graphics -Walker Consultants, 2020.

As shown in Figure 12, the majority of parcels in East LA are residential. However, not all parcels are equal in size. Thus, when looking at the actual amount of land distributed to different land uses in East LA, the amount of land dedicated to residential, while still the majority, decreases.

Figure 13 shows the actual amount of land distributed to different land uses in East LA.

Figure 13: Percent of Land Distributed to Each Land Use Type in East Los Angeles



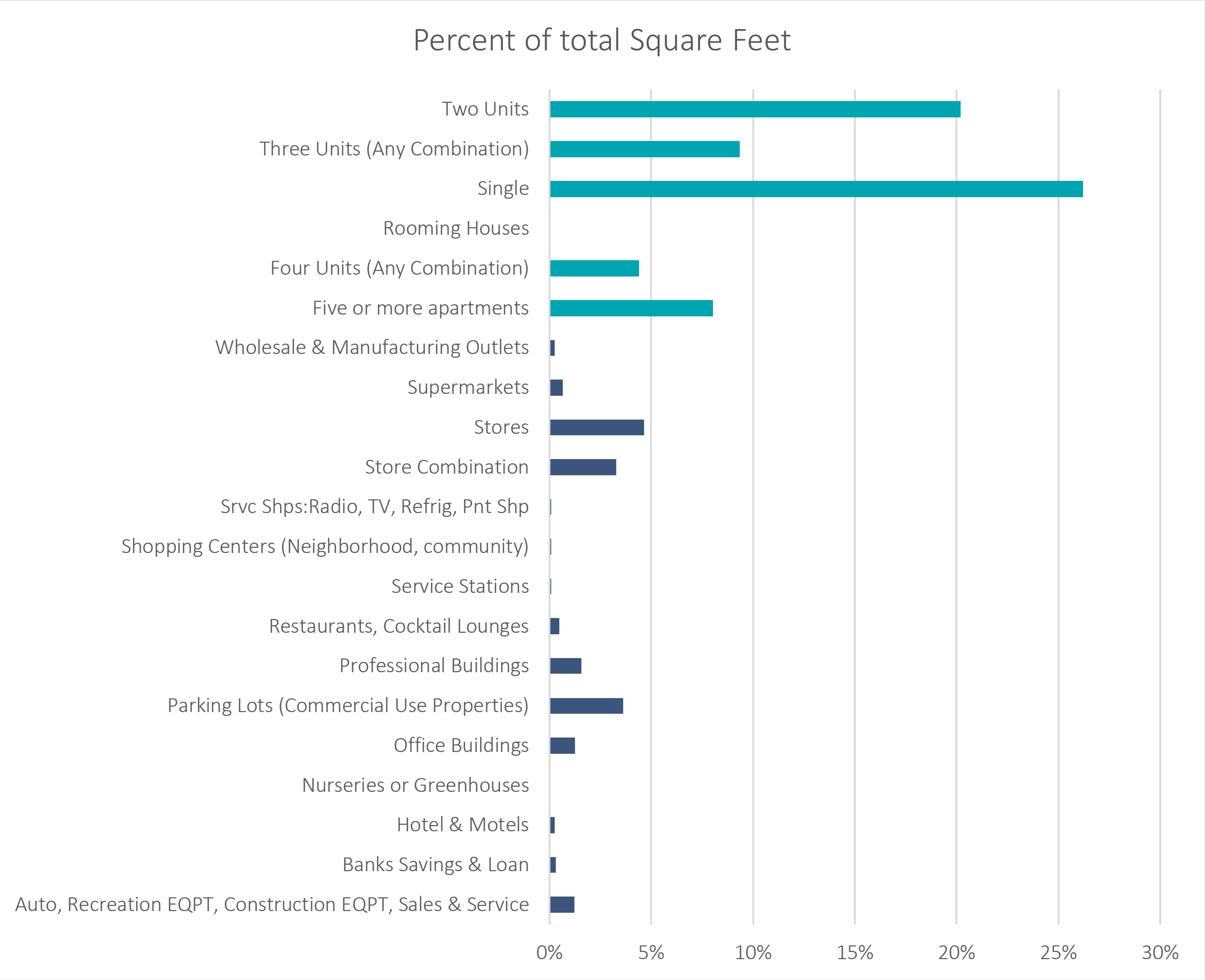
Source: Data - Los Angeles County Assessor. Graphics -Walker Consultants, 2020.

As shown in Figure 13:

- 68 percent of all land in East LA is residential,
- 18 percent commercial,
- 10 percent industrial,
- 4 percent institutional, and
- less than 1 percent is government, agricultural, recreational, and miscellaneous.

Given that the focus of this study is on residential and commercial parking, a breakdown of those two land uses is shown in Figure 14. Residential uses are shown in Teal, while commercial uses are shown in Dark Blue.

Figure 14: Percent of Land Distributed to Specific Residential and Commercial Uses in East Los Angeles



Source: Data - Los Angeles County Assessor. Graphics -Walker Consultants, 2020.

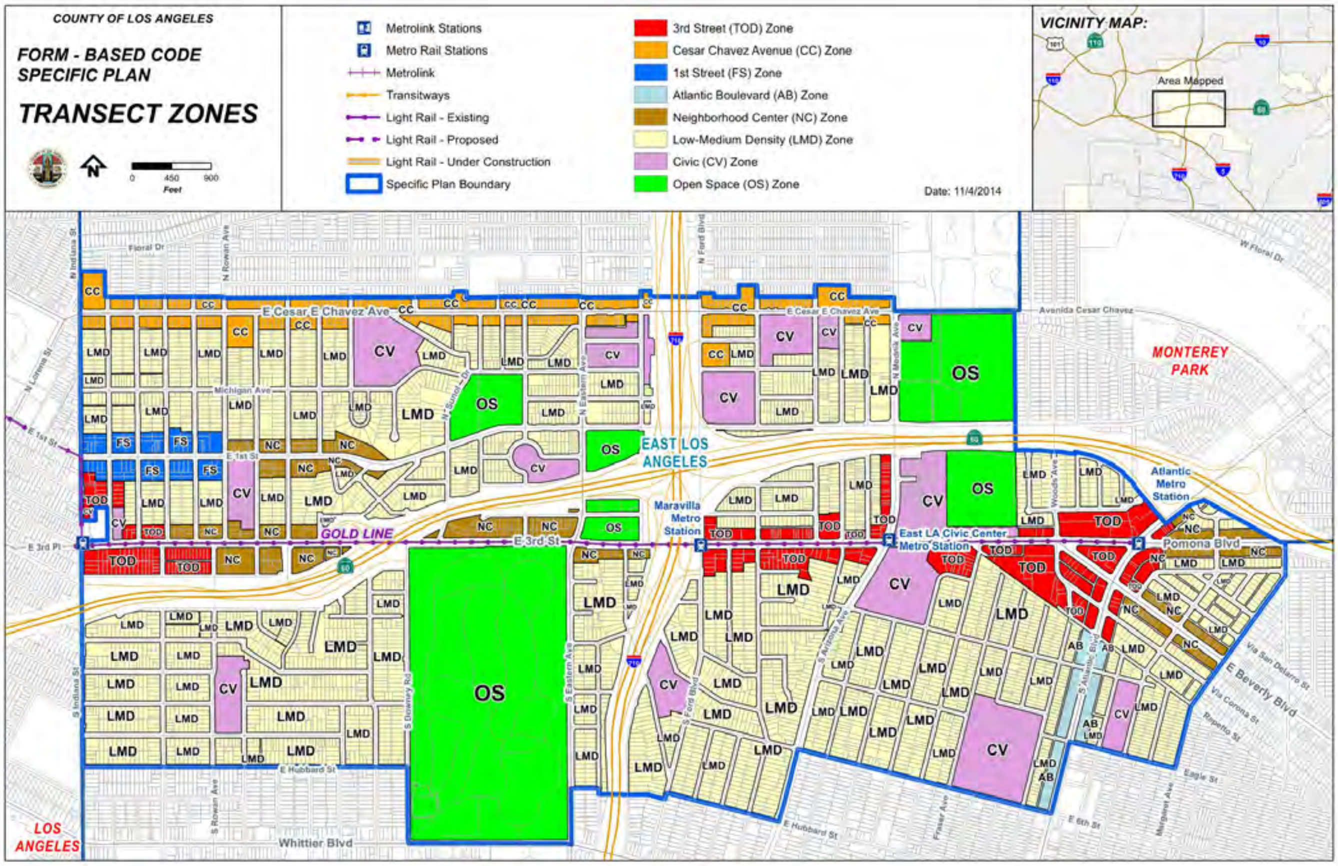
Figure 14 shows that the housing stock in East LA is predominantly single unit (i.e., single-family), followed by parcels that have two units and three units. For commercial land uses, the predominant land use with the highest footprint is stores, followed by commercial parking lots.

Third Street Form-Based Code Specific Plan

One of the main land use plans in East LA is the Third Street Form-Based Code Specific Plan. The plan enables transit-supportive development around the four Metro Gold Line Stations (Indiana, Maravilla, Civic Center, Atlantic) located along 3rd Street. The purpose of the plan is to focus on the form of buildings rather than the separation of land uses.

Within the specific plan area there are eight (8) Transect Zones. The plan area and transect zones are shown in Figure 15.

Figure 15: East LA Third Street Specific Plan Area



Source: Data - Los Angeles County Department of Regional Planning, 2020.

Each Transect Zone has its own regulations of building form. In looking at the parking requirements in each Transect Zone, the minimum number of parking spaces required is lower in the specific plan than in the rest of East LA. Table 1, shows the required number of parking spaces in these zones.

Table 1: Parking Requirements Comparison LA County and East LA 3rd Street Specific Plan (Transect Zones)

			East LA - Third Street Specific Plan*					
Zone	**Land Use**	**LA County (East LA)**	**3rd Street (TOD)**	**Cesar Chavez Avenue (CC)**	**1st Street (FS)**	**Atlantic Boulevard (AB)**	**Neighborhood Center (NC)**	**Low-Medium Density (LMD)**
Commercial	Any use permitted in Zone C-3 but not permitted in Zone R-4, including commercial, retail, or service uses and medical or dental offices	4 per ksf	0 per ksf (For developments ≤ 10,000 gross sq.ft.) or 2 per ksf (For 1,000 sq. ft. above first 10,000 sq. ft. of developments > 10,000 gross sq.ft.)					
	Business and professional offices	2.5 per ksf						
Entertainment, assembly, and dining	Conference rooms	10+ 1 per 3 persons						
	Dining rooms, cafes, cafeterias, coffee shops, nightclubs, outdoor dining areas, restaurants, and other similar uses							
	Drinking establishments, bars, cocktail lounges, nightclubs, soda fountains, taverns, and other similar uses							
	Exhibit rooms, stages, lounges, and other similar uses							
	Theaters, auditoriums, lodge rooms, stadiums, or other places of amusement and entertainment, not otherwise listed in this Chapter							
	Mortuaries							
	Dancehalls, skating rinks, and gymnasiums							
	Health clubs and centers							
Residential	Accessory dwelling units**	1 per unit.	1 per unit					1 per unit
	Adult residential facility	1 per staff member on the largest shift and 1 per business vehicle.						
	Apartment *(Bachelor)*	1 per dwelling unit.						
	Apartment *(Efficiency and one-bedroom)*	1.5 per dwelling unit.						
	Apartment *(Two or more bedrooms)*	1.5 per dwelling unit and 0.5 per dwelling unit.						
	Apartment (*Guest parking for apartment houses with at least 10 units)*	1 for guests per 4 dwelling units of the total number of dwelling units.						
	Two-family residences	3 and 1 covered or uncovered per two-family residence.						
	Farmworker housing	Spaces for each dwelling unit in the number required and subject to the same conditions as specified for "Residential uses" and where farmworker housing consists of group living quarters, such as barracks or a bunkhouse, 1 space per 3 beds.						
	Group homes for children	1 per staff member on the largest shift and 1 per business vehicle.						
	Housing developments for senior citizens and persons with disabilities	0.5 per dwelling unit and 1 for guests per 8 dwelling units.						
	Joint live and work units	2 per joint live and work unit.						
	Single-family residences	2 covered standard spaces per unit.						2 per unit
	Single-family residences on compact lots	1 per unit for units less than 750 sq. ft. with one bedroom or less.						

Notes:

All ratios shown per 1,000 square feet (ksf) unless otherwise noted.

* The Civic (CV) and Open Space (OS) Transect Zones follow the parking requirements as set for the in the Institutional Zone as prescribed in Section 22.26.020 and in the Open-Space Zone as prescribed in Chapter 22.16 of the County of Los Angeles Code.

**Per section *22.140.640 - Accessory Dwelling Units* of the County code there are exceptions in which the requirement can be reduced to zero, such as being located within one-half mile of public transit.

Source: Data – County of Los Angeles Code of Ordinances, 2020.

As shown in Table 1, parking requirements are generally lower in the Third Street Form-Based Code Specific Plan than in the rest of East LA. For example, a retail store is generally required to provide four (4) parking spaces per 1,000 square feet (ksf) in the County of Los Angeles, including unincorporated East LA. However, in looking at the Third Street Specific Plan, a retail store need not provide parking for the first 10,000 square feet, and only after the first 10,000 square feet is parking required at two (2) per 1,000 square feet.

In looking at residential uses, parking requirements within the specific plan are also lower than the County requirements. For example, The Third Street Specific Plan calls for one (1) space per unit for all developments in all Transect Zones with the exception of the Low-Medium Density (LMD), Civic (CV), and Open Space (OS) zones. On the other hand, the County requires a range depending on the housing use. For example, one-bedroom apartments are required to have 1.5 parking spaces per unit. In addition, there is no parking requirement for non-residential uses within 500 feet of a metro station.

The intent of the lower parking requirements is to facilitate transit-supportive development, and encourage and support a sustainable, pedestrian-friendly, and economically vibrant community. It is important to note that the requirement is a minimum, not a maximum, thus should developers perceive that the market calls for more parking than is minimally required they are allowed to provide it.

Note: There is also the General Plan and the East LA Community Plan, which regulates the areas outside of the Third St. Specific Plan. The County is also preparing a Metro Area Plan, which includes all of East LA and will update the Third St. Specific Plan.

Los Angeles County Transit-Oriented District Design Guidelines

The Department of Public Works for the County of Los Angeles developed a toolkit for designing for transit-oriented districts. Given the presence of the four Metro Gold Line Stations and the Third Street Specific Plan, East LA is well-positioned to take advantage of transit-oriented development. The guidelines presented in the toolkit are meant to provide a framework for a consistent approach to infrastructure and transportation-related improvements to support land use decisions in areas in close proximity to transit stations.

The guidelines provide parking strategies that aim to create a more cohesive parking system. Among the strategies listed in the toolkit are:

- Interconnected parking: link parking with adjacent development whenever possible to facilitate vehicular and pedestrian movements, especially when streets are congested.
- Joint and shared parking: Incorporate joint and shared parking opportunities amongst multiple properties, including "park once" concepts.
- Amount of parking: Consider reduced parking standards in TOD areas. In addition to a reduction in required parking, standards may include provisions for shared parking, unbundled parking, in-lieu parking fees, provisions for transit passes or other mechanisms.

While the guidelines discuss the off-street parking strategies for design, perhaps the most important consideration is on-street parking demand management. As will be discussed in the next section, East LA suffers from excess on-street parking demand in virtually all areas of the community.

02

Existing Parking Conditions

Existing Parking Conditions

Definition of Terms

Throughout this report, several terms are used to describe different components and conditions of the parking system. The following list defines those terms.

- **Study Area** – The physical boundary in which study data are collected. It is important to note that for this effort the selected study area is composed of several zones (or sub-areas) which are meant to represent a sample of parking conditions experienced throughout the community.

- **Zone (or Sub-Area)** – For this report, a zone (or sub-area) refers to a bounded area within the larger study area generally consisting of one or two land uses, the boundaries of which were defined in collaboration with County staff.

- **Block face** – The entire side of a block from one intersection to another. A conventional city block contains four sides, or four block faces.

- **Parking Supply** – The total number of parking spaces within a specified area; for example, a study area, zone, parking lot, or block face.

- **Effective Supply** – The parking supply adjusted by the optimum utilization factor, typically demonstrating that a number of spaces greater than the number of cars is desirable to allow drivers to conveniently find spaces, to take into account peak needs such as occasional large gatherings, and for traffic to reasonably circulate.

- **Parking Demand** – The number of spaces required by various user groups in a specified area.

- **Peak Hour** – The peak hour represents the busiest hour of the day for parking demand.

- **Survey Day** – The day that occupancy counts within a study area are recorded. This day should represent a typical busy day.

- **Parking Congestion** – For the purpose of this analysis we use the term "parking congestion" to convey the extent to which a defined area was found to experience a high demand for a limited number of parking spaces, negatively impacting the availability of parking spaces to accommodate the demand for parking and resulting in an unacceptably low level of parking space availability for drivers who were seeking a parking space.

- **Occupancy** – The percentage of the parking supply that is occupied at a certain point in time. For example, if a block face contains 10 parking spaces, and 5 of those spaces are occupied by vehicles, then there is a resulting occupancy of 50 percent.

Methodology

A key component of the study was to understand current parking conditions in East LA, both in residential areas and in commercial areas. To determine current parking conditions, Walker performed fieldwork in July and August 2020.

The fieldwork consisted of:

- An inventory of on-street parking spaces in the study area.
- Parking occupancy counts during peak periods for commercial, residential, and industrial uses.
    - For commercial zones, counts were conducted on weekends from 12:00pm to 6:00pm.
    - For residential zones, counts were conducted on weekdays after 9:00pm, and before 7:00am.
    - For industrial zones and zones near transit stations, counts were conducted on weekdays from 10:00am to 2:00pm.
- Observations of off-street parking lots in commercial areas during peak periods.
- Observations of off-street parking in residential areas during peak periods.

The objective of the fieldwork was to observe and study representative areas for commercial, residential, and industrial land uses that would capture existing conditions including availability, help us identify parking issues, and serve as a foundation for recommending improvements to parking in East LA.

COVID-19 Considerations

It is important to note that this analysis was conducted during the occurrence of the Covid-19 pandemic, although the field data collection during the month of August did witness conditions far busier than the slower conditions in the spring. As a response to health directives resulting from the pandemic, more workers were working from home. A portion of workers, especially those employed in the service sector, had experienced layoffs or furloughs, thus potentially impacting demand for parking in residential areas. However, it is Walker's opinion that Covid-19 did not materially impact our findings on our findings of peak conditions for residential parking. This is because the effect that the pandemic is having on parking demand is that more workers are home during daytime hours, but that does not change peak parking conditions, which for residential areas typically occur in the evenings.

While we did observe and quantify high demand during peak periods in some commercial areas, the extent to which parking demand has changed all areas is difficult to determine precisely. As discussed later in this report, business owners in East LA indicated that the conditions observed in some areas do not reflect pre-pandemic levels of parking demand. With this in mind, the analysis and subsequent recommendations will factor in the impacts of the pandemic. On a broader scale, Walker has observed that the pandemic has impacted businesses in that restaurants and stores have shifted toward a more takeout/pick-up business model. As such, we would expect shorter parking durations (and the need for parking spaces available to accommodate this). However, in the final analysis, based on the high parking demand numbers we observed during the pandemic and the feedback gleaned from stakeholders, the high level of demand overall is the basis on which we will operate as we formulate parking recommendations.

Study Area

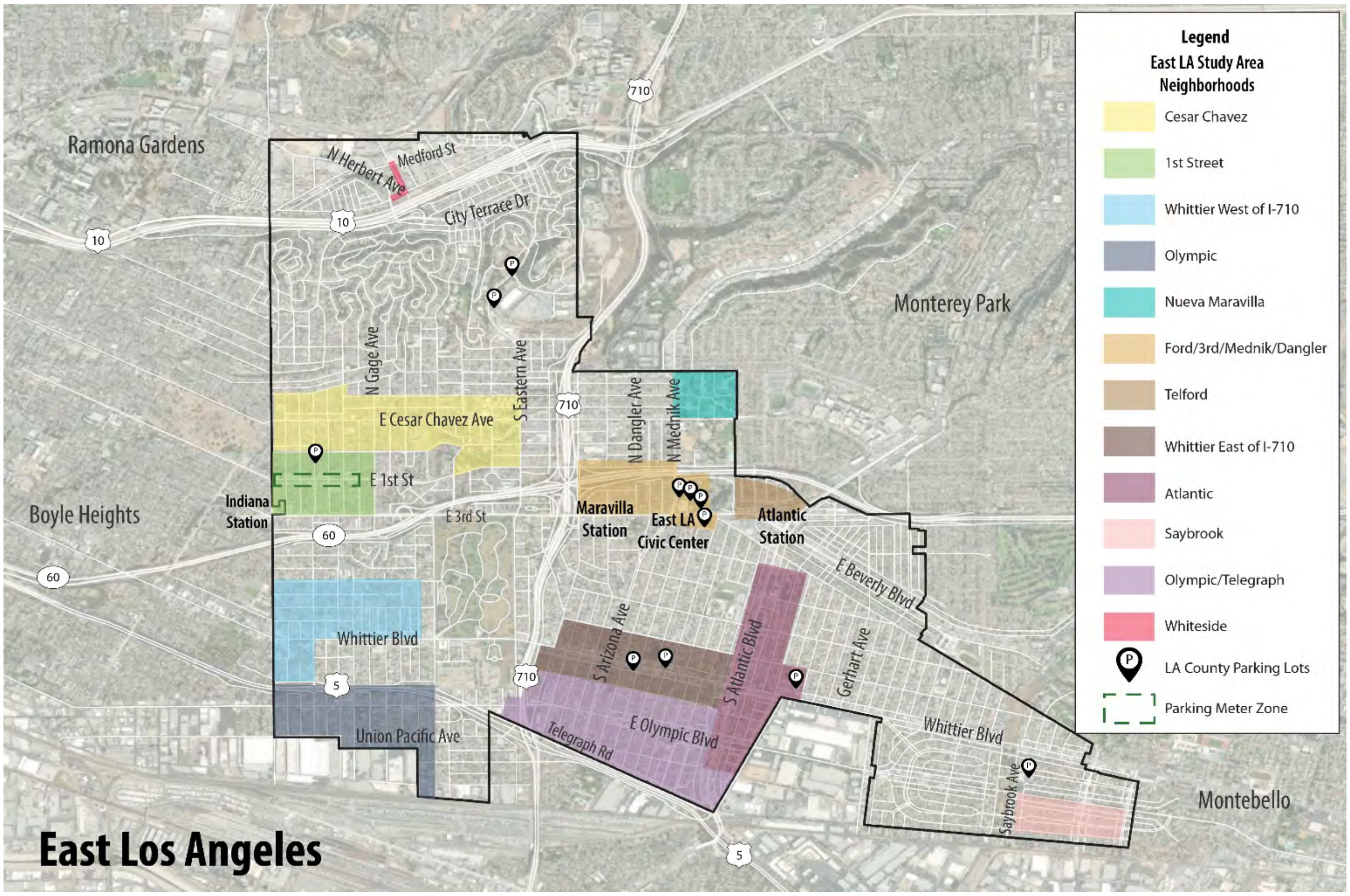
The study area for this project was selected based on information provided by various departments in the County including; Regional Planning, Public Works, Sheriff's Department, Supervisorial District 1 staff, and the Chief Executive Office. The study area includes twelve zones plus City Terrace. City Terrace is called out as it is in a different stage of the study process. As such, while inventory and occupancy counts were not conducted there, it is being studied for solutions.

The zones contain commercial, residential, and industrial areas that are known to experience parking challenges. Additionally, the selected zones also include:

- County-owned off-street parking facilities,
- Gold Line Stations, and
- The only area of East LA that has parking meters, located along 1st Street.

Figure 16 illustrates the study area zones.

Figure 16: East LA Parking Study Area Zones



Source: Walker Consultants, 2020.

It is important to note that while specific zones were outlined for data collection, the conditions observed in these zones are assumed to be representative of the whole of East LA. The outlined study area zones include:

- Cesar Chavez Avenue
    - From Indiana Street to Eastern Avenue
- 1st Street
    - From Indiana Street to Gage Avenue
- Whittier Boulevard – East of the I-710
    - From Burger Avenue to Woods Avenue
- Whittier Boulevard – West of the I-710
    - From Indiana Street to Bonnie Beach Place
- Olympic Boulevard – East of the I-710
    - From Burger Avenue to Woods Avenue
- Olympic Boulevard – West of the I-710
    - From Indiana Street to Downey Road
- Nueva Maravilla Housing Community
    - Bounded by Cesar Chavez Avenue, Mednik Avenue, and Floral Drive
- The area around Dangler Avenue
    - Bounded by 3rd Street, Ford Boulevard, State Route 60, and Mednik Avenue
- The area around Telford Street
    - Near Metro’s Atlantic Station and Kaiser Permanente Hospital
- Atlantic Boulevard
    - From Telegraph Road to 4th Street
- Area near Saybrook Park
    - Bounded by Saybrook Avenue, Olympic Boulevard, Concourse Avenue, and Hereford Drive
- Whiteside Street in City Terrace
- City Terrace areas north and south of the I-10

Parking Supply (Inventory)

On-Street

Walker conducted an inventory of the on-street parking supply in each of the zones of the study area. Table 2 shows the inventory of on-street spaces by study area zone.

Table 2: Study Area On-Street Parking Supply by Zone

ZONE	BLOCKS SURVEYED	Residential[1]	INVENTORY* Commercial[2]/ Industrial[3]	Total
César Chávez	30	1,455±	213±	1,668±
1st Street	14	598±	275±	873±
Whittier (West)	27	1,360±	152±	1,512±
Olympic (West)	29	987±	206±	1,193±
Nueva Maravilla‡	6	558±	--	558±
Ford/Mednik	8	415±	60±	475±
Telford	5	303±	39±	342±
Whittier (East)	26	827±	345±	1,172±
Olympic (East)	38	1,521±	336±	1,857±
Atlantic	37	1,047±	727±	1,774±
Saybrook	13	769±	8±	777±
Whiteside	4	46±	12±	58±
TOTALS	237	9,886±	2,373±	12,259±

Notes:

* Inventory based on vehicles parked.

‡ Each section treated as a separate block of residential parking.

1 On-street spaces on residential blocks

2 On-street spaces on commercial blocks

3 On-street spaces on industrial blocks

In total, Walker surveyed 237 blocks throughout East LA. The total number of spaces counted in residential areas was 9,886±, approximately 80 percent of all spaces counted. The total number of spaces counted in commercial and industrial areas was 2,373± (approximately 20 percent of spaces). Combined, the total number of on-street spaces counted within the study area was 12,259±.

Metered Spaces

There are 150 metered on-street parking spaces in East LA, and they are all located along 1st Street and the commercial portions of side streets that bisect 1st Street, between Indiana Street and Eastman Avenue. Figure 17 shows the locations of the meters.

Figure 17: Locations of Parking Meters in East LA

Source: County of Los Angeles – Department of Public Works, 2020.

All 150 parking meters accept only coins. Figure 18 shows an example of the type of meters that are in place in East LA.

Figure 18: Parking Meters in East LA

Source: Walker Consultants, 2020.

While there is nothing inherently wrong with having coin-operated meters, parking meter technology has advanced and there are more customer-friendly options for acceptance of payment. These include the ability to pay with credit card and mobile applications. Furthermore, upgraded meter technology can facilitate enforcement as newer smart meters can provide real-time data to parking enforcement staff and improve parking management.

ADA (Americans with Disabilities Act) Spaces for People with Disabilities

Another type of on-street space that was counted in the study area were those designated to serve people with disabilities under the American's with Disabilities Act (ADA). In the study area zones, Walker field staff counted 126 ADA spaces on residential blocks, and 16 on commercial blocks. ADA spaces account for just over 1% of the total number of on-street spaces in the study area zones.

Figure 19 shows an example of an on-street ADA space in a residential street. No assessment was made as to the compliance of these spaces with the specific rules and regulations of ADA requirements.

Figure 19: On-Street ADA Spaces in East LA

Source: Walker Consultants, 2020.

ADA spaces are generally accompanied by signage and blue curb painting as shown in the figure above. Residents can make requests to obtain an ADA space to the Department of Public Works' Traffic Safety and Mobility Division (formerly named Traffic and Lighting Division). If the requestee's residence does not have a driveway or garage access to park off-street, the department will conduct a study to determine if the requirements are met for obtaining blue curb parking.

Off-Street

While an inventory of off-street parking was not part of the scope of work for this study, Walker identified fifteen County-owned parking lots and structures within East LA. The facilities vary in terms of user groups and location. While some off-street parking facilities may be restricted to certain user groups, such as the Internal Services Department, others serve the general public. The locations of the County-owned lots are shown in Table 3.

Table 3: County-owned Parking Facility Stall Counts

				Parking Stall Counts		
Department	Parking Facility Address	Name	Public Parking	Lot	Structure	Total
Health Services	216 S Mednik Ave	Ed Roybal Comprehensive Health Center	No	17		17
Internal Services	1100 N Eastern Ave	Auto Park 81	No	1419		1419
	146 S Fetterly Ave	East LA Courthouse	Yes		339	339
	4837 E 3rd St	East LA Civic Center	Yes	225		225
	922 S Fetterly Ave	East LA Business District	Yes	104		104
Parks and Recreation	3864 E Whittier Blvd	Salazar Park	Yes	113		113
	6300 E Northside Dr	Saybrook Park	Yes	26		26
	4914 E Cesar Chavez Ave	Belvedere Regional Park	Yes	199		199
	1126 N Hazard Ave	City Terrace Park	Yes	118		118
	111 N Marianna Ave	Eugene A. Obregon Park	Yes	63		63
Social Services	759 S Belden Ave	DPSS Belvedere District	No		366	366
Public Works	124 N Ditman Ave	Belvedere Off Street Lot	No	38		38
	753 S La Verne Ave	East LA Business District	Yes	91		91
Sheriff	1104 N Eastern Ave	Auto Park 81A	No	884		884
	4108 City Terrace Dr		Yes	24		24
	TOTAL			3321	705	4026

Source: Walker Consultants, 2020.

As shown in Table 3 there are over 4,000 County-owned stalls in East LA. Of those, 3,321± (approximately 82 percent) are in surface parking lots and 705± (approximately 18 percent) in parking structures. Of the county-owned facilities, ten of them contain public parking. The total number of stalls within those facilities total 1,302.

Utilization

A key metric in any parking study is utilization. Utilization reveals how full or empty any specific supply of parking is. For this study, Walker conducted occupancy counts during the projected peak periods of parking demand for each zone in the study area. The determination of peak periods is based on the land uses that predominate each zone. For example, a parking occupancy count for residential areas was conducted in the evening when most residents should be home.

Table 4 shows the peak on-street occupancies by zone in the study area.

Table 4: Study Area On-Street Parking Occupancy by Zone

	PEAK			
	OCCUPANCY PERCENTAGE**			
	Weekday†	Weekend††		
ZONE	Residential	Residential[1]	Commercial[2]/ Industrial[3]	Total
César Chávez	99%	84%	83%	84%
1st Street	100%	87%	63%	79%
Whittier (West)	104%	89%	66%	87%
Olympic (West)	111%	94%	98%	95%
Nueva Maravilla‡	104%	--	--	--
Ford/Mednik	103%	84%	25%	77%
Telford	53%	40%	21%	37%
Whittier (East)	107%	96%	99%	97%
Olympic (East)	105%	88%	81%	86%
Atlantic	107%	89%	60%	77%
Saybrook	115%	91%	13%	90%
Whiteside	113%	96%	100%	97%
TOTALS	104%	83%	73%	81%

Notes:

** Occupancy percentage is equal to parking occupancy divided by inventory.

†† Commercial parking demand as measured during weekend peak; Industrial demand as measured during weekday peak.

‡ Each section treated as a separate block of residential parking.

1 On-street spaces on residential blocks

2 On-street spaces on commercial blocks

3 On-street spaces on industrial blocks

As shown in Table 4, in virtually every study area zone, high levels of parking occupancy were observed. In looking at the residential areas peak (weekday), almost all zones were observed to be at or above a 100 percent occupancy. This means that when the counts were conducted, not only were all the on-street parking spaces occupied, but there were extra vehicles parked illegally on the street such as in intersections, on red curbs, in front of hydrants, double-parked, etc.

There was one residential area that had low levels of occupancy as compared to the rest. In the Telford zone, the peak occupancy observed was 53 percent. The inclusion of this zone in the study area was predicated on the complaints of parking spillover from Metro riders and from the Kaiser Permanente facility. However, given that the survey days occurred during July and August of 2020, during the Covid-19 pandemic, the conditions of parking spillover were not observed. This is likely due to the significant drop off in Metro ridership during the pandemic and similarly lower hospital parking demand.

Commercial parking demand was also observed to be high in certain zones, but not exceeding capacity. Commercial parking demand peaked on the weekend. The corridors with the highest occupancies were Whittier Boulevard East with 99 percent, Olympic Boulevard West with 98 percent, and Cesar Chavez with 83 percent.

While the on-street occupancies along commercial corridors were generally high, especially along Whittier Boulevard and Olympic Boulevard, parking across the Atlantic Boulevard zone was less so. At peak, the Atlantic zone was 60 percent occupied. However, there were clusters of high parking demand observed along Atlantic Boulevard especially near blocks closer to Whittier Boulevard. Still despite some areas of high demand, along the entire corridor, parking was not as full as in other major commercial corridors.

Adequacy (Surplus/Shortfall)

While occupancy counts reveal the utilization and availability of on-street spaces, an analysis of adequacy reveals whether there is a surplus or shortfall of the on-street supply. The adequacy is determined by applying an effective supply factor to the parking supply.

Effective Supply Factor

An effective supply factor (ESF) is an adjustment to the parking supply to account for the movement of vehicles in and out of parking spaces. For example, the optimum occupancy standard for on-street parking is identified as 85 percent on any given block or block face, per current planning and transportation research and literature. This is an industry standard that dictates that the optimal occupancy generally means that there are one or two spaces vacant per block face, even during periods of typical peak demand, allowing drivers to locate an available parking space in reasonable proximity to their destination. Thus, to determine the adequacy of the on-street parking supply, we applied an 85 percent ESF to detect where there were surpluses or shortfalls of parking in the study area.

Table 5 shows the adequacy of the study area on-street parking in East LA.

Table 5: Study Area On-Street Parking Adequacy by Zone

ZONE	PARKING SURPLUS/(DEFICIT)*** Weekday† Residential	Weekend†† Commercial^2/ Industrial^3
César Chávez	-200	4
1st Street	-92	61
Whittier (West)	-256	29
Olympic (West)	-254	-26
Nueva Maravilla‡	-109	0
Ford/Mednik	-73	36
Telford	98	25
Whittier (East)	-184	-50
Olympic (East)	-305	15
Atlantic	-231	180
Saybrook	-227	6
Whiteside	-13	-2
TOTALS	-1,846	278

Notes:

*** Surplus/deficit determined by an effective supply factor of .85 for all spaces less parking demand.

† Residential parking demand as measured during weekday peak.

†† Commercial parking demand as measured during weekend peak; Industrial demand as measured during weekday peak.

‡ Each section treated as a separate block of residential parking.

1 On-street spaces on residential blocks

2 On-street spaces on commercial blocks

3 On-street spaces on industrial blocks

Source: Walker Consultants, 2020.

As shown in Table 5 the analysis of on-street parking adequacy shows two findings. The first, that there is a modest overall surplus of commercial and industrial parking in the study area, even though there are notable deficits across some zones like Whittier Boulevard East (50-space shortfall) and Olympic Boulevard West (26-space shortfall). The second, is that there are deficits in virtually every residential zone in the study, often in the hundreds of spaces.

For example, the Cesar Chavez, Whittier Boulevard West, Olympic Boulevard West, Olympic Boulevard East, Atlantic Boulevard, and Saybrook zones are all projected to have shortfalls of 200 spaces or more. The extent to which shortfalls were observed extends through the entire study area. As such, as part of the survey of current conditions, a sample of the availability of parking in residential driveways was conducted.

General Observations

Availability in Residential Driveways

Given the severity of the parking congestion on residential streets, and the sheer volume of vehicles observed parked illegally, we wanted to understand better whether or not off-street residential parking supply is being used to capacity. To determine that, Walker surveyed a sample of residential block faces throughout the study area. The survey consisted of observing driveway capacity during peak residential evening hours and counting those households that could accommodate at least one additional vehicle off-street. While the survey only accounts for one additional vehicle per household, it must be noted that many households observed have the space to accommodate multiple vehicles.

Table 6 shows the results of the survey.

Table 6: Survey Sample of Driveway Availability

ZONE	BLOCK FACES	SAMPLEOF DRIVEWAYs SURVEYED	SPACES
César Chávez	94	17	**74**
First Street	41	9	**24**
Whittier (West)	90	18	**39**
Olympic (West)	72	6	**25**
Nueva Maravilla‡	-	-	-
Ford/Mednik	23	8	**29**
Telford	16	16	**32**
Whittier (East)	65	9	**37**
Olympic (East)	100	8	**45**
Atlantic	96	13	**17**
Saybrook	40	9	**23**
Whiteside	-	-	-
TOTALS	637	113	345

Source: Walker Consultants, 2020.

As shown in Table 6, when looking at the availability of residential driveway space to accommodate more vehicles, Walker observed available capacity in driveways in every zone. Of the 637 block faces in the study area, Walker surveyed 113, and within those block faces observed capacity for at least 345 vehicles that could be accommodated in driveways.

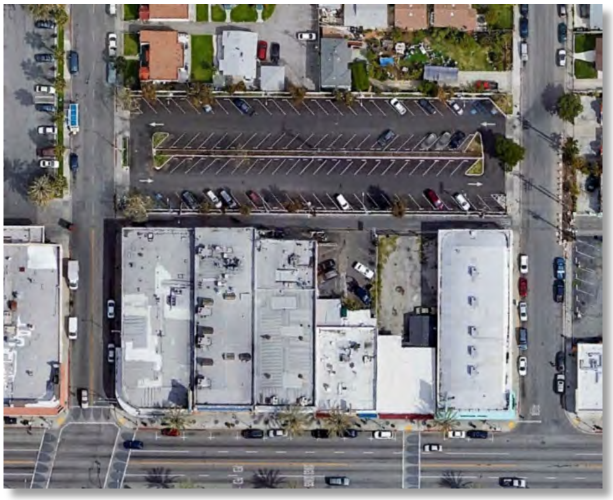
Utilizing the observed availability in driveway space per block face, on average, each block face could accommodate 3+ (345/113) vehicles off-street. In other words, on any given block face, Walker observed on average available driveway capacity for 3+ vehicles. If we apply that average to the total study area (645 block faces), there is a projected capacity for an additional 1,944+ spaces in driveways across the entire study area. This has the potential to address the 1,846-space shortfall in residential areas.

Of course, not all households have off-street parking capacity, and even some that do, may not have the physical space to fit modern vehicles. However, the takeaway from this analysis is that there is opportunity for at least some residents to fully utilize their off-street capacity to free up on-street spaces.

Off-Street Parking in Commercial Areas

While on-street demand along commercial corridors was high, off-street parking demand in the county-owned lots were not observed as reaching capacity. Of course, it must be noted that parking observations were conducted during the Covid-19 pandemic, which may have impacted demand in some commercial areas. However, in comparing satellite imagery with what was observed by Walker field staff, the conclusion is that county-owned off-street parking is not fully utilized with regularity.

One example that stands out is the lot at 753 S La Verne (shown in image to the right). The Public Works owned and operated lot was observed to have only between 10-13 cars parked at peak, when the adjacent Whittier Boulevard was at a 99 percent occupancy. Even during evening counts on nearby residential streets, Walker field staff noted only sparse use of this lot.



Source: Google Earth Professional, 2020

Another lot that was not used is the county lot at 124 N Ditman. That lot was gated and locked at the time of Walker's parking survey. With a parking capacity of 28 spaces, this lot was underutilized given the demand that surrounds it.

Lastly, the county-owned lot located on 922 S Fetterly was also observed as not reaching capacity during peak occupancy counts for the Whittier Boulevard commercial corridor. This lot, while used more than the lot at 753 S La Verne, had capacity during the peak and off-peak hours. Given its proximity to residential areas, it did appear that some residents may already be spilling over into this lot.

Ultimately, the observations of the county-owned off-street parking lots indicate that they are underutilized given that the surrounding streets are heavily congested.

03 Community Engagement

Stakeholder Outreach

While data communicates an important and objective portion of the story of existing parking conditions in East LA, it cannot convey people's actual experiences. Further, often perceptions are reality for parking system users. This section documents the qualitative information collected to complement the quantitative information discussed previously.

For this project, Walker engaged two types of stakeholders:

- The East LA community, including residents, business owners, employees, and visitors, and
- Numerous County of Los Angeles staff from several departments including: Regional Planning, Public Works, Sheriff's Department, Fire Department, Supervisorial District 1 staff, Chief Executive Office, and the California Highway Patrol.

The purpose of obtaining feedback from both the community and County staff was to get a full representation of the understandings of current parking conditions in East LA.

Stakeholder Outreach Methodology

County Departments

The methodology used to engage staff in the various County departments that were involved in this study, was through teleconference calls and through requests for information. The purpose of the calls and requests for information was to gather input on current parking conditions, challenges, and opportunities within the study. A summary of key findings from those meetings is presented in the following section.

Key Findings from County Departments Outreach

- Parking enforcement is a challenge in East LA for various reasons, among them:
  - Staff retention – many officers that join the parking detail get promoted into other positions outside of parking.
  - Hiring – receive a lot of applications, but many applicants do not pass background checks. When some do get hired, they don't always stay on.
  - Limited Coverage – Limited number of staff to cover the entire community.
- The management of parking resources is allocated between various departments. For example, Sheriff handles enforcement, while Public Works handles infrastructure and operation of on-street and some off-street parking. This fragmentation poses a challenge in management of parking.
- Issues of parking congestion are virtually everywhere in the community. Instances of illegal parking are common: parking in intersections, red curb, in front of hydrants, double-parking, etc.
- Roughly 99 percent of the calls that come into the Supervisorial District 1 office about parking are complaints.
  - Many complaints from the community are about not having a place to park. There have even been instances when some will park in another person's driveway.

- Under current conditions many in the community see that receiving parking citations is merely a part of living in East LA.
- 72-hour parking rule may need revision, currently only need to slightly move vehicle to comply.
- Vehicle storage on the street is a community-wide issue.
- Neighborhoods located near the Metro stations experience spillover from transit users. Some residents are asking for residential permit districts.
- County wants to explore whether another department may be better suited to handle parking enforcement, or if another department can support/supplement the Sheriff Department's enforcement efforts.
- With respect to City Terrace:
    - Narrow streets, hilly terrain, and dense on-street parking congestion are a problem for first responders. As such, recommendations to restrict parking to allow access to emergency vehicles were developed.
    - Many residents in City Terrace oppose the red curb and parking restrictions recommended from the 2019 study. After the first set of red curb paint and signage restricting parking went up this year, some residents removed the signs. At the same time, some residents began clearing out garages and getting rid of unused vehicles to make off-street parking on their properties available.
    - No consensus among residents regarding restrictions as some are for and some are against, this can vary street by street. The same division exists with respect to residential parking permits.
    - Some residents have asked about potentially utilizing school parking lots to increase supply in the area.

East LA Community Outreach

After several discussions with the County departments, a methodology to engage the general public was developed. Several efforts were made to receive feedback from the East LA community throughout this study. These included:

- An online survey promoted among residents, business owners, employees, and visitors in East LA.
- Given the ongoing Covid-19 pandemic, the decision was made to hold two virtual public meetings with the capability for participants to dial-in by telephone.
- Focus groups, one was held with the Chamber of Commerce, and several invitations to speak to other community groups were extended. In addition, the Chief Executive Office answered telephone and email inquiries regarding the study It must be noted that members of several groups attended the virtual public meetings.

Marketing Plan

The goal of the marketing effort was to promote the two virtual general public meetings, introduce the parking study to the community, and invite feedback via an online survey and/or via email or telephone. The methods by which the meetings and survey were marketed included the following.

Creating A Project Landing Webpage

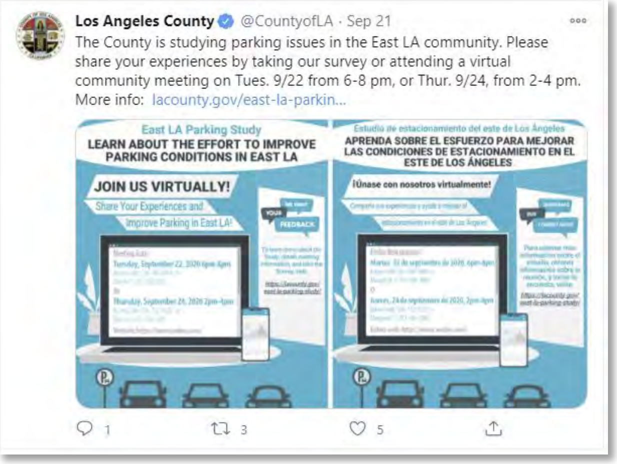
Through the County's web platform, a "landing page" was developed that served as the home and go-to source for any meeting or project information presented to the public. The link to this page was provided in subsequent marketing materials including social media, newspaper advertisements, email blasts, etc. The project website also hosted the link to the online survey, which was available in English and Spanish.

Social Media Posts

Leveraging the County's social media outlets, the virtual meetings and online survey were promoted several times leading up to the meeting dates. The social media outlets used to spread the word included the County's official Twitter, Facebook, and Instagram accounts. Reminders were sent one week leading up to the event, one day prior to the event, and on the day of the event.

Email Blasts

Utilizing the County's list of stakeholder community groups, email blasts were sent to those groups inviting them and their members to attend the meetings and provide feedback. Email blasts were sent two weeks prior to the community meetings, and reminders were sent at the same frequency as social media posts.



Los Angeles County @CountyofLA · Sep 21

The County is studying parking issues in the East LA community. Please share your experiences by taking our survey or attending a virtual community meeting on Tues. 9/22 from 6-8 pm, or Thur. 9/24, from 2-4 pm. More info: lacounty.gov/east-la-parkin...

Source: County of Los Angeles Twitter, 2020

Advertisements in Local Newspapers

Based on the community profile, 36 percent of East LA households do not have internet subscriptions at home. Given the challenges of meeting with community members in person due to the Covid-19 pandemic, the decision was made to take out ads in local newspapers. The intention was to bridge the digital divide and any language barriers that may exist in the community. As such, the ads were placed in the Spanish-language newspaper La Opinion, one of the largest Spanish language print media in circulation in the Los Angeles area.

English and Spanish advertisements were also taken out in The Eastsider LA, which is a digital platform focused on covering stories in the communities located on the eastside. The ads ran for a month, two weeks leading up to the public meetings and two weeks after, whilst the online survey was open. The Eastsider LA also published the information on its social media accounts.

The Eastsider LA
September 14 ·

El estudio evaluará las condiciones de estacionamiento existentes y desarrollará recomendaciones para mejoras. [Sponsored]
http://ow.ly/uYWk50BqIFD

THEEASTSIDERLA.COM
¡Tome la encuesta del estacionamiento en este de Los Ángeles y ayude a mejorar los estacionamientos del este...

Source: The Eastsider LA Facebook, 2020

Translation/Interpretation of Marketing Material and Community Meetings

All marketing collateral that was disbursed was available in English and in Spanish, as was the online survey. For the two virtual public meetings an interpreter was on-hand to interpret all material presented in Spanish.

Public Meetings

General Community Meetings

The two public meetings were held on September 22, 2020 at 6:00-8:00pm, and on September 24, 2020 at 2:00-4:00pm. The marketing efforts to promote the meeting guided attendees to the project landing page where instructions were provided on how to attend the virtual meetings. Options for attending were either by joining online or by phone. The format of the meeting was a slide deck presentation followed by a question/comment and answer session. The focus of the meeting was on sharing the initial current conditions analysis and gathering input from the community's residents, business owners, and visitors as they reacted to the information presented. Over 40 participants attended the first virtual meeting, and over 20 attended the second.

The key themes that emerged from the meetings are as follows:

- Enforcement is lacking
  - Illegal parking (Hydrants, Double, Intersections, Red Curb, Etc.) is widespread
  - On weekends there is seemingly no enforcement coverage. One resident noted that they were told "call back on Monday" to address a parking issue
  - No enforcement of time-restricted spaces along commercial corridors
  - The only time that community members feel they see enforcement is during street sweeping
- Lack of transparency regarding citation revenue and meter revenue
  - One attendee commented that citation revenues are divided among different entities including: The Superior Court, Sheriff Department, among others.
- Low availability of on-street parking in both residential and commercial areas
  - Low turnover of on-street parking
  - Inoperable vehicles parked on-street
  - Catering trucks parked all day
    - One community member noted that even after getting cited, trucks will remain parked. See citations as a part of doing business.
  - Street vending
  - "Reserving" of parking spaces
  - Overcrowded housing
  - Multiple car ownership
  - Under parked developments (minimum parking requirements)
  - Illegal ADUs
  - Oversized vehicles (RVs, Commercial Trucks) parked in residential areas
  - Auto repair businesses/commercial vehicles parked in residential neighborhoods
- Parking spillover
  - From surrounding commercial uses (e.g., car sales, auto body, etc.) into residential areas
  - From surrounding residential uses (e.g., parking in commercial lots, streets) into commercial areas
  - From non-residents (i.e., people from outside immediate neighborhood) into residential areas

    - From transit riders into residential areas
- Residential parking permits (RPP)
    - In the past some residents have tried to gather signatures to create a district, but there is no consensus among all residents, as some are for while others are opposed. The cost of permits was also noted as a concern; and if enforcement does not improve, seen as pointless to have a permit district.

Focus Group (Chamber of Commerce)

A meeting with members of the Chamber of Commerce took place on November 5, 2020 at 9:00-10:45am. The purpose of that meeting was to gather feedback regarding the parking issues that East LA businesses experience. In attendance were members of the Chamber of Commerce, County staff, and Walker staff.

Several key themes emerged from that meeting, among them chamber members expressed:

- Limited enforcement coverage
    - There is a sentiment across the entire community that enforcement is not meeting the needs of the community, business and residential.
    - Merchants also expressed concern over crime occurring on their private parking lots including, theft and robbery of parked cars and businesses, and intimidation of merchants and their patrons.
- Lack of on-street parking along commercial corridors
- Parking spillover from residents into commercial off-street lots
    - In City Terrace, residents utilize off-street commercial lots all-day, patrons of local businesses can't find parking.
    - 3rd Street surrounding the Metro Gold Line Station.
        - When the Gold Line Station started charging for parking it exacerbated parking congestion issues on the surrounding streets and private off-street commercial lots.
- Low turnover of on-street parking spaces in commercial streets.
    - Due to low availability of on-street parking, some people park in alleys which also prevent circulation of vehicles by blocking ingress and egress points. This is problematic for merchants and their patrons.
- Food/Catering trucks park in time-limited commercial corridors for extended periods beyond posted time limits without consequence.
    - If they are issued a citation, there are no follow-up punitive measures to discourage them from continuing to disregard posted limits. They have come to accept citations as a part of doing business.
    - Vendors also exhibit territorial behavior and have expressed their claims to merchants over certain parking spaces in the right-of-way.
    - Disregard red curbs and have even painted over red curbs to appear gray.
    - Park in private off-street commercial parking lots without permission, and their customers also utilize private off-street lots that prevent patrons of those commercial centers to park.
- Merchants in commercial centers are afraid to tow vehicles from their parking lots because they are afraid of retaliation from the vehicle owners.
    - Similar sentiment in residential areas.
- Street/sidewalk vendors are an issue for merchants across the community.

  - Their patrons often utilize private parking lots that prevent customers of those businesses from parking there.
  - Merchants/owners of private lots often must clean up after the street vendors and their customers.
- There is a broad sentiment that the parking issues are hurting the local East LA economy.
- There are several County-owned lots throughout the community, some merchants see these as an opportunity to improve parking conditions.
- Concerns expressed over a state bill that would allow garage conversions into living space without requiring any parking.

Online Survey

In light of the Covid-19 restrictions during the community outreach phase, a key tool for obtaining feedback was the online survey. The survey launched on September 10, 2020 and lasted through October 10, 2020. The survey was promoted during all outreach efforts and based on the amount of responses; the marketing efforts were successful. The number of responses needed for a statistically significant[7] survey sample size given the population of East LA is 384.

In total, 628 people responded to the survey. Of those 575 were from residents, business owners, employers, and visitors of East LA. The other 53 were just outside of the unincorporated area boundaries and further into the general Los Angeles area. Because this effort is solely about East LA, the subsequent analysis includes only the responses within East LA. Table 7 shows a summary of the online survey responses.

Table 7: Number of Online Survey Respondents

LANGUAGE	IN EAST L.A.†	OUT OF AREA‡	TOTAL
English	560	53	613
Spanish	15	0	15
Totals	575	53	628

Notes:

† Category includes all respondents who live, own a business, work, shop or dine, study, visit friends, or have medical appointments in East Los Angeles.

‡ Category includes all respondents who indicated that they live in East Los Angeles but provided location data that indicate they live outside the study area.

Source: Walker Consultants, 2020.

As shown in Table 7, of the 575 East LA survey respondents, 560 took the survey in English and 15 took the survey in Spanish.

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[7] Confidence level of 95% and 5% Margin of Error.

In an effort to capture input from residents, business owners, employees, and visitors of East LA, the survey was divided into four sections:

1. One for residents
2. One for business owners
3. One for employees
4. One for shoppers, diners, students, visitors, and patients.

If respondents identified with more than one of the sections described above, they could take the survey again for as many sections as applied to them.

Table 8 shows the breakdown of respondents by section (affiliation).

Table 8: Summary of East LA Survey Respondents by Affiliation

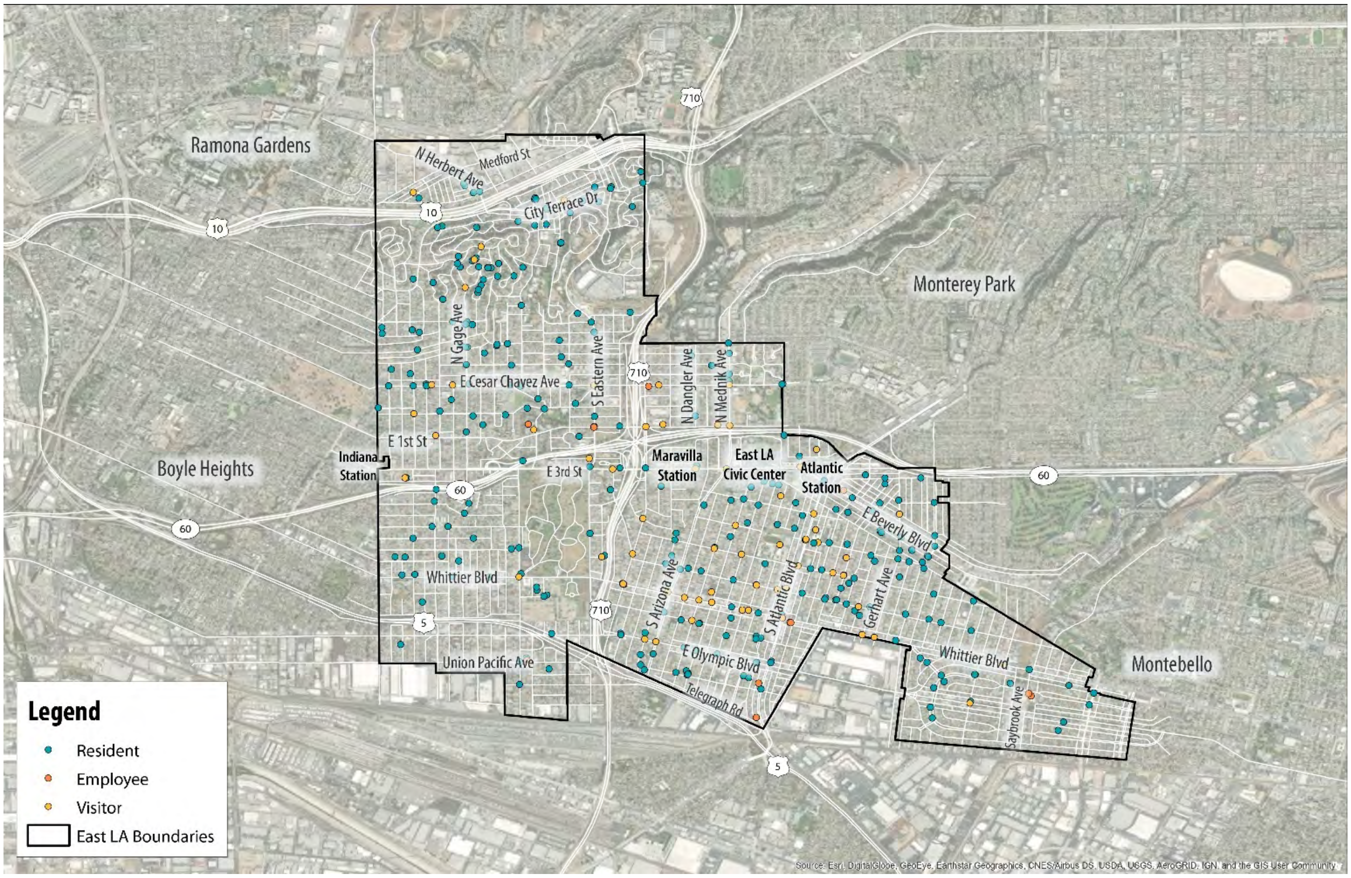
SURVEY SECTION	AFFLIATION	TOTAL ENG	ESP	ALL	%
1	I live in East LA	458	12	470	82%
2	I own a business in East LA	3		3	1%
3	I work in East LA	29	2	31	5%
4	I shop/dine in East LA	23		23	4%
	I study in East LA	3		3	1%
	I visit friends and family in East LA	43	1	44	8%
	I have medical appointments in East LA	1		1	0%
		560	15	575	100%

Source: Walker Consultants, 2020.

As shown in Table 8, the majority (82%) of respondents identify as residents of East LA. The other respondents were visitors/shoppers/diners/students (13%), employees (5%), and business owners (1%).

In each section of the survey respondents were asked to provide their address or closest cross streets to indicate the locations of their parking concerns. Figure 20 shows the geographic locations of the areas of parking concern of survey respondents.

Figure 20: Geographic Locations of Respondent's Parking Concerns



Source: Walker Consultants, 2020.

As shown in Figure 20, much like the parking issues observed in the field and the comments made during the public meetings, there are parking issues across the whole of East LA. The spread of the map indicates that parking issues are not concentrated in any one area, but occur throughout the community.

Findings from Residential Responses (Section 1)

The following highlights the results from the online survey that pertain to residential respondents.

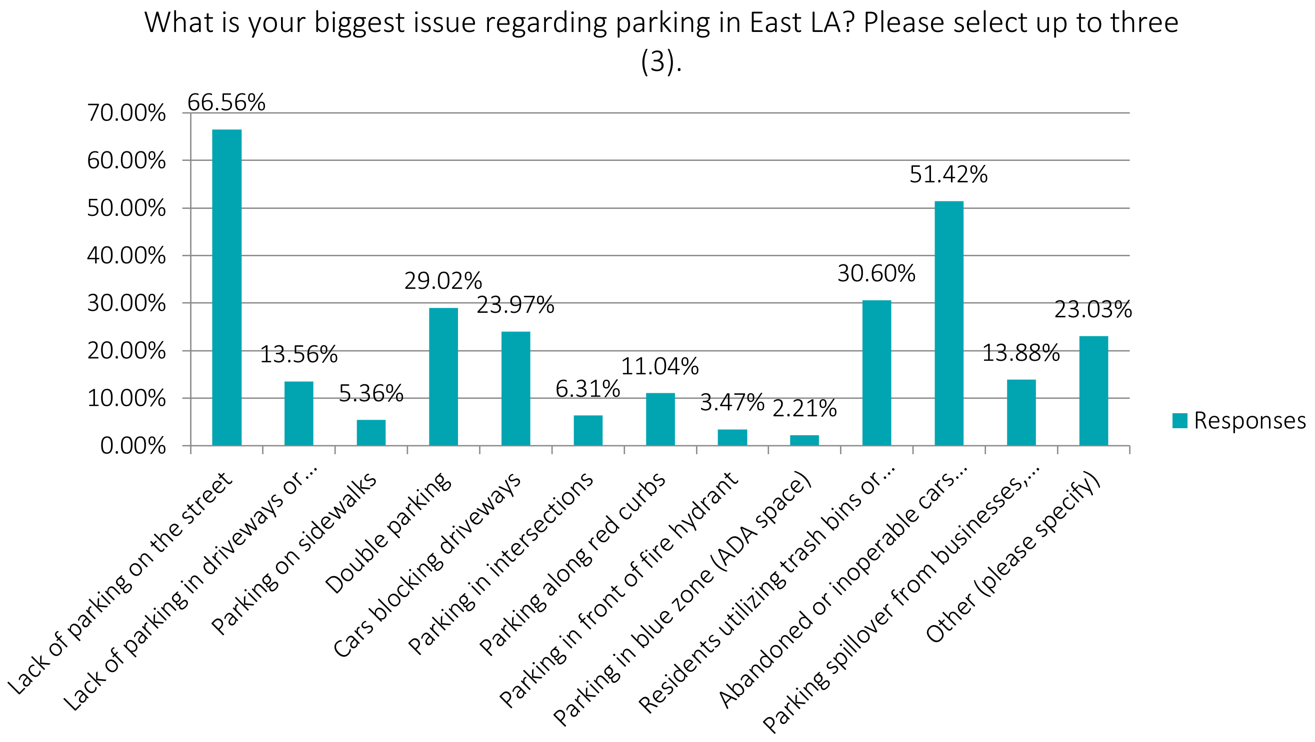
Top Three (3) Parking Issues for Residents

When asked to rank and/or list the top three parking issues in East LA, residents selected:

1. Lack of parking on the street (66.56%)
2. Abandoned or inoperable vehicles (51.42%)
3. Residents utilizing trash bins or other measures to ‘reserve’ parking on the street (30.60%)

Within the “Other (please specify)” category, common themes were:

- Zoning enforcement -- businesses being run out of private homes and generating parking demand.
- Inadequate parking enforcement
- Housing policy concerns including density leading to too many cars for too many spaces, safety concerns because of homelessness, and RVs taking up parking spaces.
- People owning excess vehicles and parking them on the street.



Most Difficult Day/Time to Find Parking

When asked what days and times are the most difficult to find parking, respondents answered:

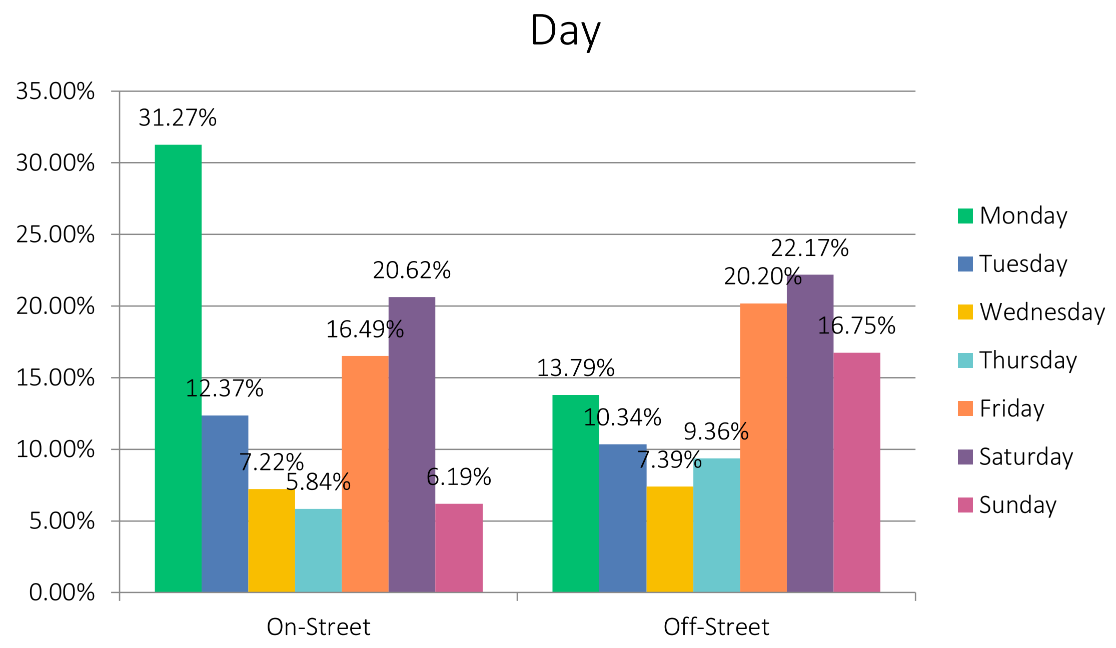
Day

On-Street:

1. Monday (31.27%)
2. Saturday (20.62%)
3. Friday (16.49%)

Off-Street:

1. Saturday (22.17%)
2. Friday (20.20%)
3. Sunday (16.75%)



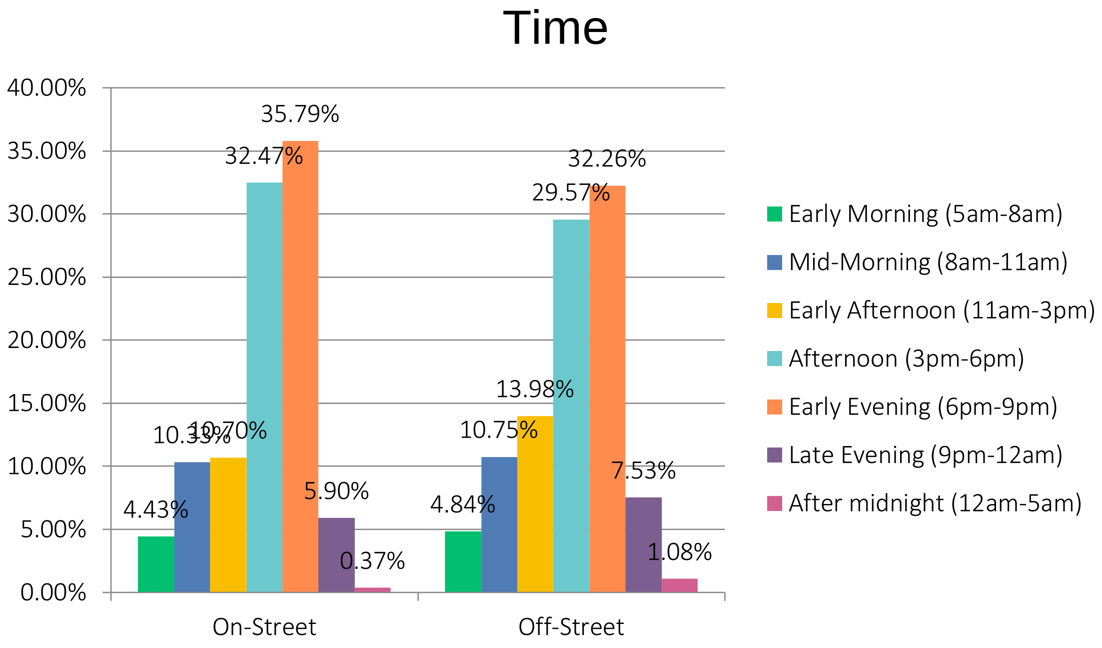
Time

On-Street:

1. Early Evening 6-9:00pm (35.79%)
2. Afternoon 3-6:00pm (32.47%)
3. Early Afternoon 11am-3:00pm (10.70%)

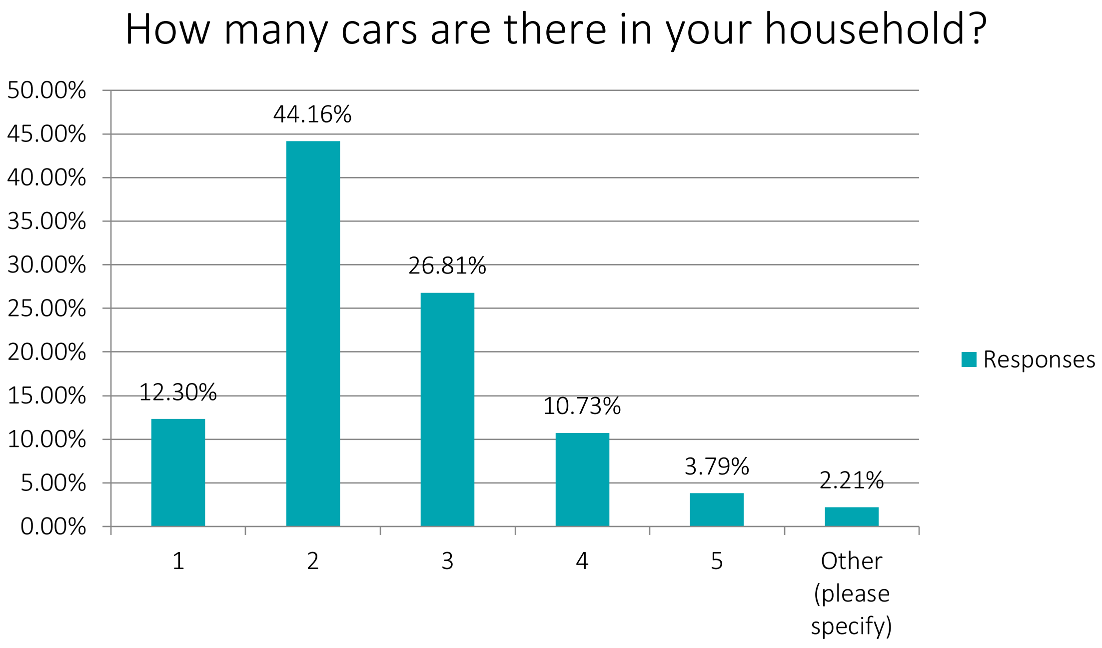
Off-Street:

1. Early Evening 6-9:00pm (32.26%)
2. Afternoon 3-6:00pm (29.57%)
3. Early Afternoon 11am-3:00pm (13.98%)



Number of Vehicles in the Household

Regarding the number of vehicles in the household, 44.16% of respondents said they owned two (2) cars, 26.81% said three (3) cars, and 12.30% said they owned one (1) car. Within the "Other (please specify)" category, three respondents said they own six (6) cars, and one respondent nine (9) cars.

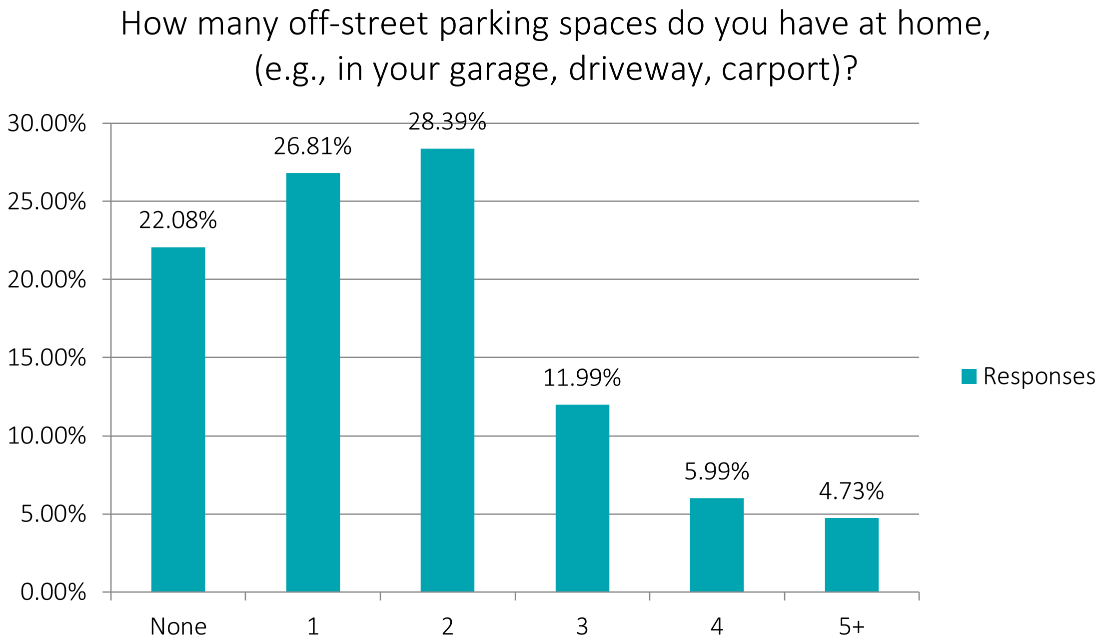


Parking Supply at Home

When asked about the number of off-street spaces that they have at home, residents answered:

1. 2 spaces (28.39%)
2. 1 space (26.81%)
3. None (22.08%)

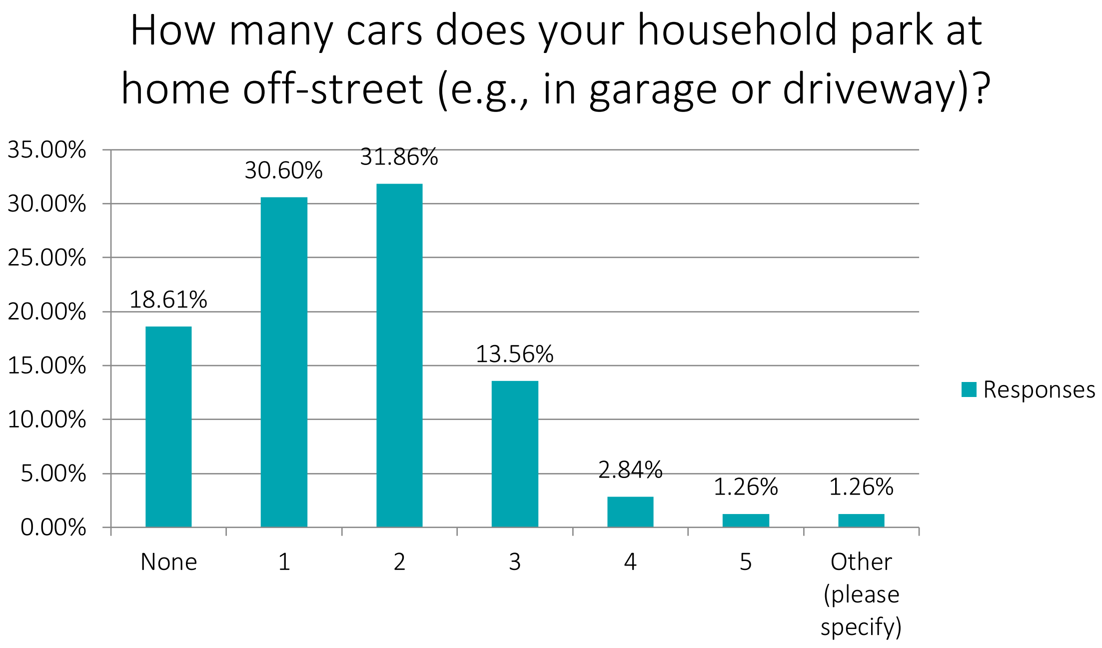
The results show that 77.92% of respondents have at least one (1) off-street parking space at home, while 22.08% have none (0).



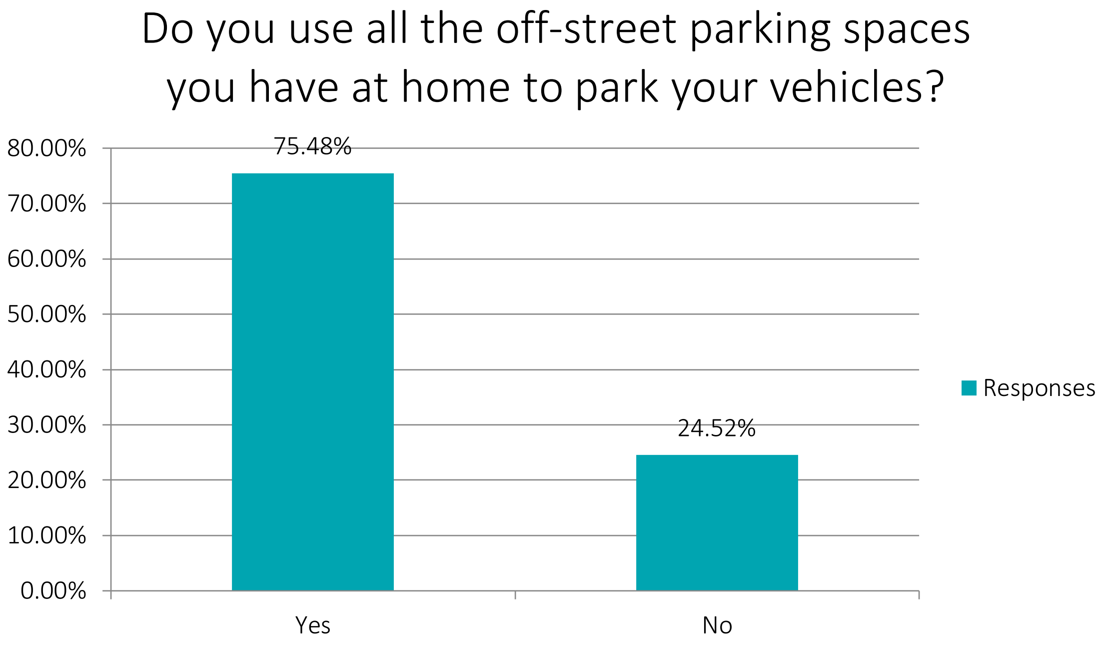
Parking Utilization

When asked how many cars they park off-street at home, residents responded:

1. 2 (31.86%)
2. 1 (30.60%)
3. None (18.61%)
4. 3 (13.6%)
5. 4 (2.84%)
6. 5+ (1.86%)

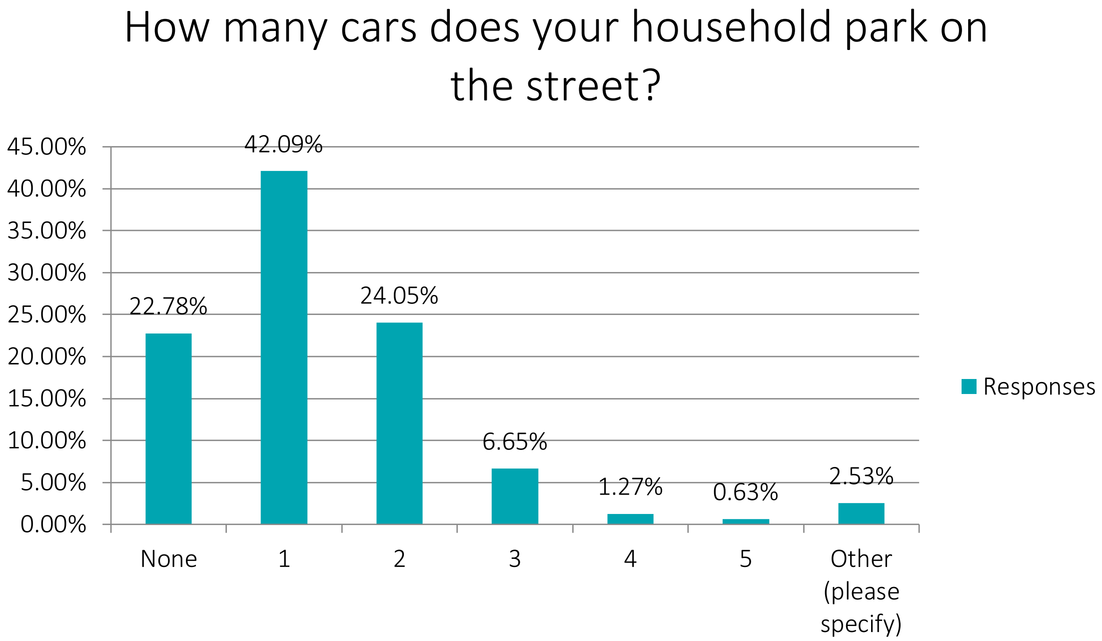


When asked if they use all the off-street spaces they have at home, 75.48% of respondents said yes, and 24.52% said no.



When asked about the number of cars residents park on the street, respondents said:

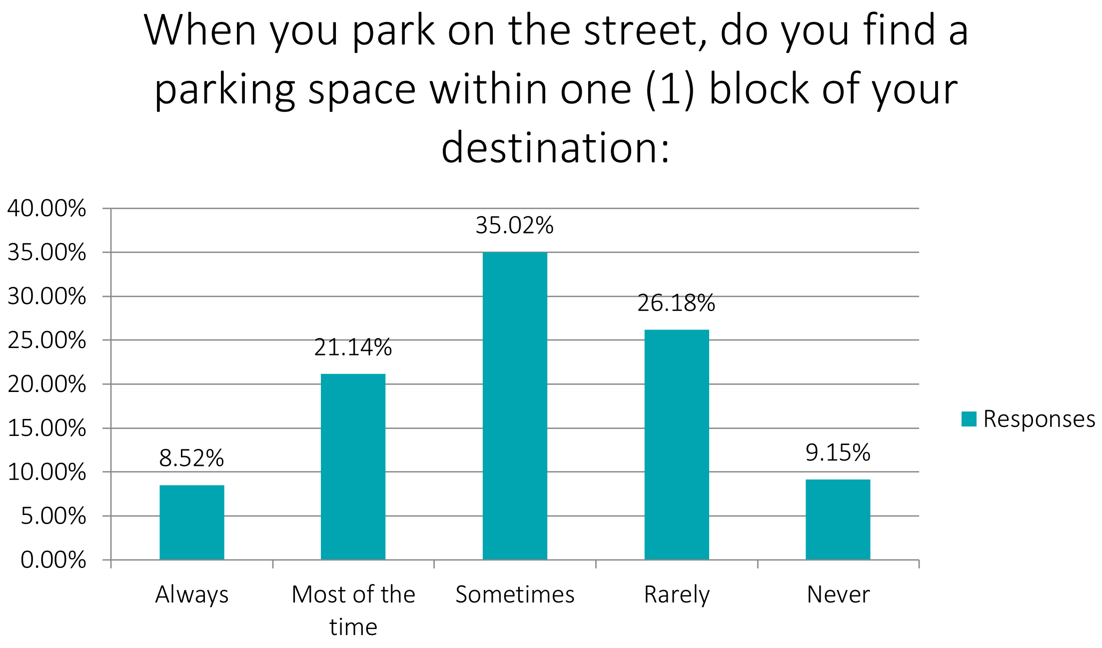
1. 1 (42.09%)
2. 2 (24.05%)
3. None (22.78%)



When asked about the frequency with which residents could find on-street parking within one (1) block of their homes, respondents said:

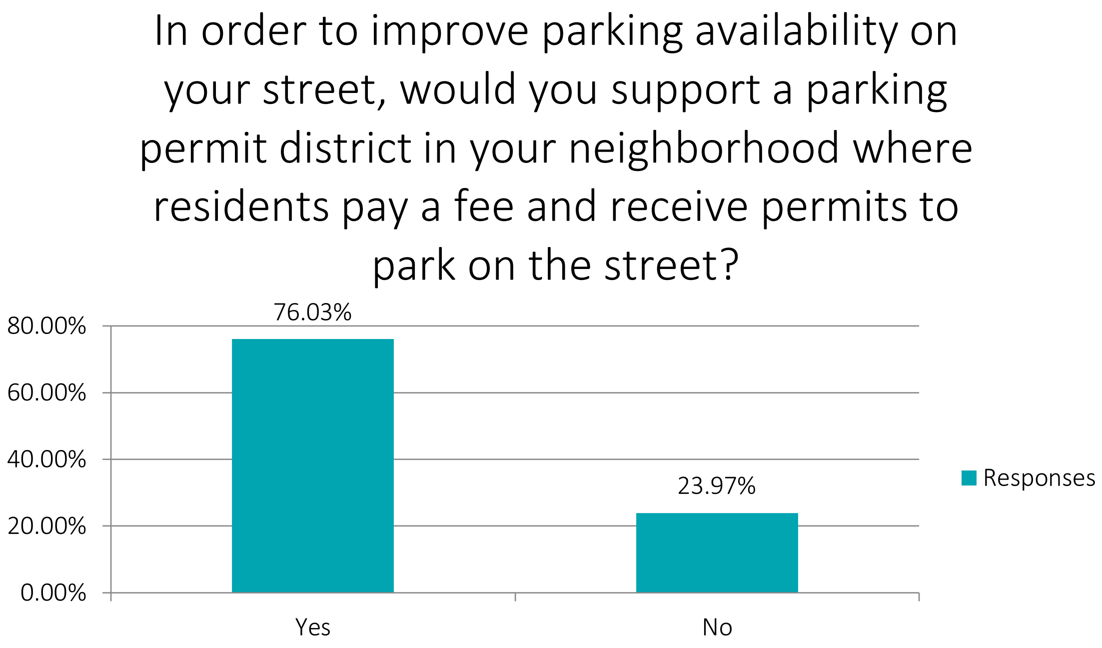
1. Sometimes (35.02%)
2. Rarely (26.19%)
3. Most of the time (21.14%)
4. Never (9.15%)
5. Always (8.52%)

In looking at the results of this question, the answers skew toward it being less frequent that residents could find an on-street parking space within one (1) block of their residence.



Parking Permits

When asked about whether residents would support a permit district in their neighborhood, that required a fee, but would improve parking availability, 76.03% of respondents said they would while 23.97% said they would not.

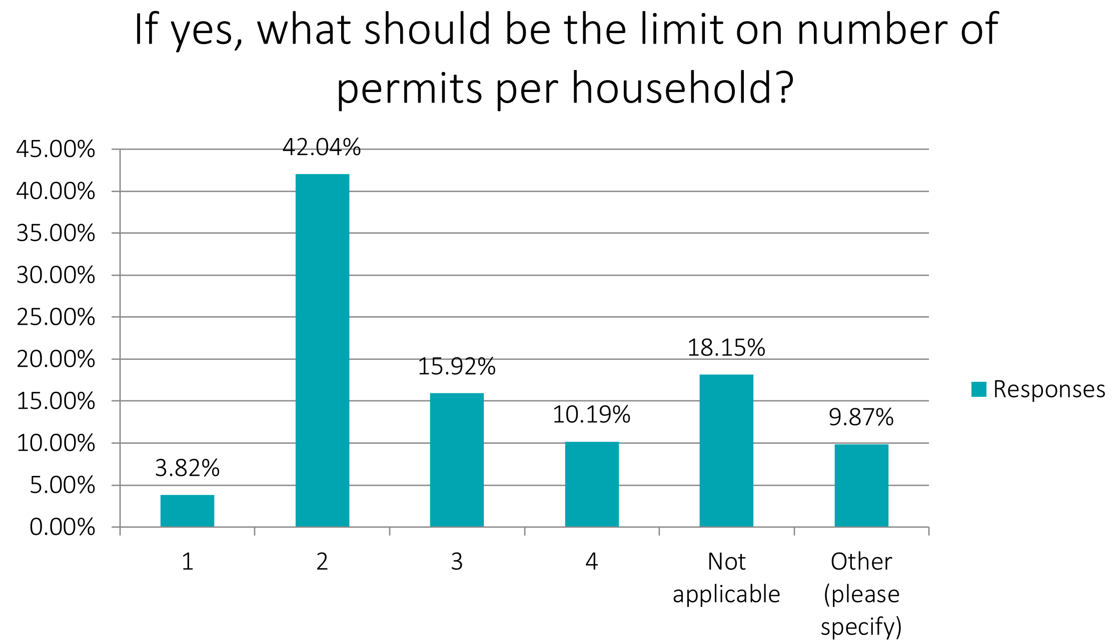


When asked about what the limit should be on number of permits issues per household, respondents provided the following:

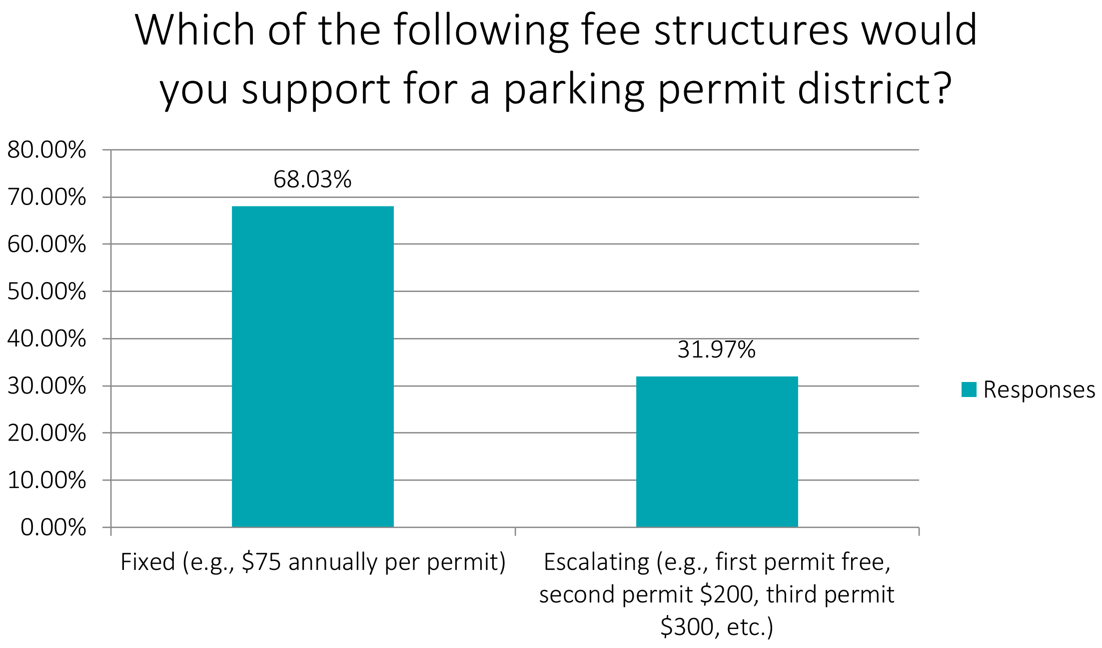
1. 2 (42.04%)
2. N/A (18.15%)
3. 3 (15.92%)

Within the "Other (please specify)" category common themes were:

- Of the 31 free responses, 12, or about 40%, want permits issued to individual drivers or cars.
- More than half would prefer permits issued by household or by size of household or number of residents.
- Almost ten percent oppose a parking permit program.

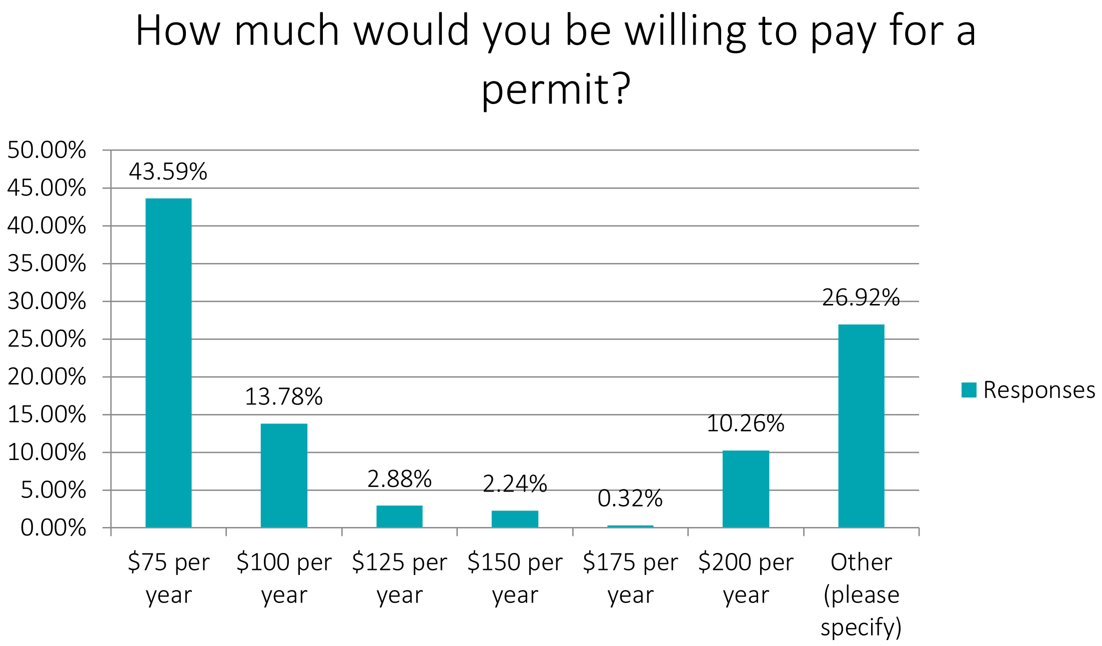


A follow-up question to residents was whether they preferred a fixed rate or variable rate for permits. The results indicate a preference for fixed permit rates.



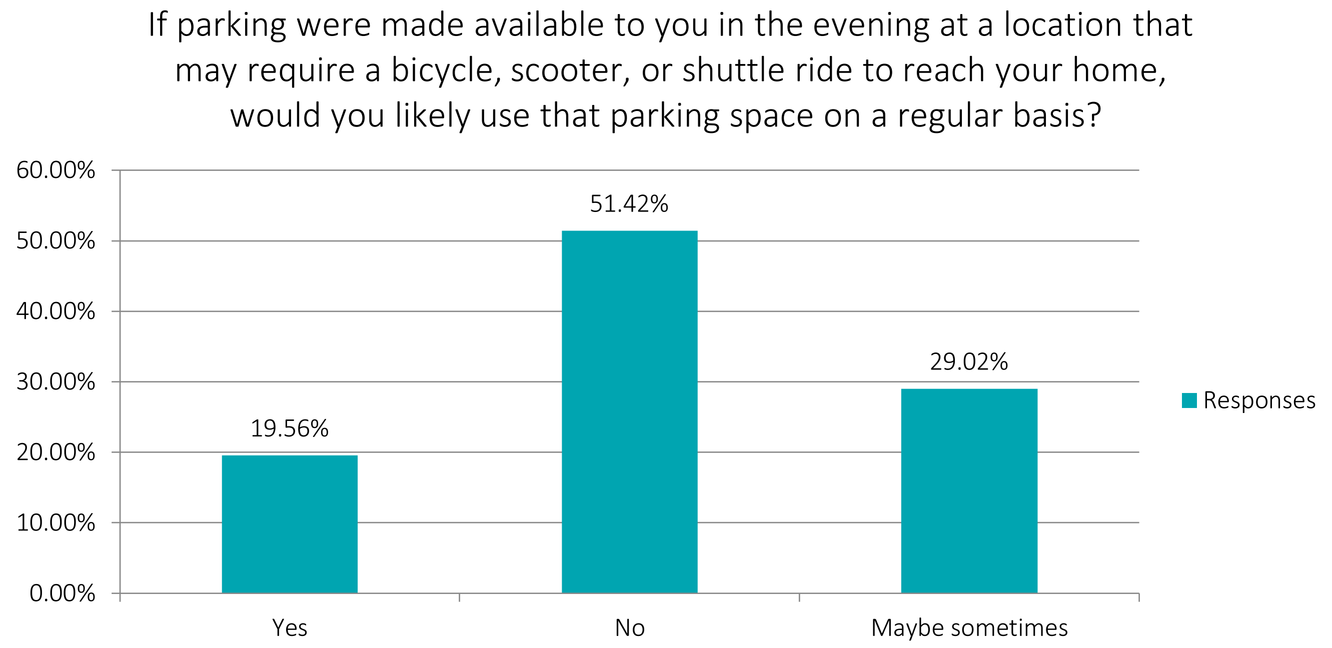
Respondents were then asked how much they would be willing to pay annually for a permit. The results show that 73% are willing to pay at least $75 per year. Within the "Other (please specify)" category, respondents said:

- Not willing to pay a fee
- Willing to pay: $20, $24, $25, $30, $35, $50, $80
- Should be a sliding scale for senior citizens, low income residents.
- Consider offering a number of permits free.

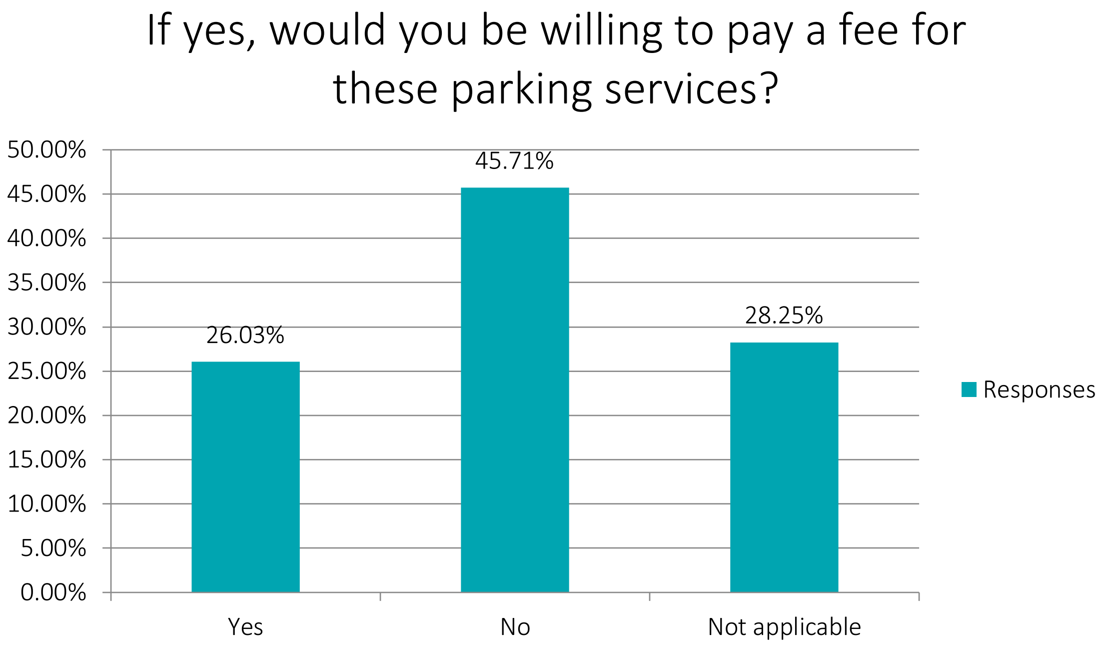


Remote Parking Option

Respondents were asked how likely they would use remote parking on a regular basis if it were made available to them. Most (51.42%) respondents said that they would not use remote parking, while 29.02% said they may sometimes.

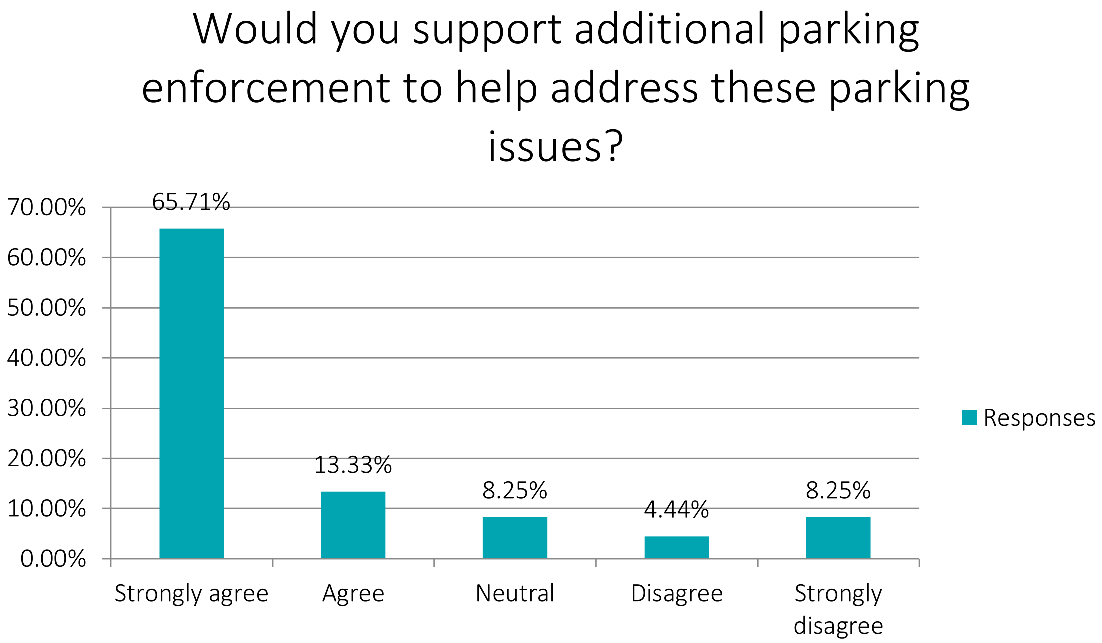


As a follow-up question, respondents were asked if they would be willing to pay for this parking and transport services. The results indicate that many (45.71%) would not, but 26.03% would.



Increased Parking Enforcement

Given the concerns centering around parking enforcement, respondents were asked if they would support increased enforcement to help address the parking issues that they experience. The results show that residents strongly support more enforcement.



Findings from Employee Responses (Section 3)

The following highlights the results from the online survey that pertain to employee respondents.

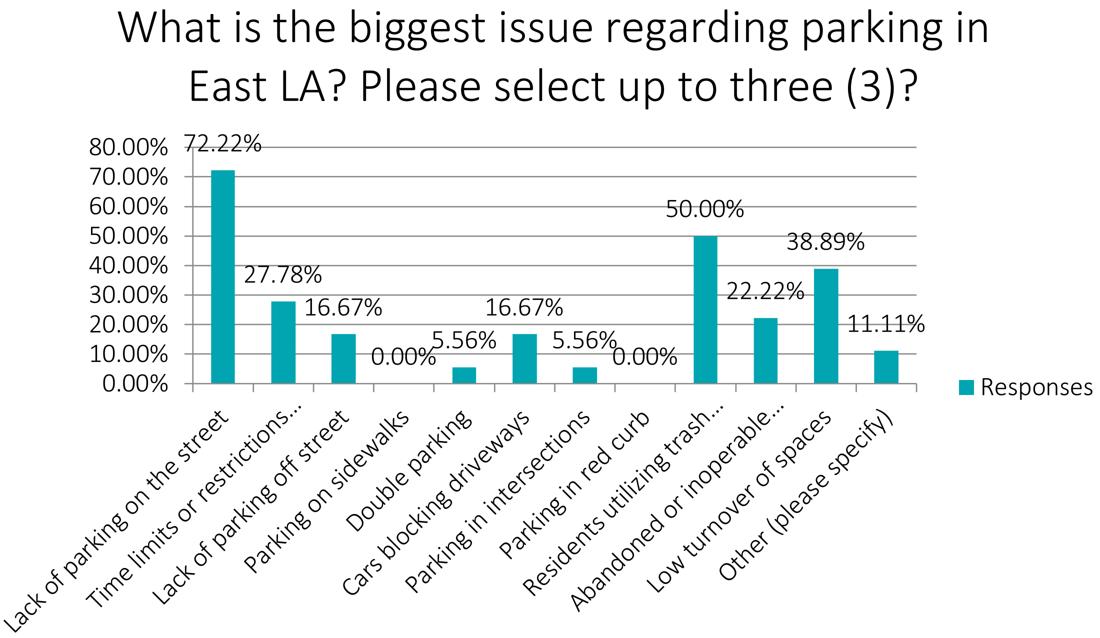
Top Three (3) Parking Issues for Employees

When asked to rank and/or list the top three parking issues in East LA, employees selected:

1. Lack of parking on-street (72.22%)
2. Residents utilizing trash bins or other measures to ‘reserve’ parking on the street (50.00%)
3. Low turnover of spaces (38.89%)

Within the “Other (please specify)” category, common themes were:

- Lack of available ADA parking, lack of safe sidewalks, lack of enforcement for ADA violations
- Lack of parking on street sweeping days



Most Difficult Day/Time to Find Parking

When asked what days and times are the most difficult to find parking, employee respondents answered:

Day

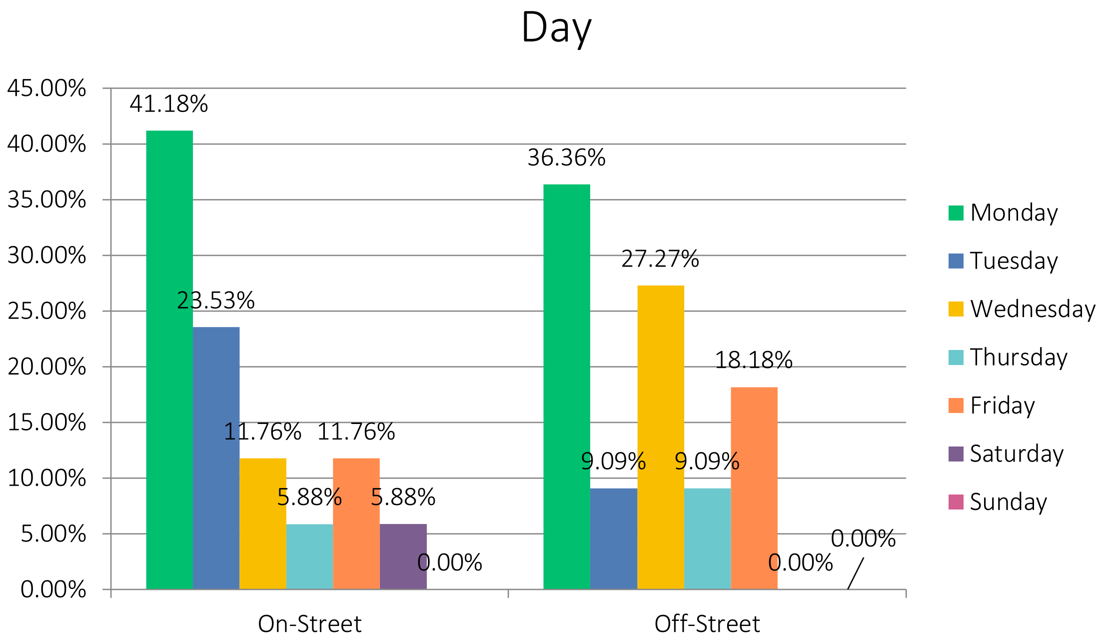
On-Street:

1. Monday (41.18%)
2. Tuesday (23.53%)

3. Wednesday and Friday (11.76%)

Off-Street:

1. Monday (36.36%)
2. Wednesday (27.27%)
3. Friday (18.18%)



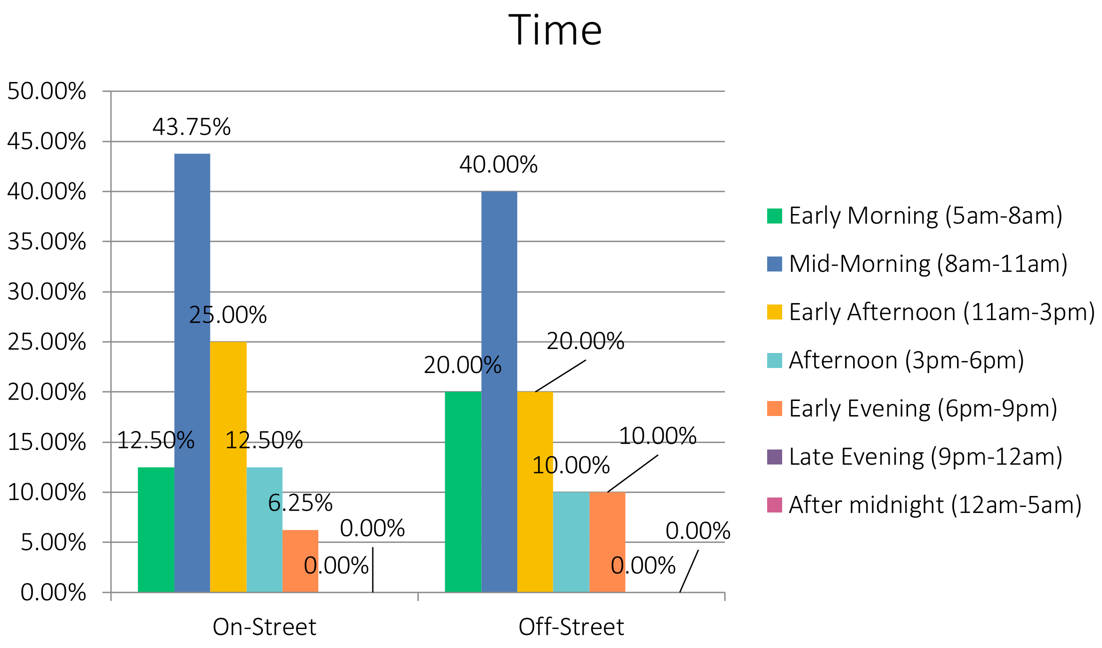
Time

On-Street:

1. Mid-Morning 8-11:00am (43.75%)
2. Early Afternoon 11am-3:00pm (25.00%)
3. Early Morning and Afternoon (12.50%)

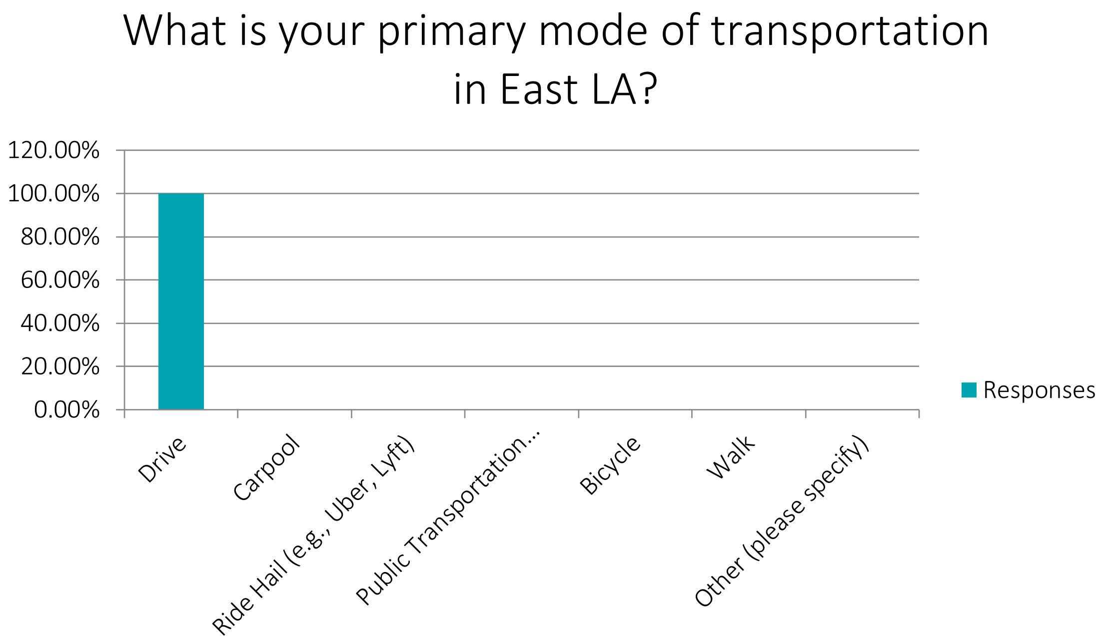
Off-Street:

1. Mid-Morning 8-11:00am (40.00%)
2. Early Morning and Early Afternoon (20.00%)
3. Afternoon and Early Evening (10.00%)



Commute Mode Split

When asked how they commute to work in East LA, 100.00% of respondents said they drive. While not uncommon to find most respondents drive, the 100% split may be explained by the fact that the survey was focused on parking, thus it was more likely that those that experience parking issues are also drivers.



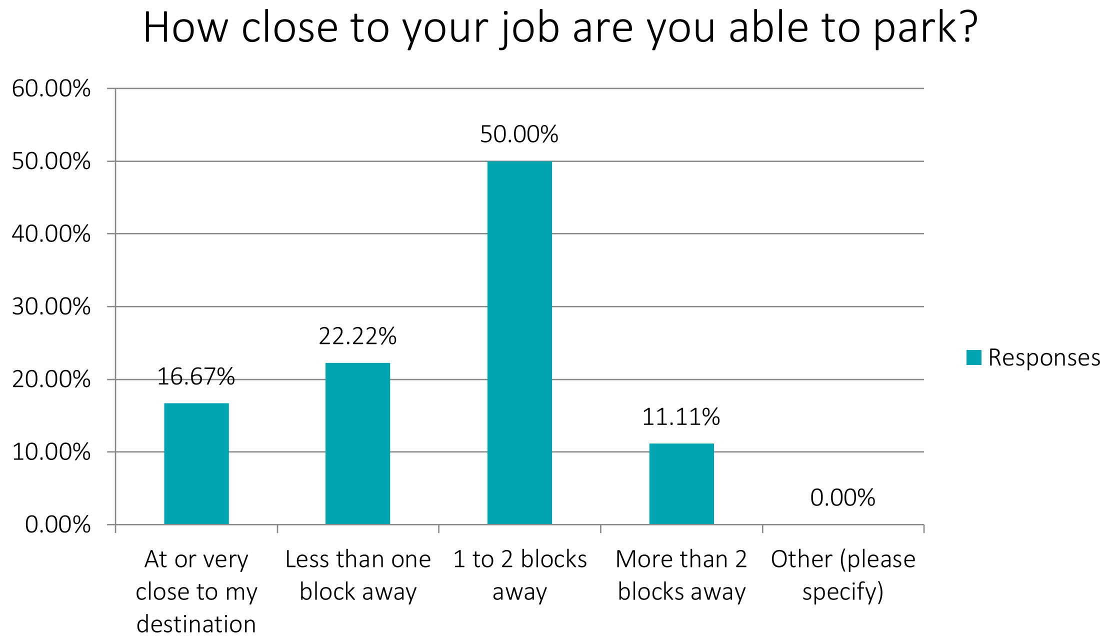
As a follow-up, respondents were asked if they commute by driving, where do they park. Common themes from the responses were:

- On the street
    - Sometimes in residential area
    - Sometimes blocks away from work
- Onsite, if the parking lot is not full
- On a family member's driveway

Proximity of Parking to Workplace

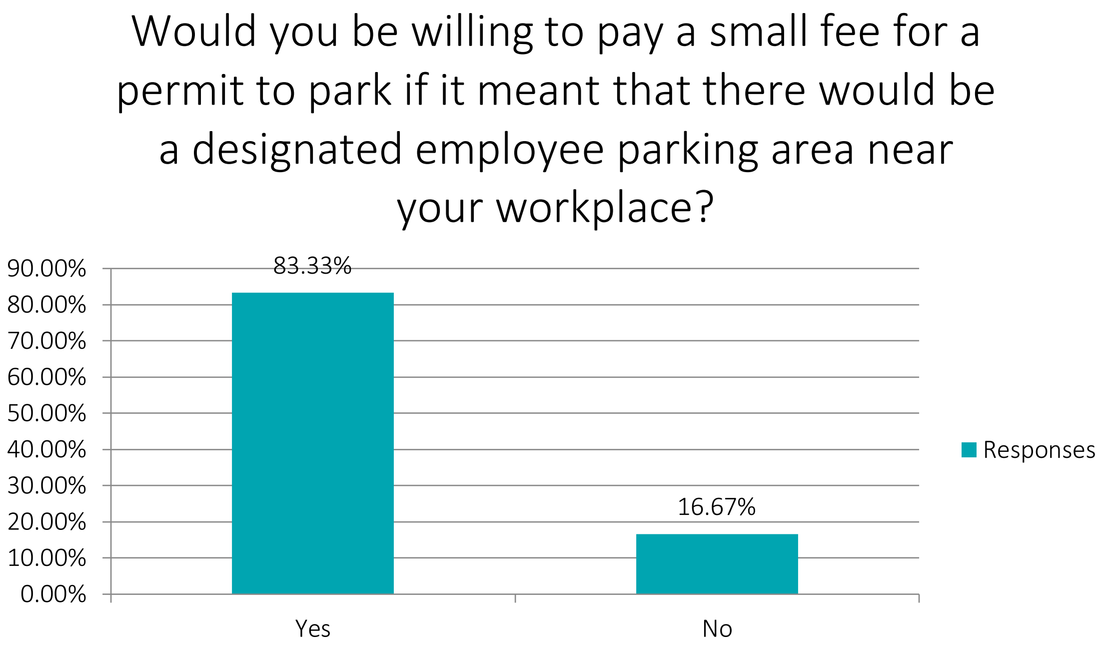
When asked about the proximity of available parking at or near their place of work, respondents said that they can find parking:

1. 1 to 2 blocks away (50.00%)
2. Less than 1 block away (22.22%)
3. At or very close to destination (16.67%)



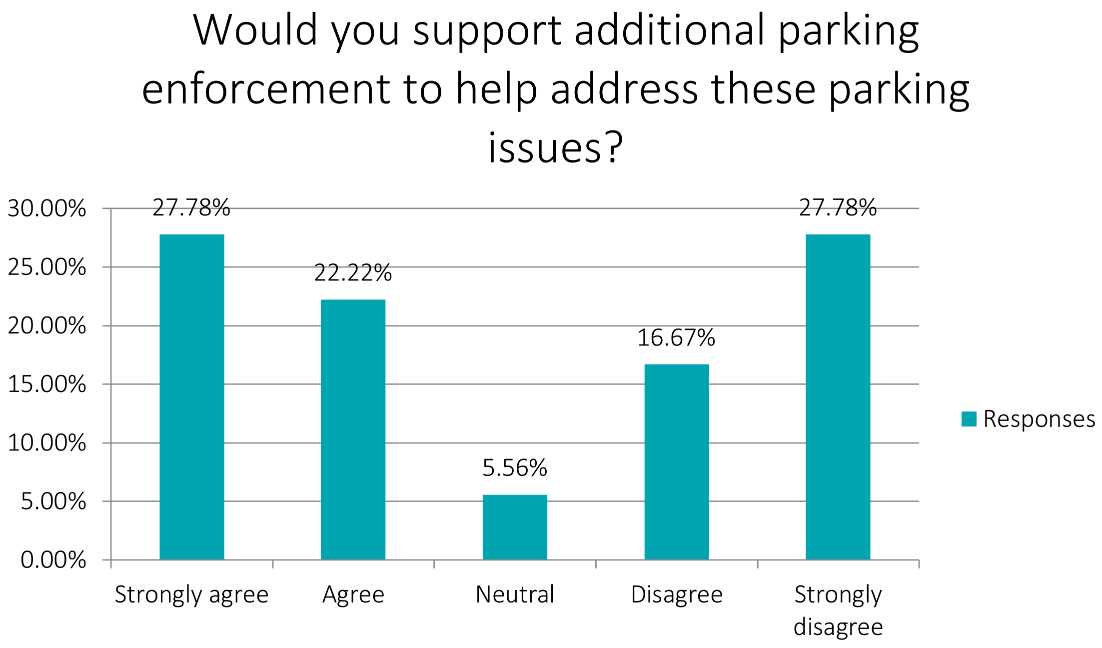
Parking Permits

When asked about whether employees would support a permit district that required a fee, if it meant they would have a designated place to park near work, 83.33% of respondents said they would and 16.67% said they would not. The results show that employees are willing to pay a fee for permits, if it meant that parking would be more readily available near their place of work.



Increased Parking Enforcement

Given the general complaints around enforcement in East LA, respondents were asked if they would support increased enforcement to help address the parking issues that they experience. The results show that employees are split on this question. The results indicate that while some employees would want enforcement to try and address the availability issue on the street, others have probably been affected by citations, likely street sweeping, since many of them park in residential streets.



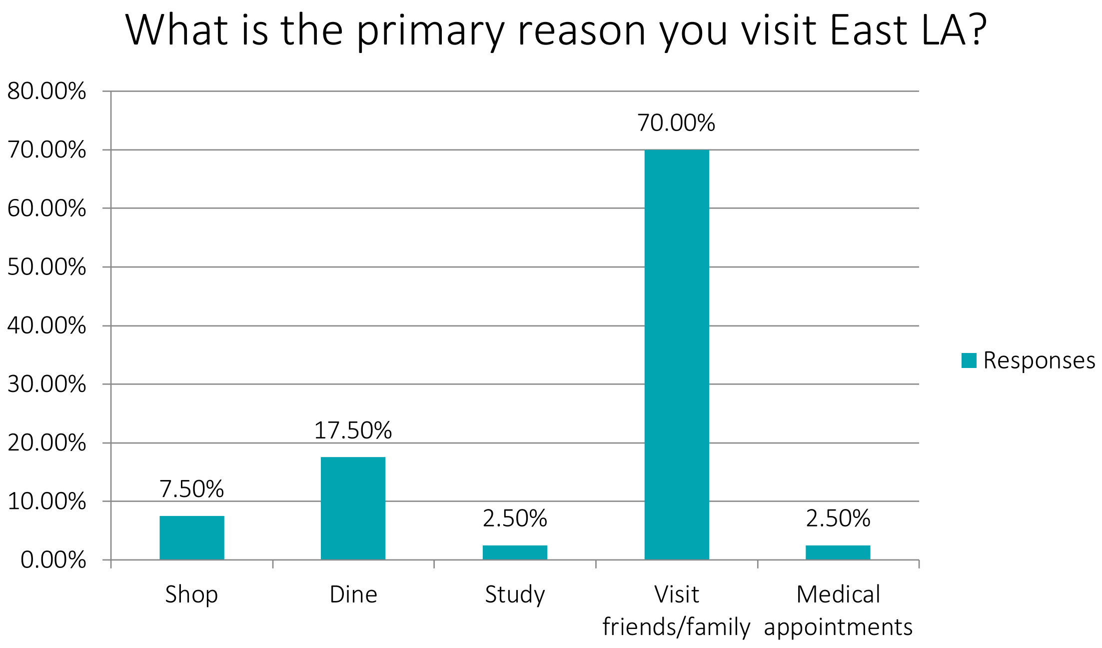
Findings from Visitor Responses (Section 4)

The following highlights the results from the online survey that pertain to visitors of East LA.

Primary Reason for Visiting East LA

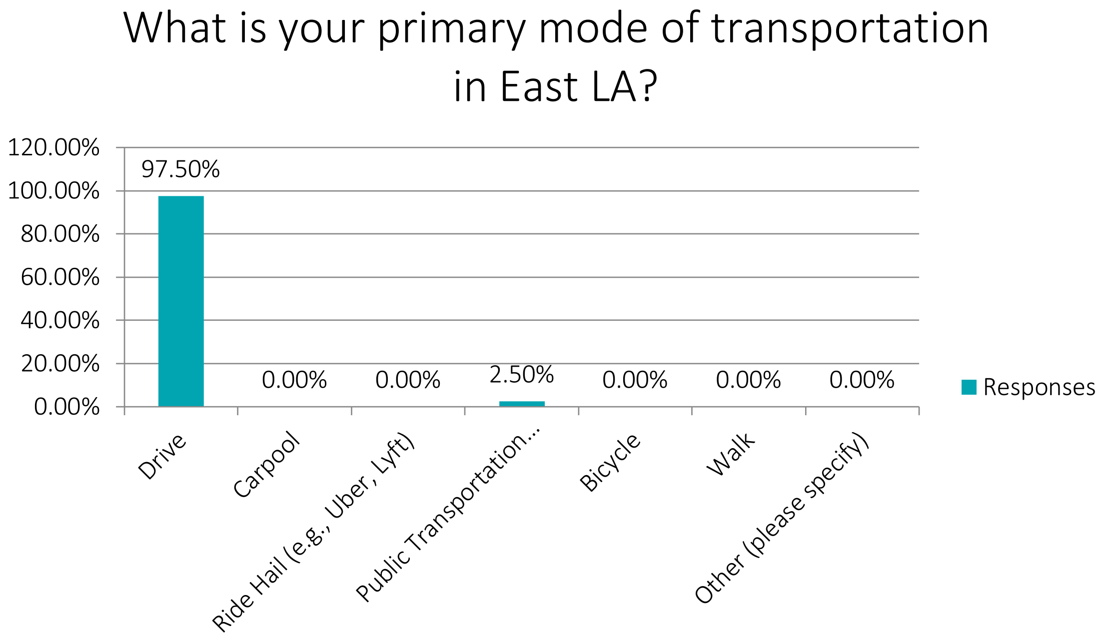
When asked about the main reason they visit East LA, respondents said:

1. Visit friends/family (70.00%)
2. Dine (17.50%)
3. Shop (7.50%)



Transportation Mode Split

When asked how they travel to East LA, 97.50% of respondents said they drive, and 2.50% said they take public transportation.



Top Three (3) Parking Issues for Visitors

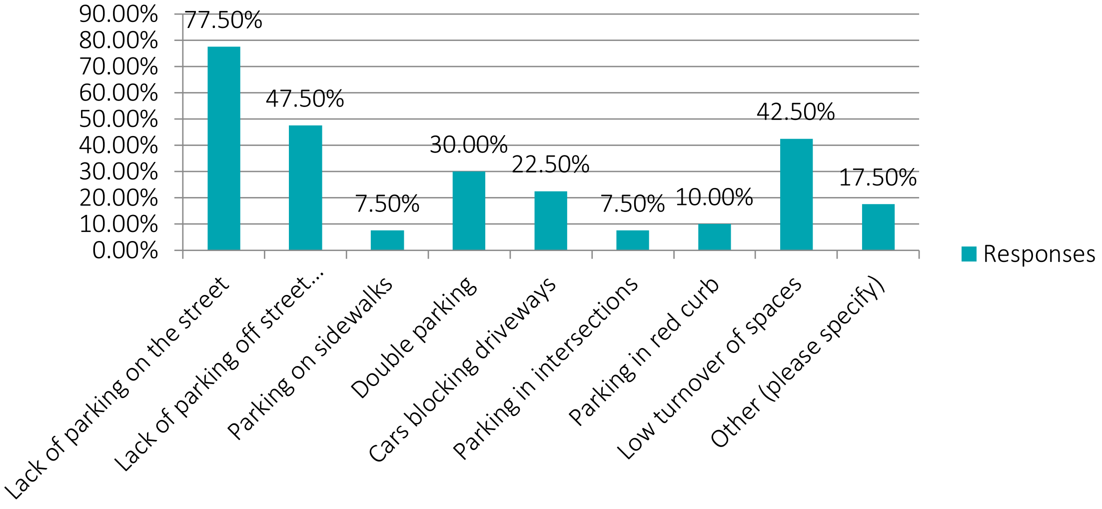
When asked to rank and/or list the top three parking issues in East LA, visitors selected:

1. Lack of parking on-street (77.50%)
2. Lack of off-street parking (47.50%)
3. Low turnover of spaces (42.50%)

Within the “Other (please specify)” category, common themes were:

- Spillover from transit users
- Underutilization of driveways
- Multi-vehicle ownership
- Oversized vehicle parking congestion
- Parking vehicles inefficiently to ‘reserve’ parking

What is the biggest issue regarding parking in East LA? Please select up to three (3)?



Most Difficult Day/Time to Find Parking

When asked what days and times are the most difficult to find parking, visitor respondents answered:

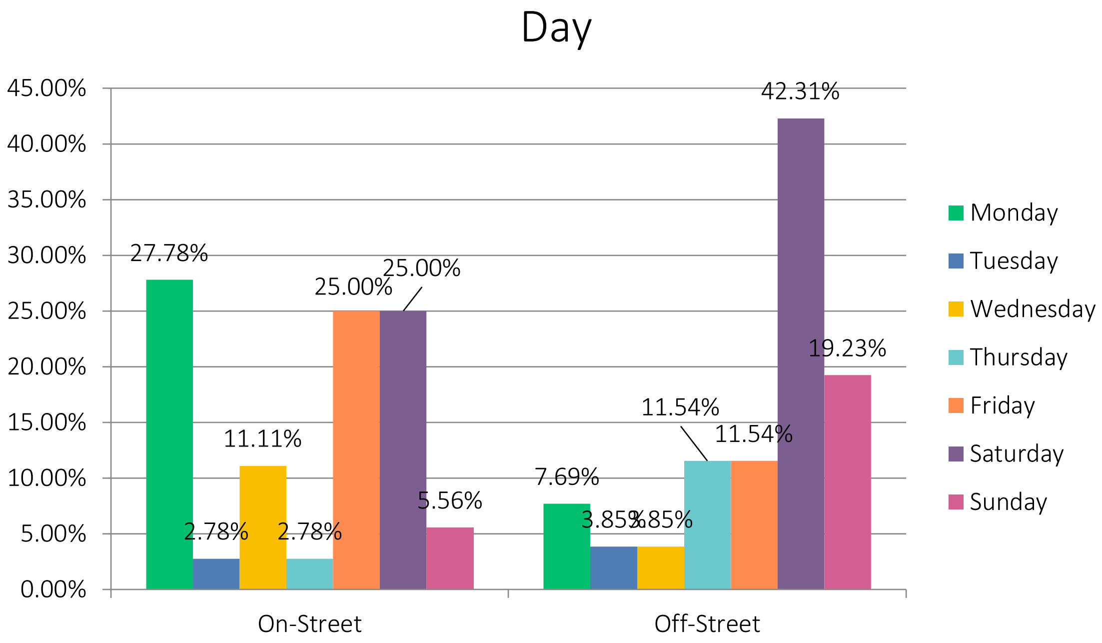
Day

On-Street:

1. Monday (27.78%)
2. Friday and Saturday (25.00%)
3. Wednesday (11.11%)

Off-Street:

1. Saturday (42.31%)
2. Sunday (19.23%)
3. Thursday and Friday (11.54%)



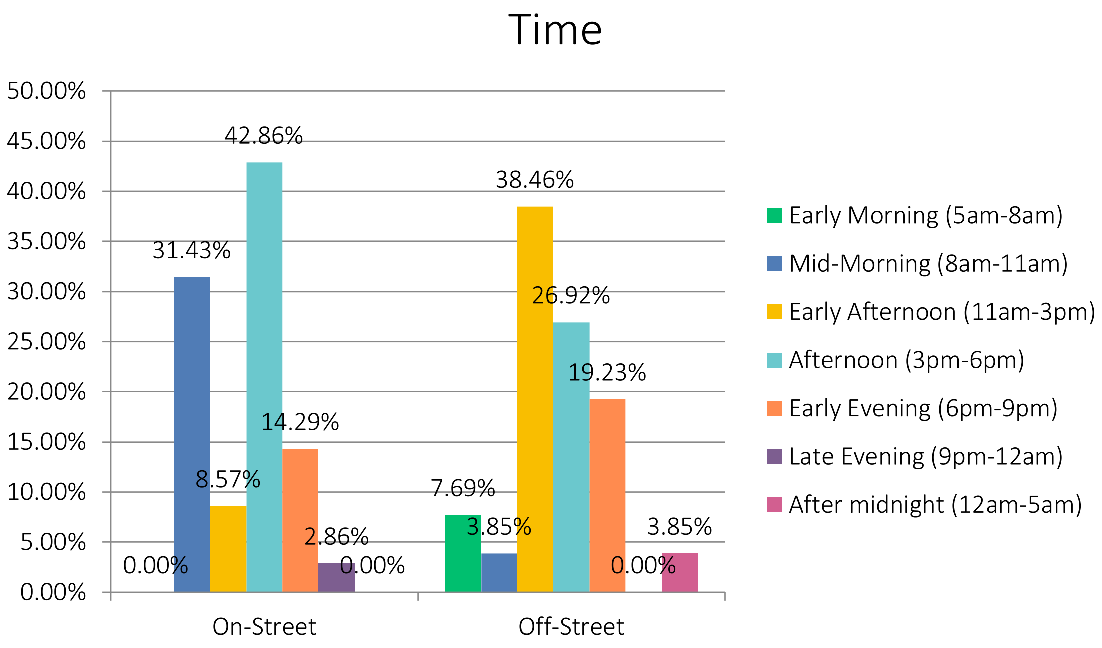
Time

On-Street:

1. Afternoon 3-6:00pm (42.86%)
2. Mid-Morning 8-11:00am (31.43%)
3. Early Evening 6-9:00pm (14.29%)

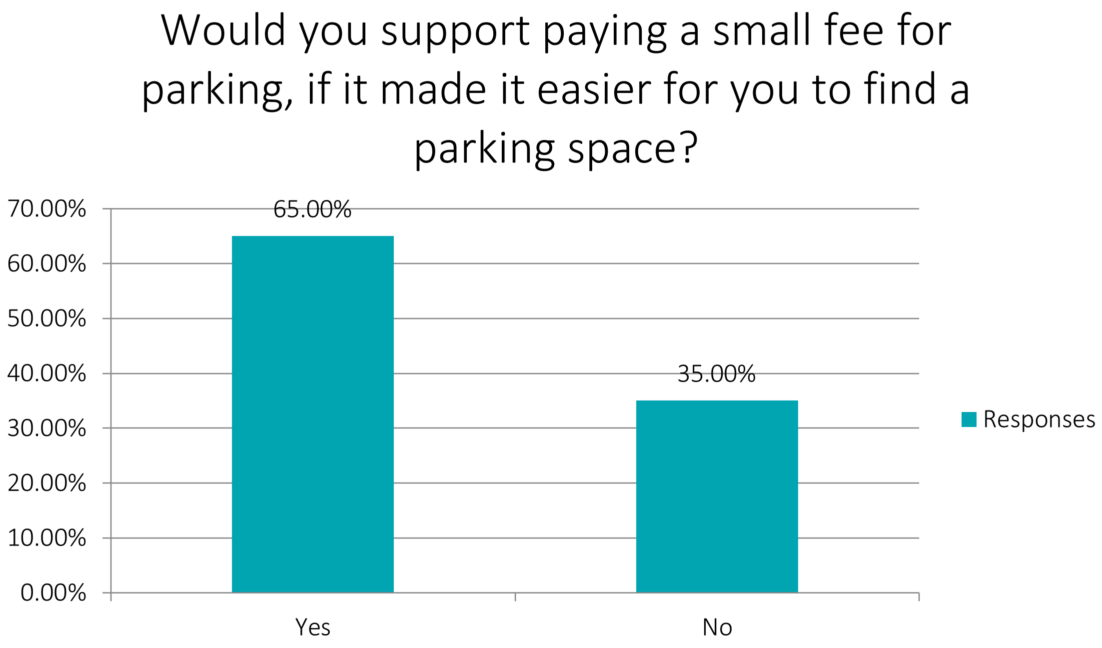
Off-Street:

1. Early Afternoon 11am-3:00pm (38.46%)
2. Afternoon 3-6:00pm (26.92%)
3. Early Evening 6-9:00pm (19.23%)



Paid Parking

When asked about whether visitors would support paid parking if it made it easier to find parking, 65.00% of respondents said yes, and 35.00% of respondents said no.

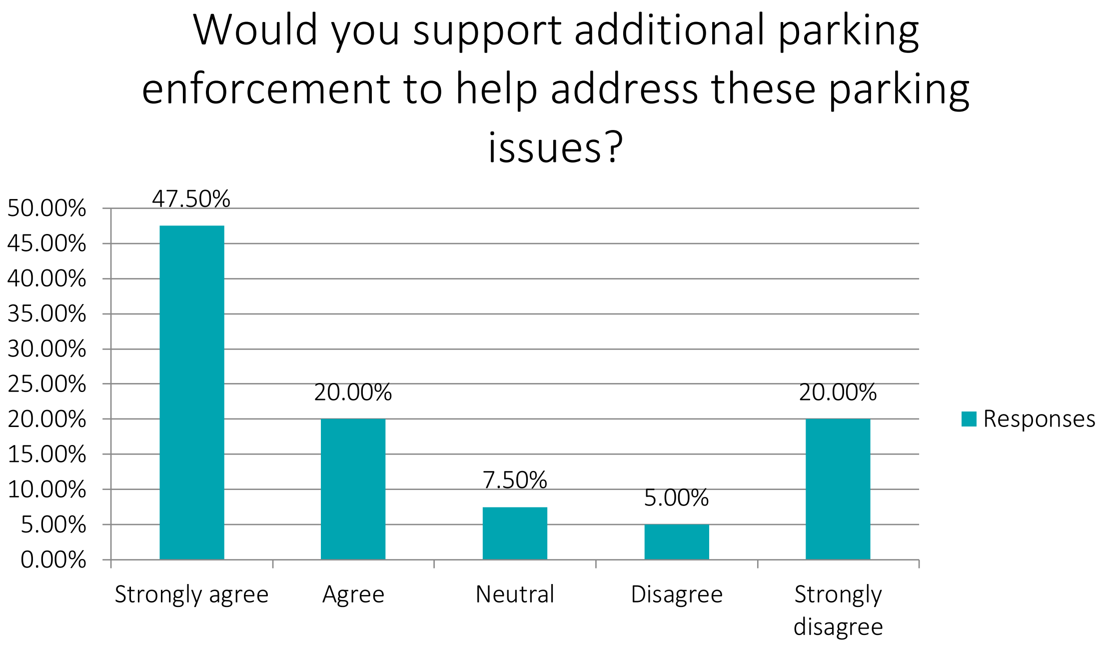


Increased Parking Enforcement

When asked about whether visitors would support additional parking enforcement to help address parking issues, respondents said:

1. Strongly Agree (47.50%)
2. Agree and Strongly Disagree (20.00%)
3. Neutral (7.50%)
4. Disagree (5.00%)

Most visitors, 67.50% of respondents, said that they would support increased enforcement if it meant that there would be more available parking.



Summary of Key Findings from the Online Survey

The response to the online survey has provided much insight into the parking issues experienced by community members of all types. Below is a quick summary of the highlights gleaned from the various East LA parking user groups.

Residents

Residents accounted for the highest number of respondents to the survey with 470. Among the key findings from this group were:

- Lack of on-street parking was the most common parking issue for East LA residents.

- Monday is the most difficult day to find on-street parking, while Saturday is the most difficult day to find off-street parking.
- The early evening (6-9:00pm) is the most difficult time to find parking.
- Approximately (~) 78% of residents have at least one (1) off-street parking space at home.
- ~71% of residents own 2-3 cars per household.
- On average, East LA households own 2.48 cars.
- On average, East LA households have 1.67 off-street spaces at home. This means that on average, households own more cars than spaces.
- On average, East LA households park 1.55 cars off-street in their place of residence.
- When parking on the street:
    - ~35% of residents noted that they sometimes find parking within one block of their residence
    - ~26% say they rarely find parking within one block
    - ~21% say they find parking within one block of their residence most of the time.
- In terms of permits, ~76% are for residential permits while ~24% are opposed.
    - ~42% of respondents said that they support a limit of two (2) permits per household
    - ~68% expressed a preference for a fixed-rate permit system.
    - ~44% are willing to pay $75 annually per permit.
    - ~30% are willing to pay $100 and over per permit.
    - ~13% respondents are not willing to pay a fee for permits.
    - ~11% of respondents are willing to pay between $15-$50 annually per permit.
- Just over half of respondents are unwilling to use parking on a regular basis if it were offered in a remote location during evenings.
    - ~29% would use remote parking sometimes, while ~20% would use it regularly.
    - ~46% would not be willing to pay for remote parking or transportation services, while 26% would.

Business Owners

While there were a handful of respondents that identified as business owners, some of them were located outside of unincorporated East LA, and thus their responses do not apply to the community's issues. The other respondents submitted partial responses and thus no additional analysis was possible. Still, the feedback from the community meetings and the focus group with the Chamber of Commerce helped provide some context regarding the issues that businesses face in East LA with respect to parking.

Employees

In total, 31 respondents whom are employed in East LA took the survey. Here is a summary of their responses:

- Like residents, the most common parking issue is lack of available on-street parking.
- Monday was noted as the most difficult day to find on and off-street parking.
- The mid-morning (8-11:00am) is the most difficult time for employees to find on and off-street parking. This aligns with the conventional peak commuting hours.
- 100% of employee respondents indicated that they drive to work.
    - They park in residential streets near work
    - They park onsite if their work's parking lot is not full
    - Sometimes have to park several blocks away from work.

- Half of all respondents indicated that they park 1-2 blocks away from their jobs.
    - ~39% park at or very close to their jobs, or less than one (1) block away
    - ~11% park more than two (2) blocks away from their place of employment.
- 83% of respondents said that they are willing to pay for a parking permit if it meant that they had a designated place to park near work.
- With respect to parking enforcement, respondents were split with approximately half of respondents for increased enforcement and half against.

Visitors

In total, 71 respondents whom identified as visitors to East LA took the survey. Here is a summary of their responses:

- The primary reason given by this group for visiting East LA is to visit friends and family. 70% of respondents selected this reason.
- With respect to the mode of travel that visitors use to get to East LA, 97.5% said that they drive, while 2.5% said that they use public transportation.
- The most common parking issue among visitors is the lack of on-street parking, followed by a lack of off-street parking, and low parking space turnover.
- Monday is the most difficult day to find parking on-street. Saturday is the most difficult day for this group to find available parking off-street.
- The afternoon (3-6:00pm) is the hardest time for this group to find on-street parking, and the early afternoon (11am-3:00pm) is the most difficult time to find off-street parking.
- With respect to paid parking, 65% of visitors would be willing to pay a fee for increased availability of parking, while 35% would not.
- When asked about increased enforcement, 67.5% of respondents were in support of increasing enforcement, 25% were against, and 7.5% were neutral.

Community Suggestions

Throughout the stakeholder engagement process, the community provided some possible solutions to the parking challenges that they experience in East Los Angeles. In the online survey, the solutions offered by the community fall into several categories, among them are:

- Enforcement, of parking policies and code enforcement (e.g., inspections)
- Infrastructure improvements
- Increased parking capacity
- Residential parking permits (RPP)
- Land Use, transportation, and housing policies
- Education and incentives

Within those categories, community members offered the following solutions.

Enforcement

- Increased citations
- Towing
- Increased night patrols
- Increase building inspections to ensure that new housing stock contains adequate parking
- Hold residents accountable for holding inoperable vehicles and parking them for sale
- Keep track of abandoned vehicles
- Prevent parking of oversized vehicles in residential streets
- Limit the number of people operating mechanics shops out of their homes
- Educate residents and enforce the code on hardscapes to prevent front yards from being turned into parking lots.

Infrastructure Improvements

- Mark and stripe parking stalls on the street like Maywood to prevent people from parking inefficiently.
- Place parking meters near businesses
- Make ADA spaces dedicated to the household that requires it
- Add speed limit signs and speed bumps in residential areas
- Add back parking that was removed in City Terrace

Increase Parking Capacity

- Build off-site parking to allow residents to park, and offer lower to no-cost options for low income bracket households
- Provide parking lots for residents
- Add parking horizontally and vertically
- Build on underutilized lots
- Use empty/underutilized lots as parking

Residential Parking Permits (RPP)

- Should be based on household size
- Should be equal only to the number of spaces on the street
- 1 permit per household
- 2 permits per household
    - 2 permits at the same, escalated fee up to 4, contingent upon registration and insurance
- 3 permits per household
- 4 permits per household
- Based on per driver rather than amount of cars
- Should be based on number of registered vehicles
- Based on the number of bedrooms per household
- Based on the number of people on a home lease

Land Use/Transportation/Housing Policies

- Shuttles in residential areas for improved connections to regional transit
- Rent control so families don’t have to live together
- Landlords need to allow renters to park off-street
- Paid parking
- Address homelessness, allocate a place for people living in their vehicle to park and access resources
- Mandate sufficient parking for renters

Education and Incentives

- Encourage property owners to clean up their garages and not use them for storage
- Education on parking restrictions
- Limit number of cars per household
- Focus on getting residents with off-street parking to utilize it
- Make it easier for people to offload their inoperable vehicles
- Educate residents on illegal dumping

04 Issues and Impacts to the Community

Issues and Impacts to the Community

As revealed in the existing conditions analysis, there are numerous parking issues that the East LA community faces regularly. Among the key issues and common themes observed and gathered from the stakeholder outreach are:

- Lack of available on-street parking
- Limited enforcement coverage
- Illegal parking (Hydrants, Double Parking, Intersections, Red Curb,
- Low turnover of on-street parking
- Unofficial 'reserving' of parking spaces
- Parking spillover from surrounding commercial uses (e.g., car sales, auto body into residential streets
- Parking spillover from street vendors and catering trucks into private commercial off-street lots
- Parking spillover from surrounding residential uses (e.g., parking in commercial lots, streets)
- Parking spillover from non-residents (i.e., people from outside immediate neighborhood)
- Parking spillover from transit riders into residential and commercial streets and private commercial off-street lots
- Oversized vehicles (RVs, Trucks) parking on the street
- Inoperable vehicles parked on the street
- Multiple car ownership
- Inconvenient street cleaning hours
- Under parked developments resulting from land use policy (minimum parking requirements)

While there is no single source of the parking issues experienced in East LA, there are some overarching issues that if addressed can begin to provide relief to residents and businesses with respect to their parking issues. The following section highlights the main issues in East LA and their impacts on the community.

Lack of Available On-Street Parking

The number one issue identified by residents and businesses in East LA was the lack of available parking on the street. This was especially prominent in residential areas, where Walker staff observed over one hundred percent occupancies in virtually every study area zone. Along commercial corridors, high parking congestion was also observed, and stakeholders also expressed the conditions of unavailable on street parking near their businesses. For some residents and businesses, those whom do not have off-street parking, the availability of on-street parking is vital.

Impacts of Unavailable On-Street Parking

In residential areas the impacts of a lack of available on-street parking mean that parking is a daily problem for residents and their visitors, especially those that do not have access to off-street parking. This is because they compete with other residents for the on-street parking supply on any given block. As shown in the community profile, East LA is one of the densest residential areas in the county, and with most people relying on vehicles to access their jobs and services, the parking issues are prominent.

Parking is a quality of life issue. When asked if they 'worry about losing their parking space on the street if they moved their car', 90 percent of respondents to the online survey agreed that they worry about on-street parking availability. Moreover, when asked if they must plan their day around the availability of on-street parking, more than 80 percent of respondents indicated that they plan their days around the availability of on-street parking. Residents in East LA must factor parking into their daily routines.

Because available parking is so scarce, residents have become accustomed to holding onto their on-street parking spaces, for fear of losing their space on the street. This practice inevitably begets more holding of spaces by other residents as everyone tries to ensure that they maintain a space near their residence.

Still, perhaps the biggest noticeable impact to on-street parking in residential areas is illegal parking. Instances of illegal parking were so widespread that they were observed in every zone, and lead to occupancies over 100 percent in most residential areas. Because available on-street parking is so sparse, some residents have resorted to parking wherever they could find space, be it along red curbs, in front of hydrants, in front of driveways, in intersections, and double parking, to name a few.

In commercial areas, the impacts of a lack of available on-street parking mean that customers may not find convenient parking when they wish to patronize East LA businesses, which in turn can impact the patronage of those businesses. Similar to how residential on-street parking results in the 'reserving' of spaces, commercial areas also experience a form of 'reserving' in that spaces do not turn as often as they should. This is due to the substantial presence of mobile vending trucks and stands that stay well beyond the posted time limits. A parking space that is intended to turn cars at least five to ten times a day (for example, using a two- or one-hour time limit), may only park one to two vehicles a day if occupied by a business owners, employee or food truck, and effectively provide no customer parking for surrounding businesses.

During the public meetings, focus groups, and online survey, business owners, employees, and visitors of East La noted that a lack of on-street parking is the number one issue for them. This issue is key, especially for those businesses that do not have their own off-street parking. Thus, ensuring the availability of short-term on-street spaces is vital for East LA businesses.

Factors Leading to Parking Availability Shortfalls

There are a number of reasons for the severity of the on-street parking conditions observed by Walker and expressed by the community, among them are:

- Inconsistent or ineffective enforcement of current regulations
- A free to park system, which makes enforcement challenging and may encourage people to leave cars parked at a given location for a longer period of time
- High automobile reliance
- Newer vehicles may not easily fit in older garages limiting off-street parking options
- The preference or necessity of residents to park on the street
    - Some residents don't have an option but to park on the street
- Insufficient parking demand management

Parking Spillover

The issue of unavailable on-street parking leads to issues of spillover when no apparent off-street parking spaces are available. Parking spillover generally refers to when parking demand for one land use spills over into the parking supply of an entirely separate use. Residents and business owners highlighted parking spillover issues in various forms.

In residential areas:

- The community noted parking spillover from car repair businesses and from auto sales businesses into residential streets.
- In the survey, employees in East LA noted that they utilize residential on-street parking when off-street parking is unavailable at their place of work.
- Community members noted that parking spillover from transit users occurs into surrounding residential streets.
- Lastly, residents complained that non-residents (i.e., people from outside of the immediate neighborhood) often park on their streets.

The impact to residents from parking spillover has increased competition for the finite parking spaces that are available on any given residential street. Thus, propagating the tendency for residents to hold onto their spaces.

In commercial areas, spillover issues were noted from:

- Catering trucks and street vendors occupying space in private off-street lots and their customers parking in those lots; thus, taking up parking allocated for patrons of adjoining shopping centers.
- Similarly, East LA business owners and tenants noted that catering trucks and their patrons occupy on-street parking along the major commercial corridors, and as a result occupy short-term spaces that are meant for patrons of commercial corridor-lining store fronts and restaurants.
- Spillover from transit users into private commercial parking lots and commercial street occurs near the transit stations.
- Walker also noted and observed residential spillover into off-street parking lots during off peak hours.

The impact that spillover has on commercial businesses is mainly highlighted by the fact that these spaces are not turning over as they should. Business owners have noted that catering trucks, street vendors, and transit users utilize parking spaces meant for their patrons often all day long. As a result, the impact to businesses is less opportunity for patronage.

Limited Enforcement Coverage

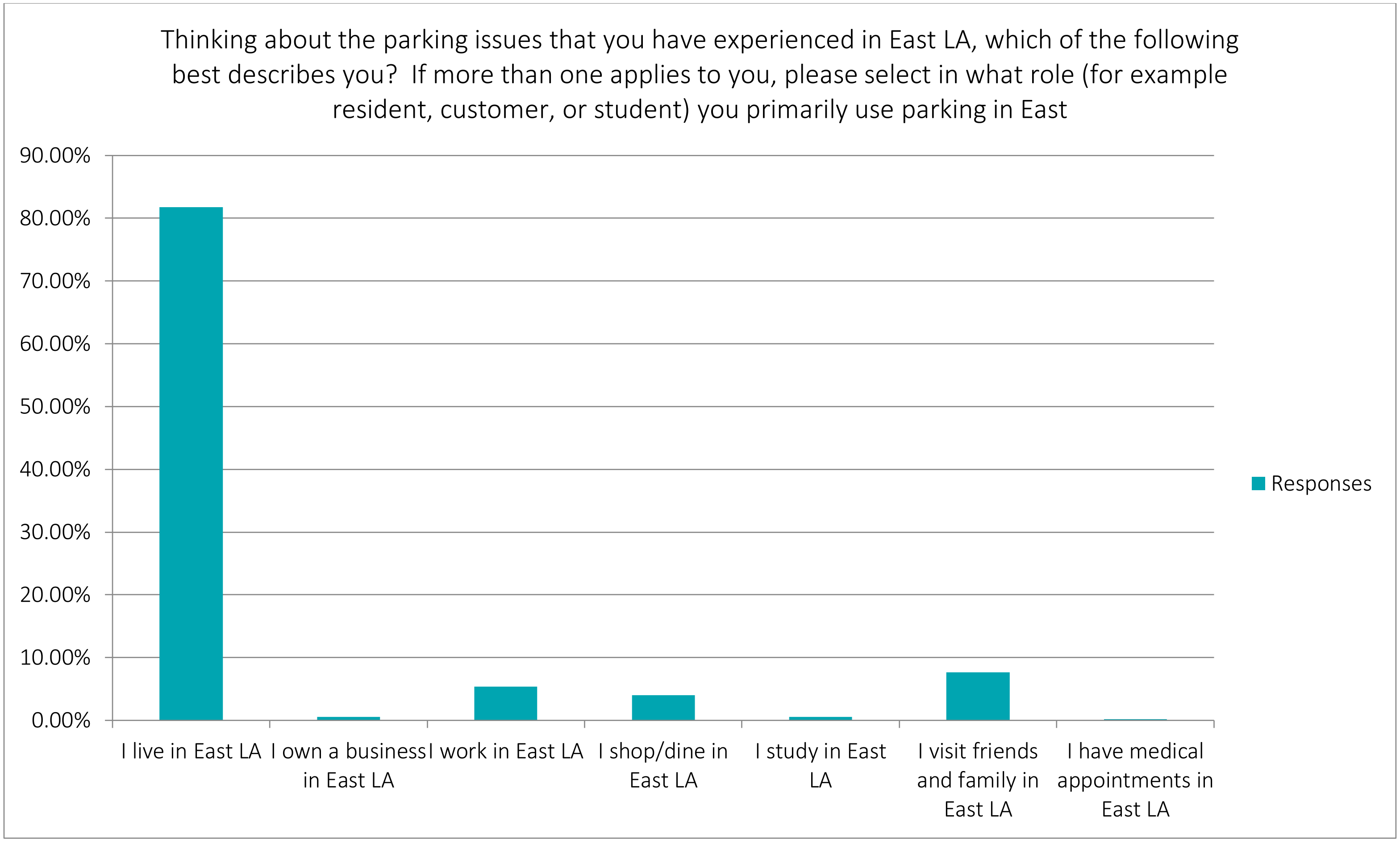
There is a general sentiment in the community that parking enforcement is not meeting the needs of the community. Residents feel that enforcement does not do enough to address the parking issues that impact their neighborhoods outside of street sweeping hours. Business owners and merchants feel that enforcement does not do enough to ensure that short-term spaces along commercial corridors turnover to allow customers to patronize businesses.

As part of this study, Walker is conducting a thorough review of current parking restrictions and enforcement practices to identify where and how improvements to enforcement can be made. The following chapter (Task 3) provides that review.

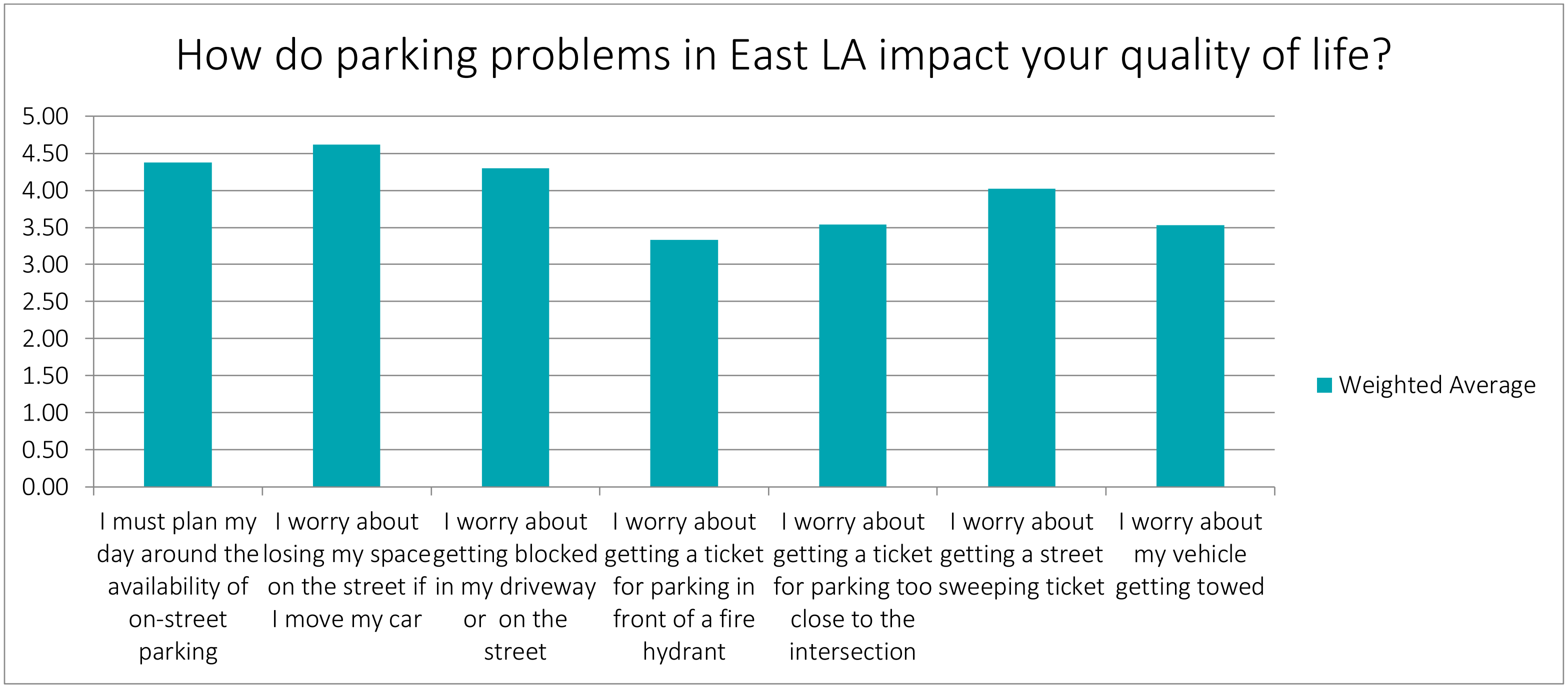
05 Appendix

Appendix A: East Los Angeles Parking Survey Results (English/Spanish Combined)

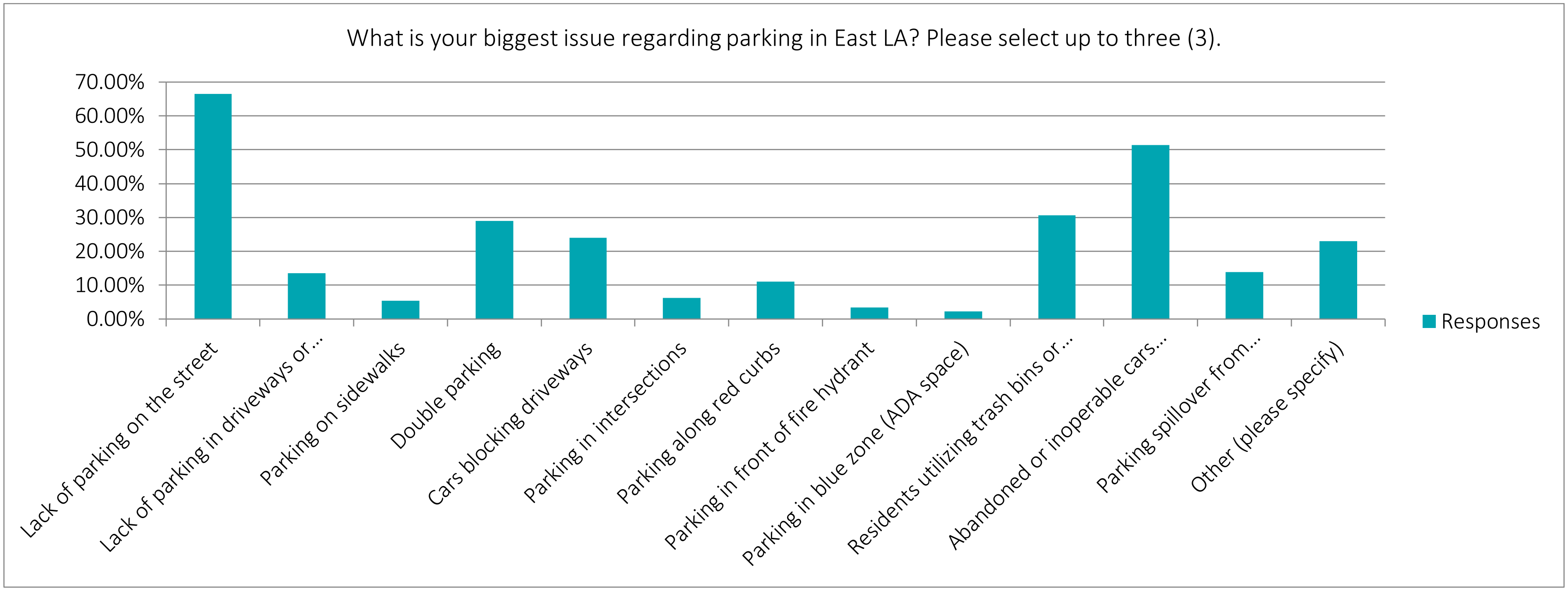
Question 1



Question 2


How do parking problems in East LA impact your quality of life?
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
I must plan my day around the availability of on-street parking
I worry about losing my space on the street if I move my car
I worry about getting blocked in my driveway or on the street
I worry about getting a ticket for parking in front of a fire hydrant
I worry about getting a ticket for parking too close to the intersection
I worry about getting a street sweeping ticket
I worry about my vehicle getting towed
Weighted Average

Question 3



Respondents	Other (please specify)
1	Households not utilizing their driveways for their vehicles
2	multiple cars from one house
3	residents parking their unused but operable cars out in the street because they own to many cars.
4	not enough parking at local businesses

5	Parking overnight in alleys because there are no signs posted not to park; worry about an emergency vehicle not being able to enter the alley because of all the cars parked overnight.
6	People moving trash cans on trash day to park their car on that spot and sometimes my trash doesn't get picked up because the bin is on the sidewalk
7	Parking illegally in alley
8	Overcrowded housing, apartment complexes/multi-unit housing that do not provide housing. Too many people with access to driveways in their home do not use them
9	Rent being too high, multiple families living together to afford the high rent -which means more cars.
10	The Sheriff Parking Enforcement NOT diligently doing their jobs. They drag their feet and it takes so much struggle/effort to give illegally parked cars tickets/towed. They should ticket/tow cars without having residents make a complaint. They are NOT earning their paycheck if we have to do this. They need to stop being so damn LAZY! Someone in higher position needs to pound the Sheriff Department on this. It should start with this practice until the end of the year before making drastic changes.
11	Used car salesmen that use the street as their dealership! People HAVE TO RESORT TO PUTTING TRASH CANS! I had to get an electric scooter to save my parking and a tiny car so that I can actually have a life after 2 pm.
12	Neighbors that are running a car repair business at their home & taking up car spaces!
13	Recently our residential street lost 50% of our already overcrowded parking & now people are SPEEDING thru our neighborhood.
14	Homeowners with renter not allowing them to use their parking stall, and blocking the drive ways, Homeowner; selling cars from their home created limited parking,

	apart. units on Miller St. w/no parking for their tenants. Homeowners not using their driveways to park their cars, but the street.
15	We have two neighbors, one has a washing machine repair shop, he parks his fully loaded trucks onto our streets and takes 3-5 spots, other neighbor sells cars and parks at least 6 cars which is taking useful residential parking for us that DO NOT have driveways.
16	Lack of enforcement by the sheriff's parking staff. Before the pandemic, they only came around street sweeping day or when we call to report an abandoned vehicle
17	People fighting over parking
18	Owning way to many vehicles for sales and profit.
19	Up to code commercial trucks and vehicles - air pollutant concerns
20	Some people don't use driveways and too multiple families in one household
21	On some occasions there is not enough parking do to several neighbors having 6 to 7 cars per house hold. But lately it's been ok this is for stringer ave.
22	Multi generational homes have multiple cars that take up a lot of street parking
23	I am selecting other due to the limit of only being allowed to select three, in reality all these are issues. not just three.
24	People experiencing homelessness have their cars/RVs on Alma between Whittier & Verona
25	Difficulty getting handicapped spaces
26	Used car dealerships parking their overflow inventory on the residential streets - this is MAIN reason why there is a lack of parking for streets off of Atlantic Blvd. Between the 60 f-way and 5 f-way. That is the auto squat of ELA. More than 20 dealers. It's

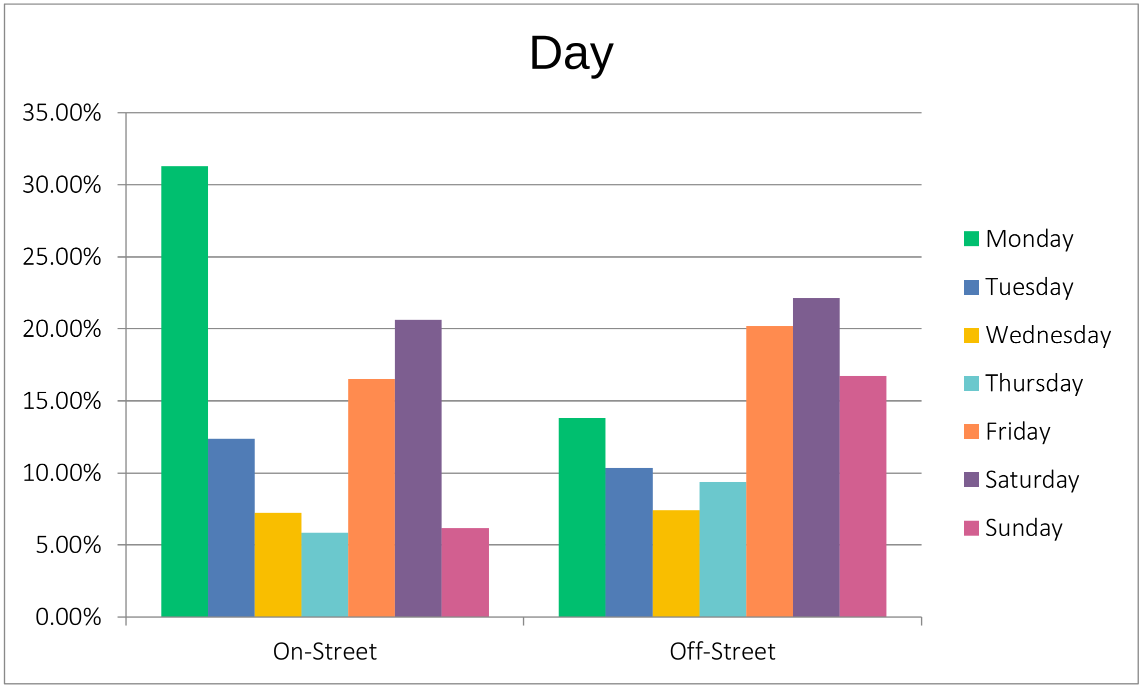
	really bad at Olympic and Atlantic because there are several down west on Olympic Blvd.
27	People selling cars on our block and taking parking spaces from residents
28	House holds have 7, 8 junk cars just parked on the street
29	Neighbor running auto repair business at home taking multiple parking spaces on street.
30	People operating a mechanic shop out of their home and using the street to park all of the cars they need to fix.
31	Having 1 neighbor have 12 none working cars parked on the street and never moving them.
32	Abandon cars, cars parked double park in my street, and cars blocking always! Only using a space for trash day but annoyed when they move them in the middle of the street and when they leave they don't put it back.
33	Too many apartments/duplex zoned and no parking for the cars so multiple families living the with multiple cars.
34	Neighbors that don’t use their driveways
35	Neighbor leaving car in front of our house for over 72 hours, tires need to be chalked and enforced
36	Lots of people leave broken cars on their driveway and park their working cars on the street
37	People with more than 12 cars that park on the street and have driveways
38	only one side of our street is usable for parking.

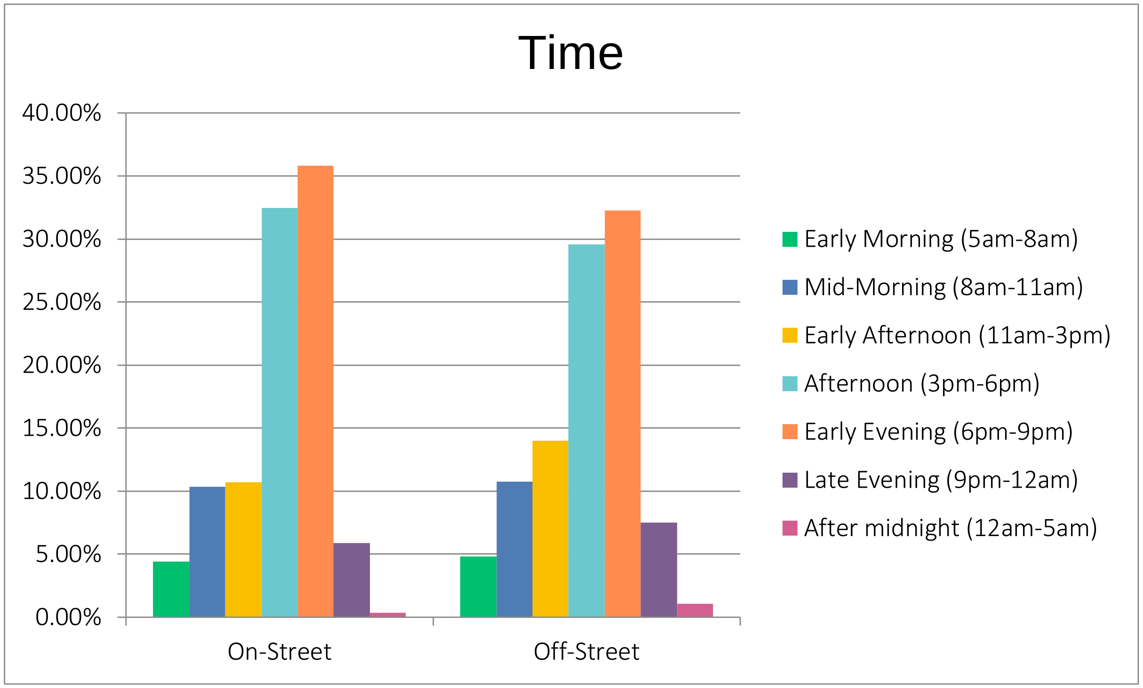
39	RVs set up as homeless encampments taking you space on street, with trash spilling over onto street and sidewalk, making me feel unsafe walking too close to it.
40	Some residents have multiple vehicles that they use to save parking, often taking up the whole space in front of a home with one car parked in the middle. This is to prevent someone else parking there so they save the space for someone else in their family. They will frequently move one car forward and park their other car behind it and wait for the street sweeper to pass by so they can move their car back there so no one else gets "their" parking spot. This is likely due to their landlord not providing them enough parking in their property.
41	People having multiple cars from another street parked on my street.
42	street cleaning tax
43	kipp school not having parking for staff and parents at there school they expanded but did not supply parking for them. Our street during school time is busier than Whittier blvd the noise level is if we lived next to a freeway then the noise from the school makes since was a quiet neighborhood at times unbearable we have 3 other schools and for over 20 years no noise until kipp opened. Neighbors trash bins are in the middle of the street due to them blocking driveways or squeezing a car that partially blocks a driveway Neighbors block their own driveway cause there is no parking.
44	People having way too many cars per house.
45	People with multiple cars!
46	Too many homeless people parking in the street and taking over parking areas.
47	Apparent Used Cars dealers take up parking in our streets
48	Too many cars due to illegal auto repair in a residential area, parking on the corners of streets

49	Apt complex don’t have parking which causes the to use SfD parking a domino effect.
50	Residents not having permits to park in their neighborhood
51	cars that doesn't move more than 72 hrs; loitering while parked; trash
52	Cars using more than one space not allowing another car a slot.
53	The streets are too small and cars park on both sides- peoples cars get hit all the time.
54	Too many cars per household
55	Residents not utilizing their driveways
56	Not being able to park in front of my own house
57	The current parking situation is horrible, the housing projects residents park multi PK lenders on our street and reserve for their household members. As well as neighbors saving parking and not utilizing there driveways
58	People from the metro station parking on the street
59	Too many cars per residence.
60	Using driveways as businesses. Too many cars!!!
61	There are too many cars on the already tight streets. There have been a number of incidents in our neighbor hood. Car accidents, altercations over parking and cars blocking driveways 3 in the past month. There are houses that have 5-6 vehicles.
62	HUGE WORKING TRUCKS PARK ON RESIDENTIAL STREET BLOCK THE VIEW ONCOMING TRAFFIC COMING OUT OF DRIVE WAYS OR CROSSING INTERSECTIONS. THIS TRUCKS COLLECT METAL SCRAPS AND HAVE CARGO UP TO 10 TO 15 FEET HIGH.

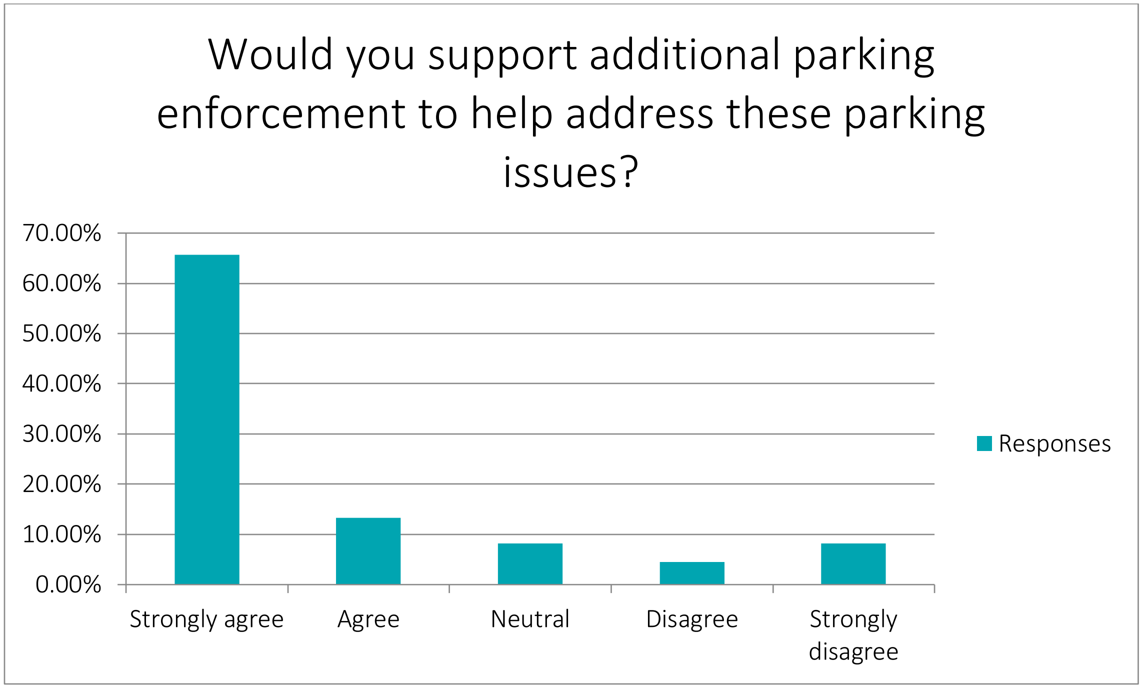
	ALSO Residents utilizing trash bins or other measures to 'reserve' parking on the street
63	People taking 2 spots to save for family members
64	People have large numbers of vehicles. My neighbors have up to 6-7 vehicles per house in a single family home. They also have vehicles that are not in use just taking up space.
65	People parking in the middle of two parking spaces
66	Large vehicles parked in corners obstructing the view of drivers trying to turn
67	Motorhomes used as dwelling.
68	Motorhomes or Business trucks parking taking up multiple spaces
69	Households with more vehicles than they have space for.
70	Large vehicles
71	People living in their cars and RVs has lead to public dedication or urination, trash being littered on the sidewalks, unwalkable sidewalks
72	I have more than three because parking is not enforced in East LA. I am adding Parking on sidewalks, Double parking,Cars blocking driveways , Parking in front of fire hydrant, Abandoned or inoperable cars parked on the street

Question 4 - What day and time is it most difficult to find parking in East LA?

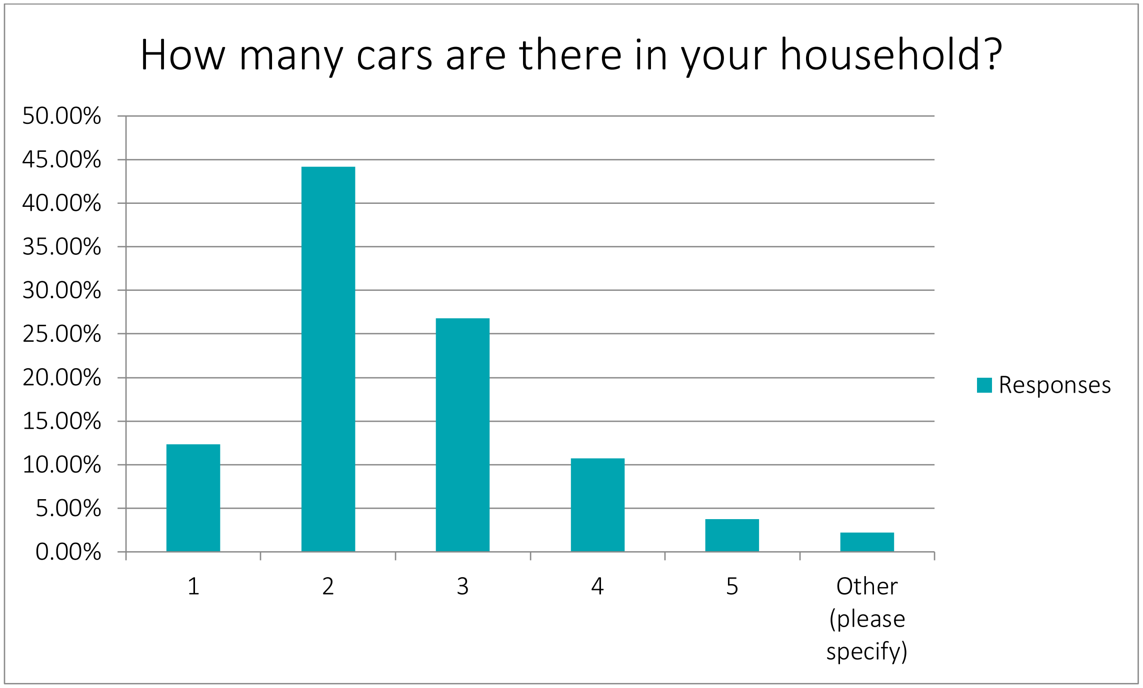



Time
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
On-Street
Off-Street
Early Morning (5am-8am)
Mid-Morning (8am-11am)
Early Afternoon (11am-3pm)
Afternoon (3pm-6pm)
Early Evening (6pm-9pm)
Late Evening (9pm-12am)
After midnight (12am-5am)

Question 5


Would you support additional parking enforcement to help address these parking issues?
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Strongly agree
Agree
Neutral
Disagree
Strongly disagree
Responses

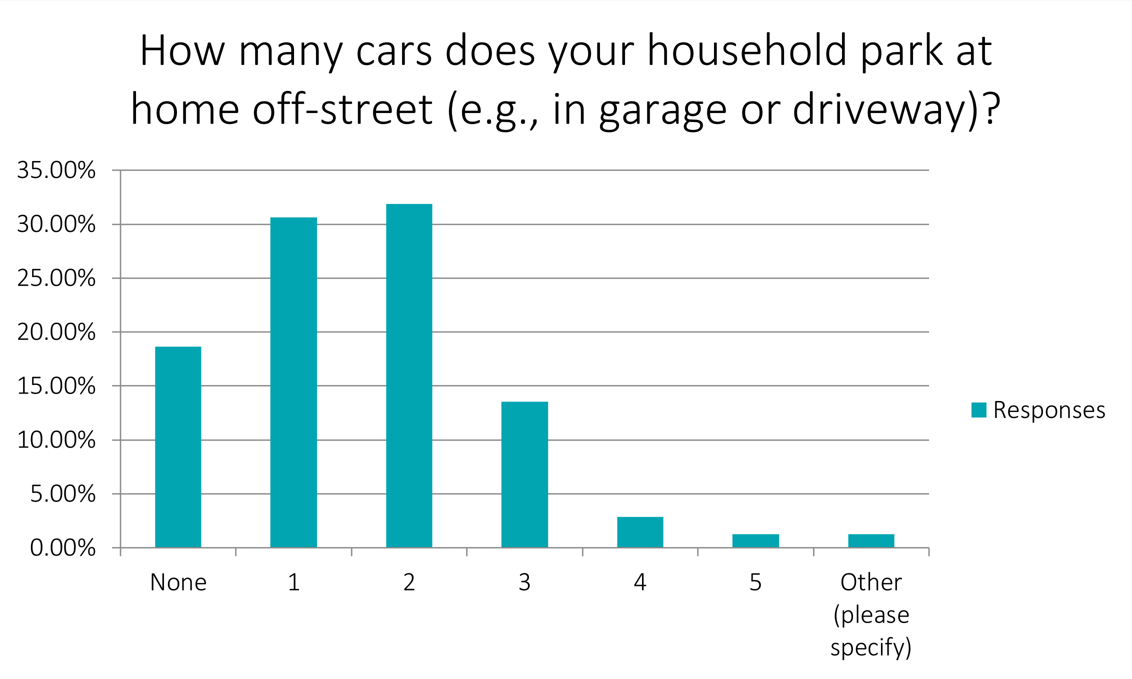
Question 6



Respondents	Other (please specify)
1	9
2	6
3	Other tenants have more than 4 cars per tenant

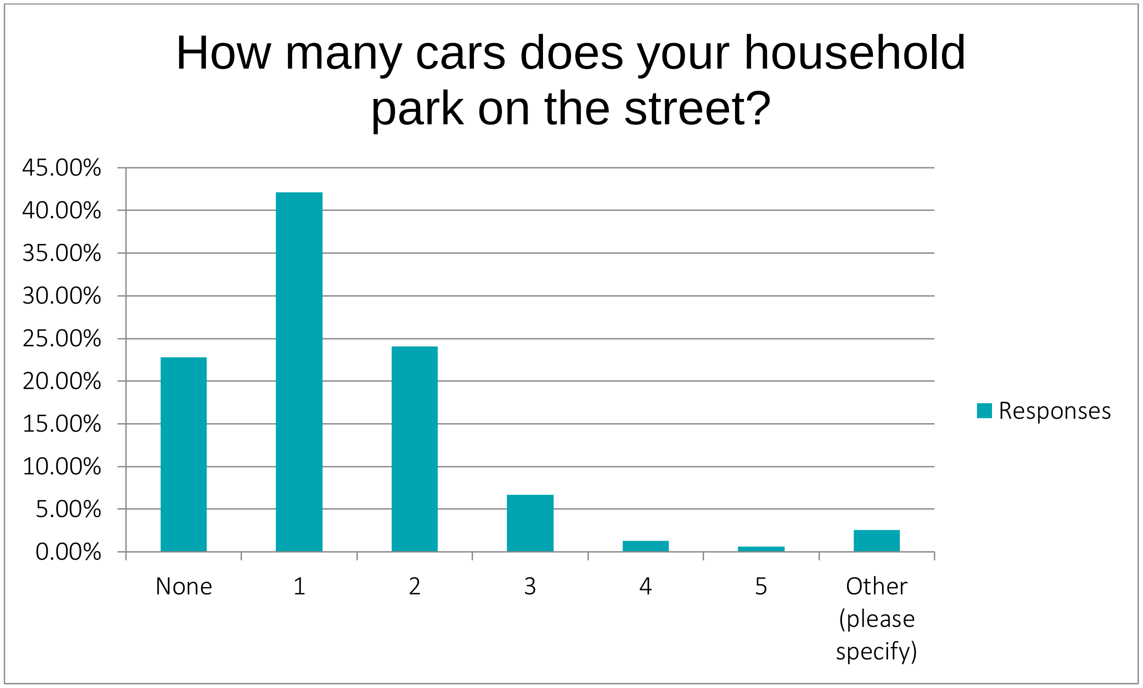
4	We have our own parking inside, what I hate is when they move the trash to use for parking.
5	6
6	6
7	Multiple, but all are parked in our property

Question 7



Respondents	Other (please specify)
1	We own our home and have no drive way. I park both my cars on the street
2	We have 6, only 1 parks outside but when no parking, we take it inside.
3	6
4	We have designated spaces in the Maravilla Housing but even then households with extra cars have been parking their cars inside without hav

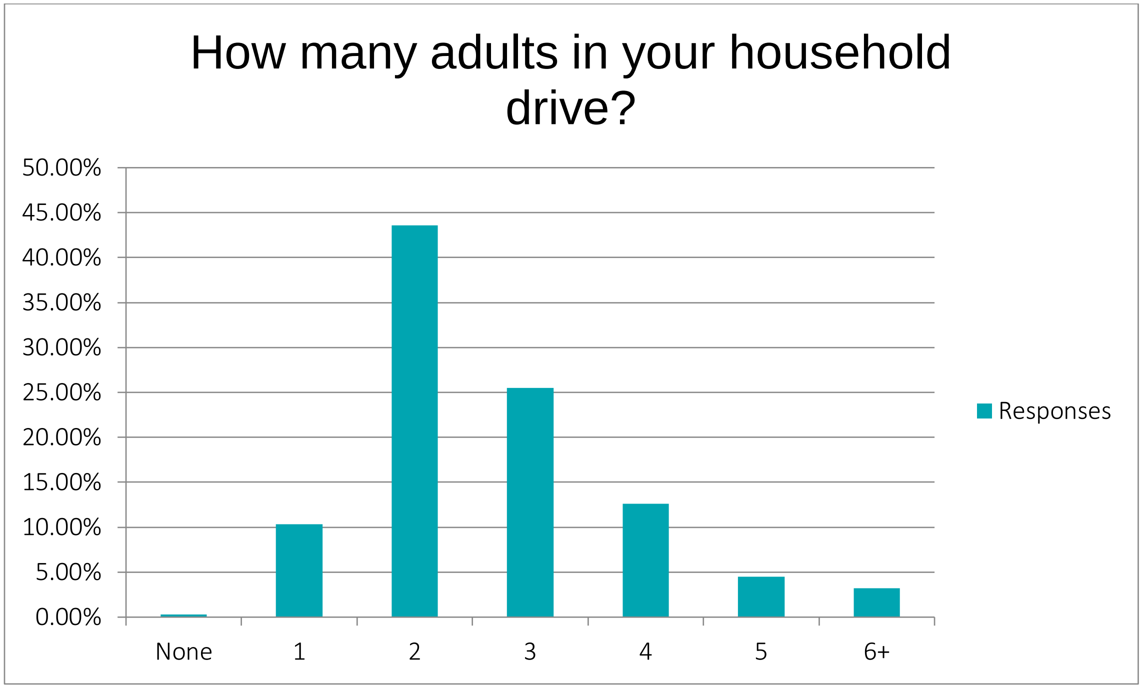
Question 8



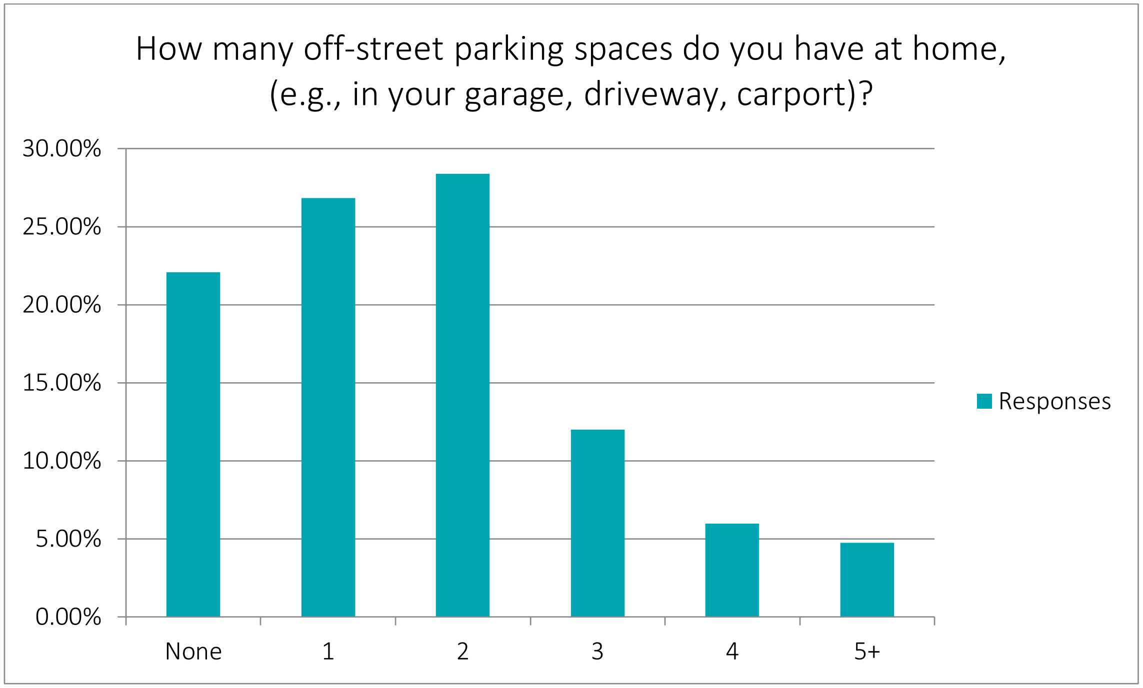
Respondents	Other (please specify)
1	1 only when running errands
2	I sometimes park on street if there is a spot
3	7
4	We own our home and have no drive way. I park both my cars on the street

5	Friends can’t visit due to no parking
6	Sometimes 2 depending on my guests.
7	Not able to park on street always occupied
8	Don’t have parking soace

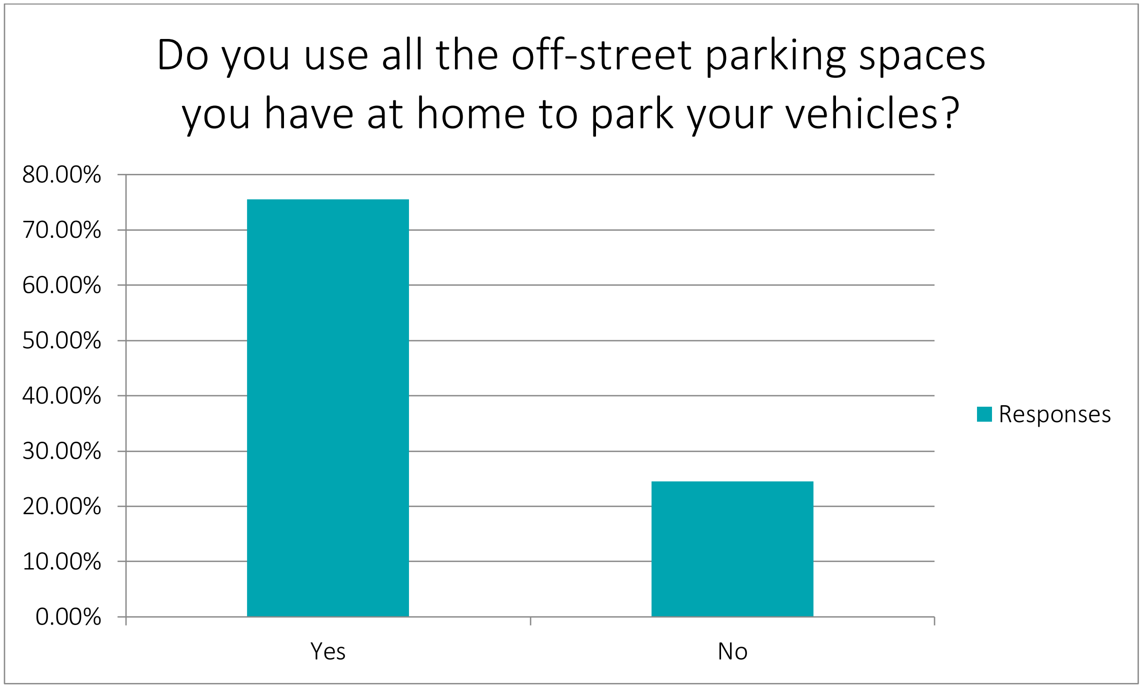
Question 9


How many adults in your household drive?
50.00%
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
None
1
2
3
4
5
6+
Responses

Question 10


How many off-street parking spaces do you have at home, (e.g., in your garage, driveway, carport)?
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
None
1
2
3
4
5+
Responses

Question 11



Respondents	If no, why not? (please specify)
1	I want to park my car in front of my house on street. I don't like anyone parking in front of my house. My neighbors are filthy. They leave food and trash in front of my house .
2	Not allowed to
3	Currently have a vehicle on one side of the driveway that is inoperable other vehicle I park in the driveway..husband vehicle blocks the driveway.
4	Space too tight

5	I don’t have any.
6	Don't have a driveway
7	no off-street parking options available to us
8	I don't have any off street parking
9	No driveway.
10	there are so many young people in their 20s in the neighborhood living at home with two or more cars . I mean they own two vehicles themselves . Then they complain when there’s not enough parking on the streets . It would help if we had one or two dedicated parking lots especially for residence in the neighborhood . Also It’s hard to get out of my driveway... especially with so many cars parked on the street and I don’t have a sliding gate.
11	We have no access to off-street parking spaces.
12	We keep one car to the front of the house because other cars will park in front of our home and leave the full week without moving it. The owners of the cars usually live an estimated 8 houses down from our home.
13	I have a driveway. If I have friends visit they park on the street - or I move my car to the street and give them my driveway.
14	I don’t have a driveway or spot to park my vehicle therefore I have to park on the street
15	n/a
16	Don't have off-street parking.
17	I recently got a ticket for parking in front of my own garage! My garage blocks only my personal entrance - doesn't block a sidewalk or any other public area.
18	We dont have a driveway.

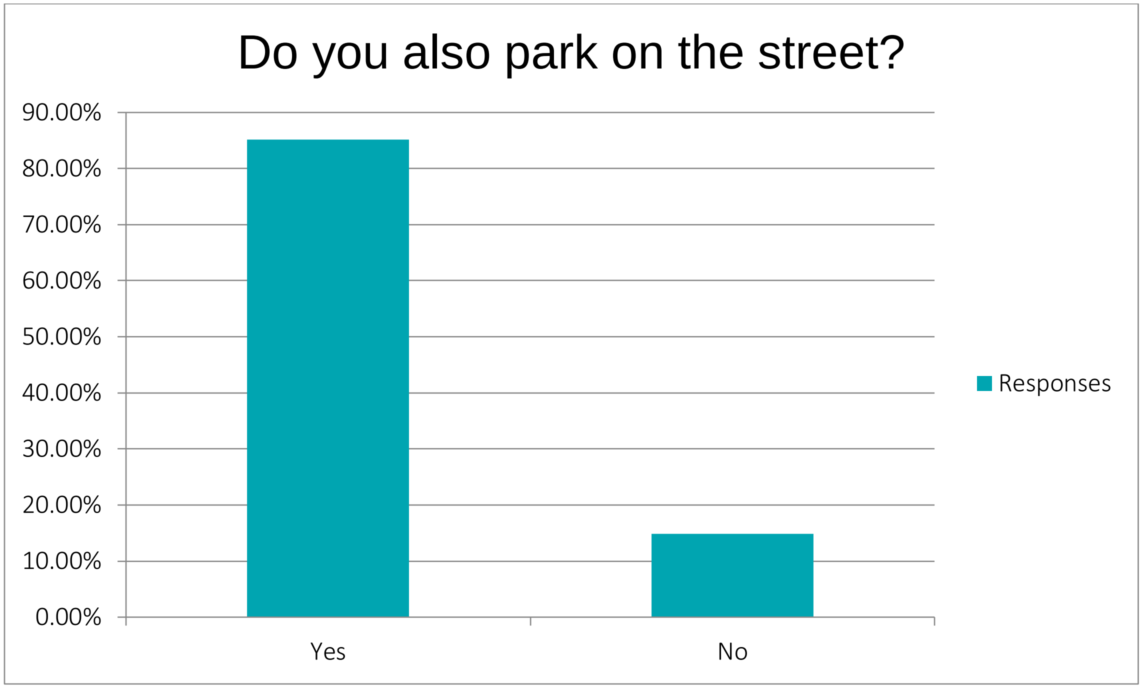
19	I park in my driveway.
20	Because having to move cars for other people who drive in the household. we all have different schedules.
21	Because I have no driveway or off-street parking
22	I rent a garage for $75 to allow me to have a parking space. The garage is too small for my vehicle and many times people park in my spot. I leave notes and at times had to call police.
23	Garage to small
24	I don't have a driveway
25	I use all the parking slots assigned to me in my unit but due to planning codes, I must still park one of the vehicles on the street
26	do not pay for parking space
27	I do not have off-street parking available owner uses them
28	Because I have neighbors that have more than 5 cars per member they use all the parking spaces don’t move cars for days and when they do they call other family members to park where they are parked makes it so hard for people to find parking they use big working trucks that occupy at least two parking spaces and don’t move this cars for days
29	Garage was built in 1920, only fits 1 compact car. Front of house has no parking sign due to narrow street.
30	There’s never parking so I can’t never park outside my home
31	Because my driveway gets blocked and I can't get out in case of emergency. I care for an elderly person.
32	Don’t have any parking

33	Unable to park
34	We leave the 1 garage spot available for guests because the parking Is so difficult
35	Have to park in front of our house or people will park and block the drive way and not able to get out. Have been late for work, dr appointment, special engagements. I have almost hit cars trying to get in or out of driveway when it's blocked on both sides.
36	No space
37	garage used for storage, and play area for toddler in household
38	It makes it hard for us to move and rotate cars the driveway is straight, my landlord parks her car so when she goes out we have to move and rotate cars
39	We use our driveway for different things.
40	No off street parking is available.
41	Our driveway parks three cars but we only own 2
42	no off street parking
43	We only have 2 cars
44	Parking not available. Some residents have 9 vehicles they park on street. They leave driveways as yard space.
45	I rent an apartment
46	driveway small for handicapped persons in home total 2 handicapped persons one vehicle is to large for driveway
47	Its hard to find parking, theirs a mechanic neighbor that has all his work parked out in the street.

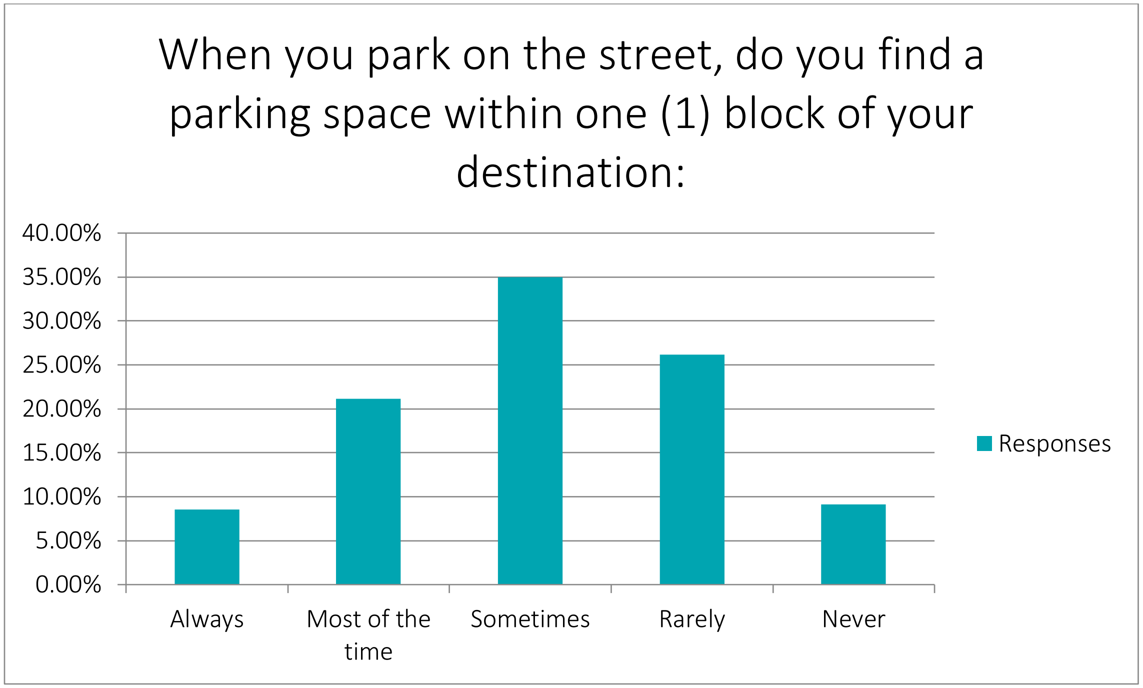
48	I don't have a parking spot, we have three units that have small parking garages in the back alley, but all three are used by one tenant who pays rent for them. So two of us have to park in the street, but the tenant who rents the other two garages, puts one of his cars, which is a van, in a spot in the back that was said can be used, first come first serve. The other two small garages he uses for his business and has three other cars that he parks in the street.
49	Drive way is too narrow only compact car fits
50	none available, live in apartment
51	Different work schedules
52	we live in a front house no driveway
53	We also use our driveway, sometimes one car on the lawn.
54	leave it for guest.
55	other tenants park inside
56	Cause we only have 2 vehicles
57	Cars will be left in front of my house for too long .
58	I don’t have off street parking
59	Garage storage
60	We don't have that many cars
61	This is NEVER an option for us. There are way too many cars in our street. Some if not a lot don't belong in our neighborhood we need permits we need to enforce regulations
62	Only have two cars at this time

63	I don't have off street parking
64	I don’t have my own parking space
65	Never parking in front of my home
66	My car doesnt fit in the garage
67	Yes I do but on night when the street sweeping passes cesar chavez people park their unpermitted cars inside maravilla housing
68	Full of stuff
69	Roommate is in and out and not convenient to park in driveway
70	Can’t park inside renting
71	Unless I’m leaving again
72	Extra off-Street space is kept open for family who assist with child care
73	As a tax payer I feel like should have the option to park in front of my property.

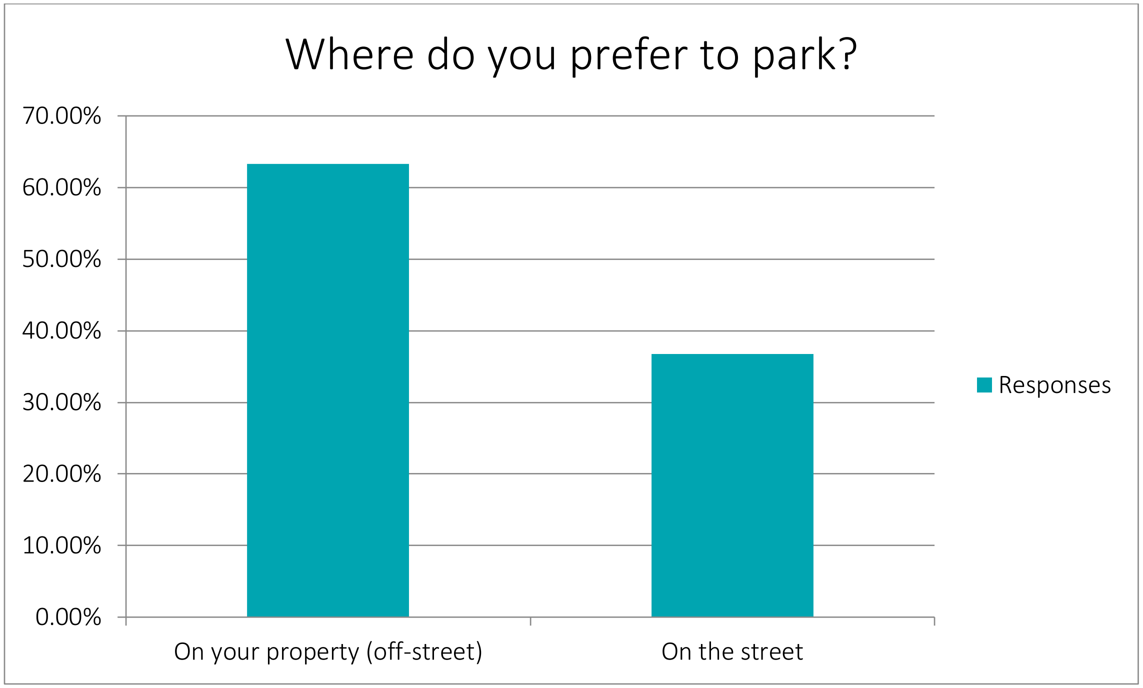
Question 12


Do you also park on the street?
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Yes
No
Responses

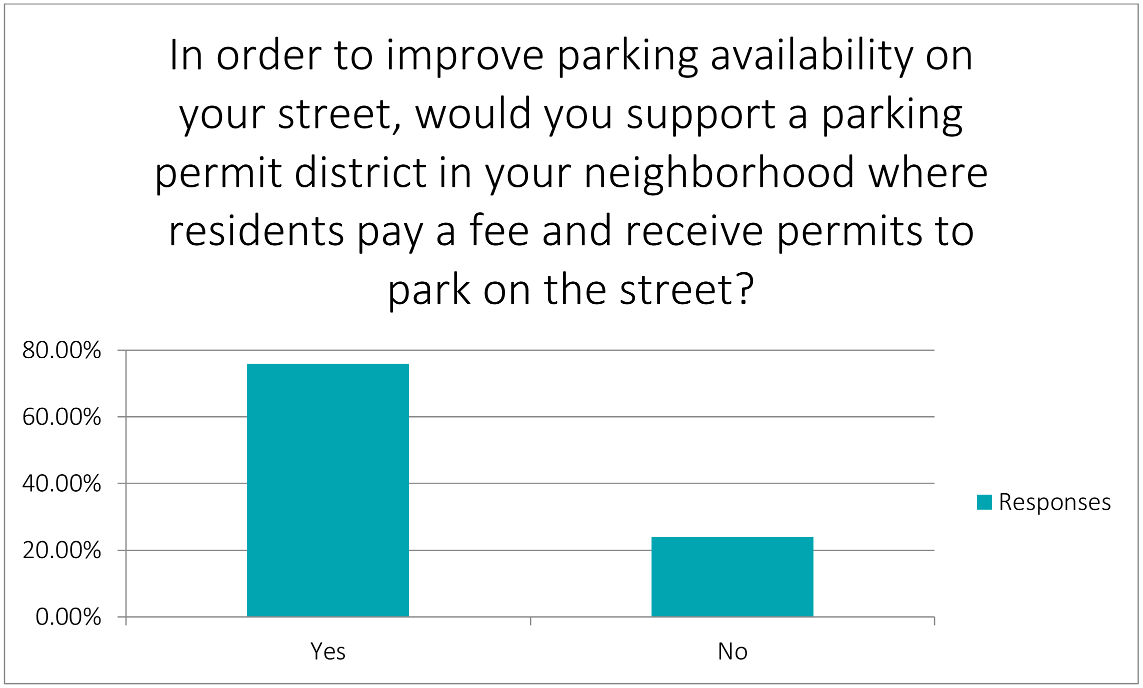
Question 13


When you park on the street, do you find a parking space within one (1) block of your destination:
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Always
Most of the time
Sometimes
Rarely
Never
Responses

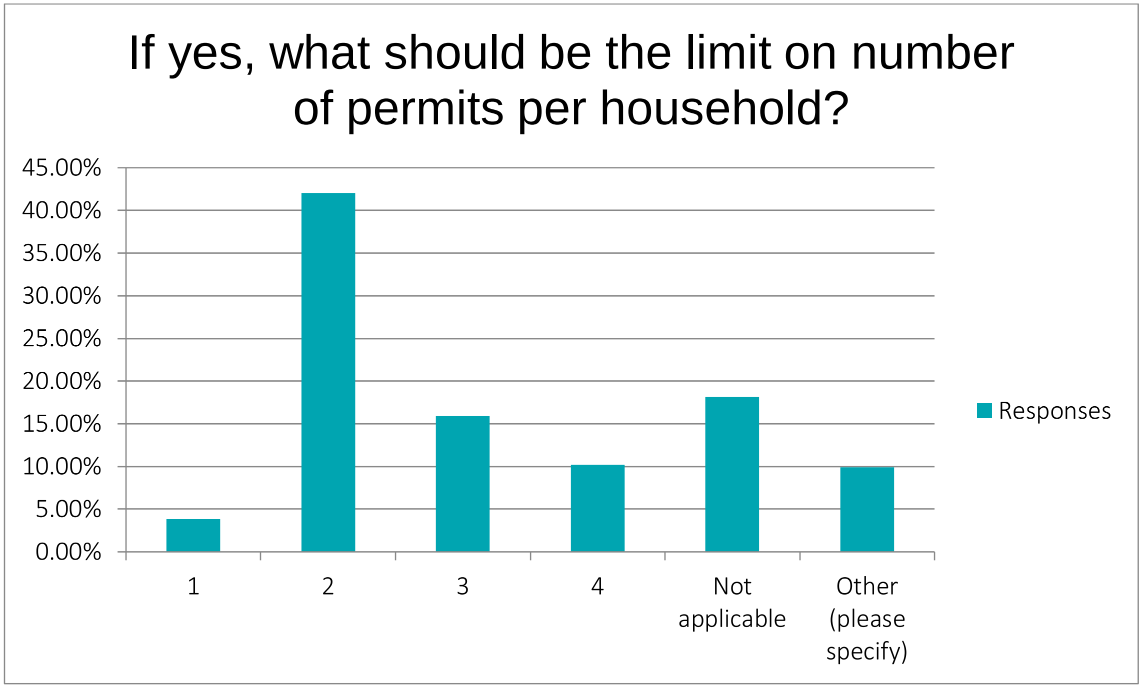
Question 14


Where do you prefer to park?
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
On your property (off-street)
On the street
Responses

Question 15


In order to improve parking availability on your street, would you support a parking permit district in your neighborhood where residents pay a fee and receive permits to park on the street?
80.00%
60.00%
40.00%
20.00%
0.00%
Yes
No
Responses

Question 16

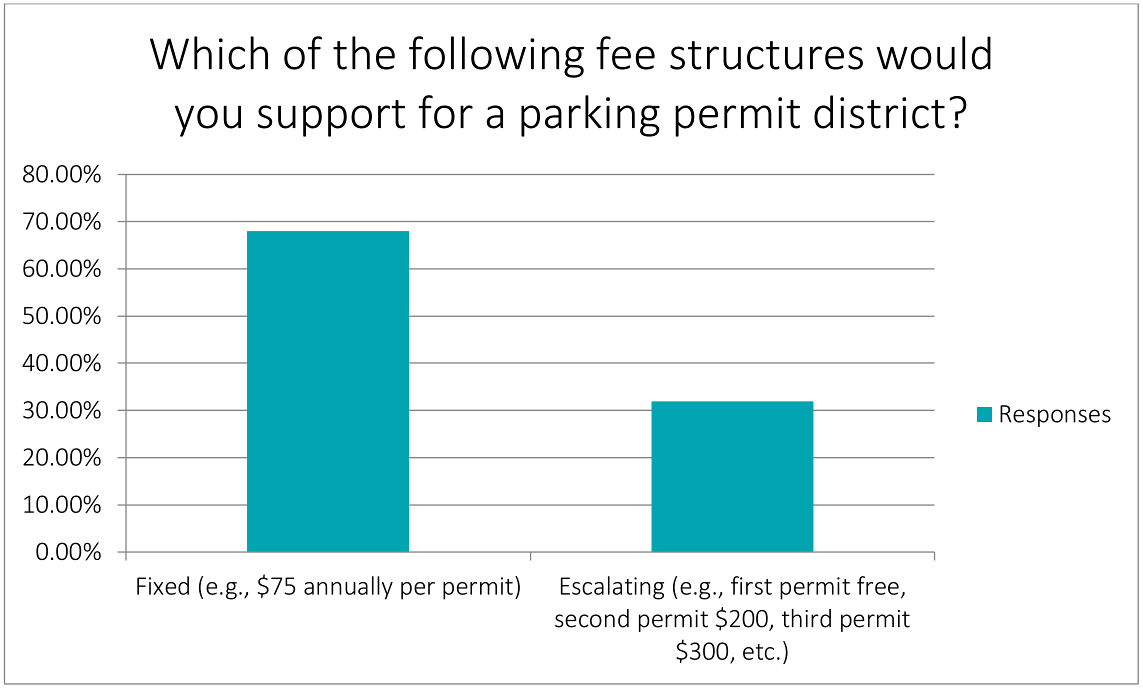


Respondents	Other (please specify)
1	Depending how many drive in the house
2	Equal the of cars parked on street only
3	In my neighborhood and the parking problem is due to a lot of young people owning more than one vehicle. It's not like they need a work truck and a car they just have the luxury of only two vehicles and still living at home with their family

4	The answer to 15 is YES and NO. It's not just residents - what about friends and although I don't have family here, but family for those that have visiting family members.
5	Have them pay for all the cars that they actually use
6	It depends on the family size within reason and how many cars each family owns; case by case bases. Any if they have driveway; it should be used.
7	Do not support parking permit district
8	I do not agree with the permit parking, I think parking enforcement should be increased in evenings and on weekends. Double parking and blocking sidewalks is a big problem. I would like to see a parking structure for resident use.
9	uit
10	At least 2-3 per household, I have 3 units and total we have 6 cars.
11	Maybe it is per driver rather than the amount of vehicles.
12	one permit per car in household
13	Unlimited
14	There should be no limit as long as it is for a resident
15	It should perhaps depend on the size of property- one or two cars per room?
16	1 permit. Houses have driveways! Leave street parking OPEN for visitors!
17	It should be according to how many residents have registered running vehicles.
18	4 for permanent homeowners or renters and availability plto purchase guest permits for family from out of town that visit

19	One fee for two permits; fee for extra up to 4, contingent on proof of current registration and insurance.
20	depending on household size
21	2 paid one free for guest (guest hours will need to have a time frame not able to use for overnight)
22	Unable to answer since household incomes and sizes vary. I would hope strong messaging incentivizes households to limit cars and donate non-functioning vehicles to make room for easy flow of traffic.
23	The amount of licensed drivers
24	I car per driver license
25	Depends on the number of residents zoned for each building
26	one permit for each current driver's license
27	Should be number of permits based on number of bedrooms.
28	Depends on how many bedrooms are in the home. I don't think a 2 bdrm should have 5 cars because that signal overcrowding
29	Depending on number of people on a lease for the home/apartment; that should be the limit
30	It should be based on home size.
31	Based on # of bedrooms for property

Question 17


Which of the following fee structures would you support for a parking permit district?
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Fixed (e.g., $75 annually per permit)
Escalating (e.g., first permit free, second permit $200, third permit $300, etc.)
Responses

Question 18

Respondents	Other (please specify)
1	0
2	$25
3	$50

4	between 100 to 200- some families sell cars and take all parking spaces- on Boswell St-Downey Rd
5	50
6	I am not interested in paying for a parking permit.
7	$50
8	$80
9	$20
10	$24 per year
11	I am not in support of a permitting practice. The area is largely low to extremely low income. To impose a fee/fine is predatory. Please address the challenges with regards to overcrowded housing first.
12	None
13	The permit won't help because most of the people taking up parking in my neighborhood our residence. We recently had the city close off Herbert Circle so that city workers could get through. As a result people started parking over in my immediate street and taking parking from residents that live on that block. Another big problem is that sometimes landlords are letting large amounts of people live in one house and they're not often immediate family. So if your house has an extended family or friends renting and there are seven or eight people then they have a lot of vehicles
14	Zero if these fees will be given to the Sheriff Dept. operations budget. They don't deserve more money if they don't do their job efficiently. I can bet my life you can get rid of 3 inefficient employees and hire 1 good efficient one. They are lazy, arrogant and drag their feet when servicing public complaints on parking.

15	No permits! We already pay taxes & very high rent - do not make us pay more to live here.
16	$50 per year per permit. Where does the money go?
17	nothing, parking is public space. you don't have to pay to go to a public park
18	0
19	0
20	$0 - $25
21	$50 per year
22	0.00
23	None
24	Not willing to pay for a permit
25	none, off street parking should never be paid for. The economic structure in East LA wouldn't make sense for a low socioeconomic neighborhood
26	Don't agree with permits the issue is current residents specifically two naighbors have to many cars for there house hold and they park all there cars on the street. We also have one neighbor that h as a driveway park there cars on the street wail the driveway is empty. This for stringer ave and Pomeroy st.
27	Zero..we.are on a fixed income and cannot afford any of the above
28	$50 because anything above that fee would become inaccessible for working class community members.
29	$0

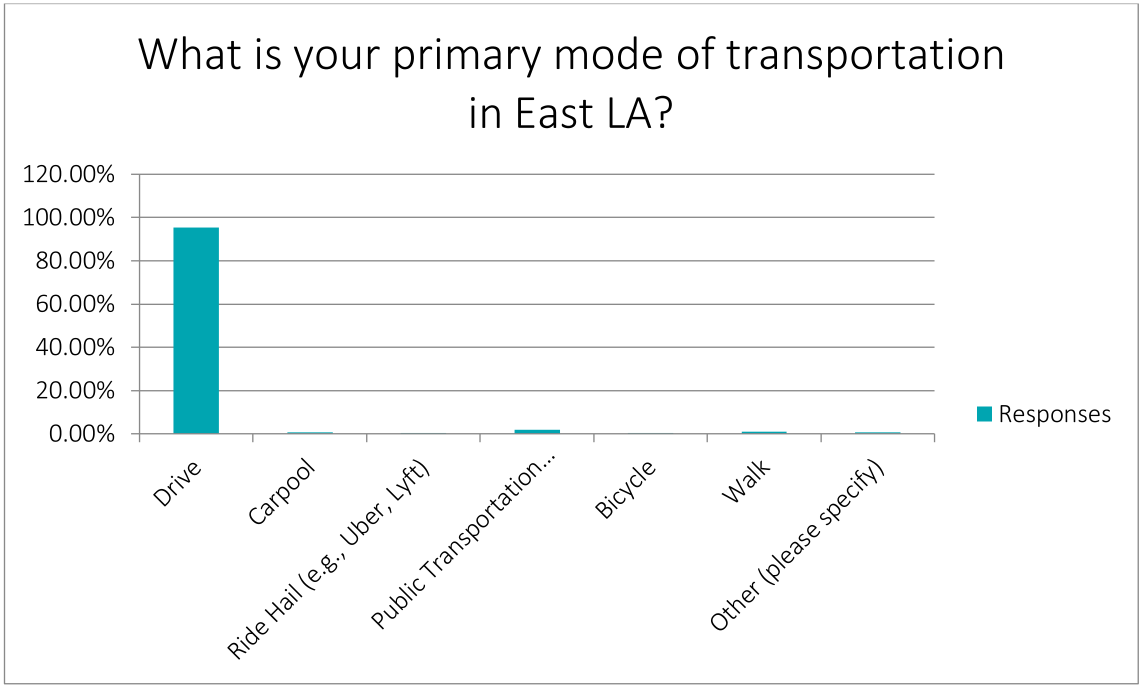
30	50.00
31	Should be included in property tax
32	Nothing!!!! We already pay enough taxes!!!!!! :O
33	50
34	As a home owner i should not be charged a fee to park on the residential streets - MY PROPERTY TAXES SHOULD COVER THST! GO AFTER THE BUSINESS THST PARK THRIR INVENTORY ON OUR STREETS!!!!!!
35	Two free permits per households
36	None
37	$50.00
38	0
39	Can we get discounts for more than 1, $75 is okay. As a homeowner, I would have to pay for my tenants. I would say yes! The permit would only be for cars outside.
40	I think this should be determined by the avg median salary in this area
41	I would rather not pay anything
42	Disabled $0, one free other escalate
43	25.00
44	None
45	50.00

46	$50 per year
47	0, I do not approve
48	Nothing
49	0.00
50	$15
51	$50
52	0
53	lHomeowners pay alot in taxes already we pay 00for curb and street maintence I think it would be nice 4 permits per home at 100.00 for all 4 plus visitor pass if only evening permits then less people who handicap have nurses and therapist that come throughout the day would need additional assistance if permits needed theoughout the dayt
54	$50
55	none
56	50.00
57	50
58	First 2 should be free per household; $100/year additional
59	0
60	1st one $75, any more than that $300each
61	$40

62	$25
63	50.00
64	Prefer no fee to park in my area
65	$25-$50/year. This is a low income neighborhood, I want my neighbors to be able to afford it
66	35.00 per year
67	None. Parking should be free!
68	None
69	20.00
70	If you are a property owner or lease holder it should not cost more than $40 annually
71	0$
72	It should be free we pay property taxes
73	$30
74	0
75	50
76	Nothing
77	50
78	I don't support fees
79	25

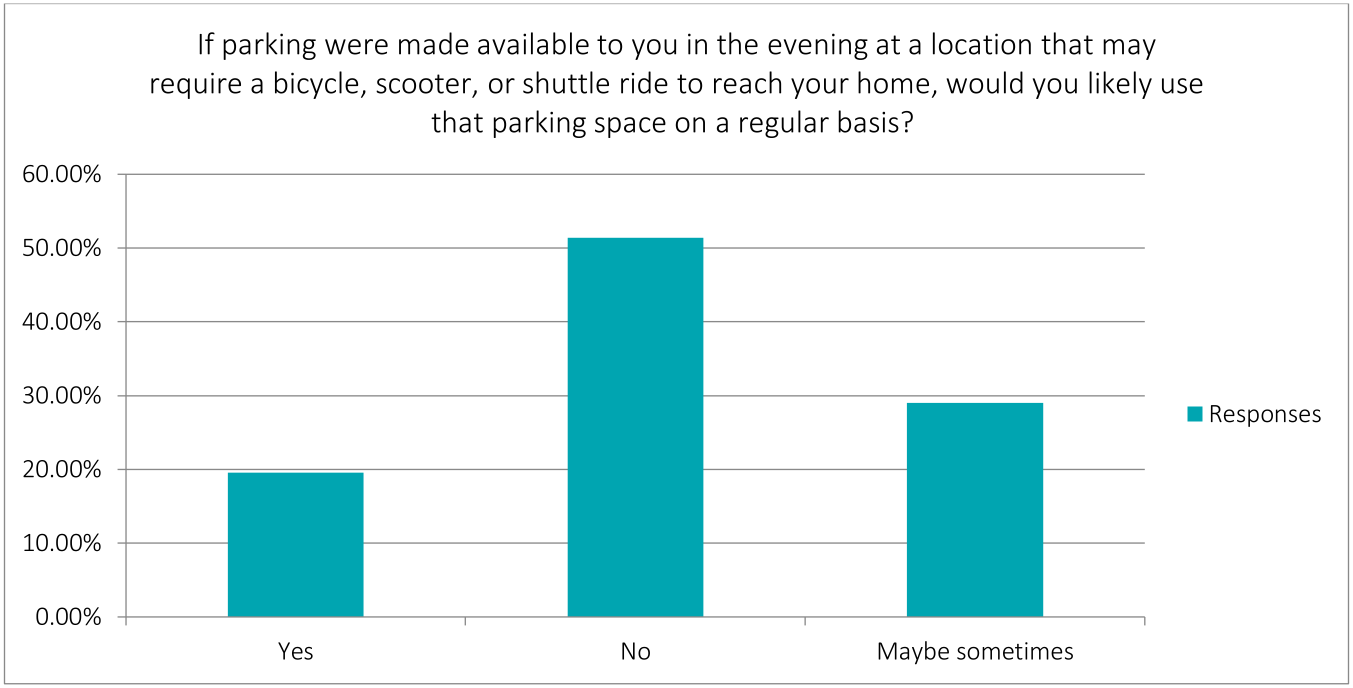
80	Sliding scale Sr. Ctzn
81	I'm not paying for parking ,my Taxes should be enough make permits available for home owners at no cost
82	None
83	$50

Question 19

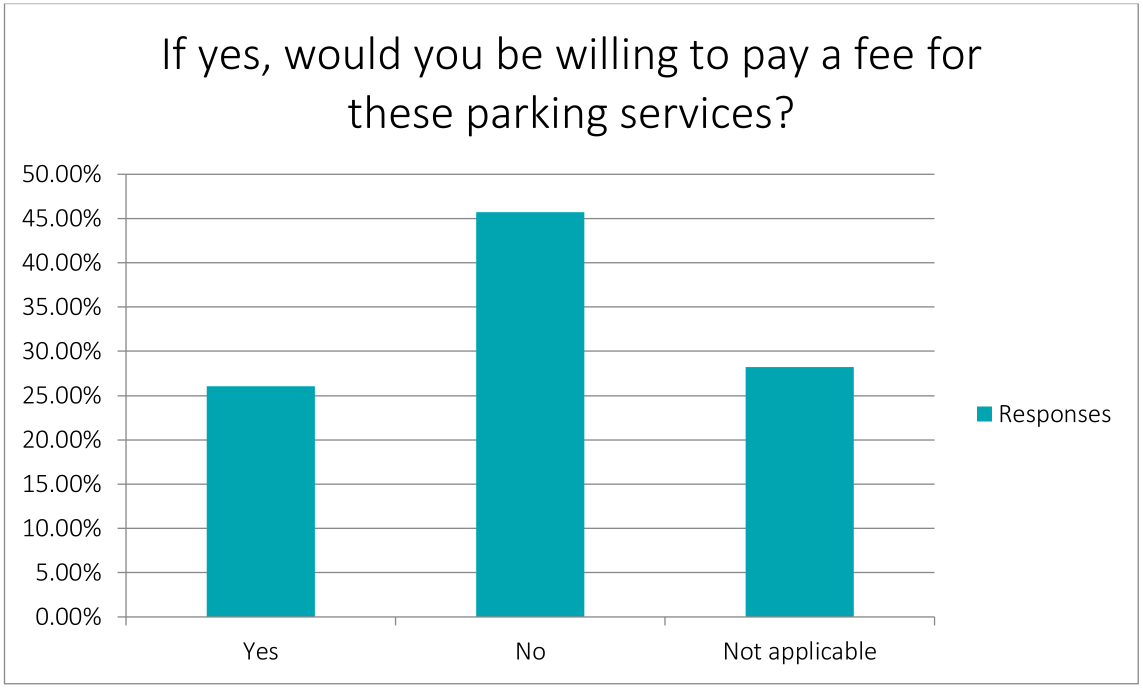


Respondents	Other (please specify)
1	I drive and take public transit interchangeably depending on the needs of my job
2	Company vehicle

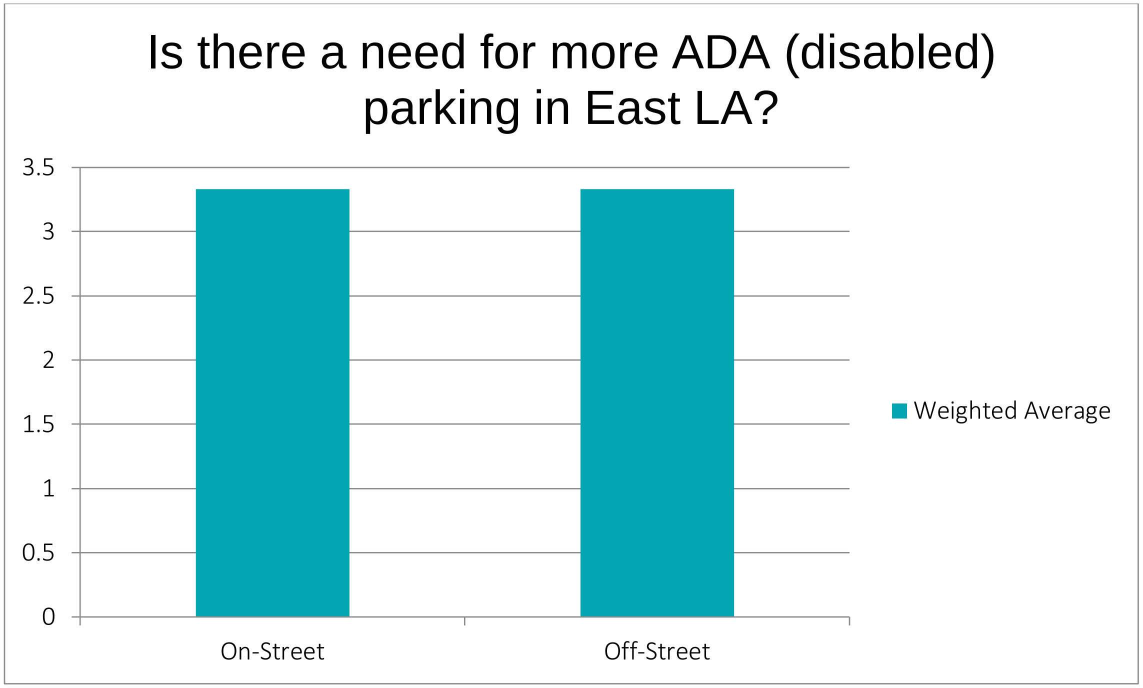
Question 20


If parking were made available to you in the evening at a location that may require a bicycle, scooter, or shuttle ride to reach your home, would you likely use that parking space on a regular basis?
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Yes
No
Maybe sometimes
Responses

Question 21


If yes, would you be willing to pay a fee for these parking services?
50.00%
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Yes
No
Not applicable
Responses

Question 22


Is there a need for more ADA (disabled) parking in East LA?
3.5
3
2.5
2
1.5
1
0.5
0
On-Street
Off-Street
Weighted Average

Question 23 - Please provide address or closest cross-streets to your home.

Refer to Figure 20 for a reference map. Actual addresses not shown for the privacy of respondents.

Question 24 - Please provide any additional comments that you may have regarding parking in East Los Angeles.

Respondents	Responses
1	Parking was fine onwoolwine till they put no parking signs on one side of the street forcing all those vehicles to find other parking alot of cars are also abandoned there never moved all this started whe. Covid started it makes it very difficult on everyone n the situation
2	Too many red and loading zones.
3	Too many cars parked on street. Some households have up to 8 cars parked on street. This should be unacceptable.
4	I have called the ELA Parking enforcement several times and can never get a hold of anyone. And leaving a message is impossible, the voice mail is always full.
5	We need help in contacting street sweeping. answers we may have .
6	They don’t give tickets for expired tags or abandoned cars ... parking violations are not unforced ..
7	Cars that dont run that are left parked in one spot until it's time 2 move them for street sweeping.
8	I support parking enforcement issuing citations and tows to repeated offenders.
9	I feel that there are too many cars that are out order and are just move from side to side to prevent tickets from street cleaning. Those cars need to be removed.
10	Implement marked street parking spaces to prevent cars from parking too close to driveways and intersections.

11	Need to actively clean up and remove excess cars not operable. They are an eyesore
12	Not enough parking at businesses. 2-3 metered parking would help. Parking fines should decrease in amount. Over $50 is too high.
13	There's neighbors that park there cares that they don't drive to save parking. They double park.
14	Too many cars per house hold and people outside the area park cars in front of my home and drive off with someone else
15	Low income families with cars that are inop leaving cars collecting webs on street
16	People in East LA sometimes space their cars too far apart and it waste space. There are also a lot of commercial trucks with junk in them taking up space on residential streets.
17	There are many households that have 3-4 cars and all of them have e expired tags/ registration and are parked on the street, therefore there is no available parking on the street, would suggest looking into that
18	Help us with this parking situation it's really bad
19	Na
20	The parking problem could be remedied if property owners are encouraged to clean up their existing garages and use these spaces for car and not for storage. Also, the city allowing people to convert their garages into living spaces is not helping matters. I have a neighbor that has 7 cars and he was allowed to convert his garage into a living space.
21	Asking supervisor solis and the planning department to issue residential parking permits. also need pay per parking space meters on whittier blvd.

22	Unless sufficient parking enforcement is maintained, parking issues will not improve only worsen.
23	I believe residents should be educated on the parking testrictions for example, can't park close to or block driveway. There are markings on the street and residents either don't know but the majority of the time don't care.
24	There are many unused vehicles taking spaces. Many vehicles belong to 1 address.
25	there are too many inoperable vehicles and campers parked illegally without valid registration and we need the street sweeper to clean the streets. our streets are filthy!
26	City help to add second driveway for 2 homes on a lot. Reserved parking I'm front home for at least 1 car
27	home parking space is used as car storages for non working cars for years. Limited number of cars per household should be implemented my neighbor has 3 parking spaces in their home whichvthey use plus have 7 cars parking on street
28	I really wish parking enforcement would do their job. There are so many cars that park on corners blocking the view of intersections and ada corner sidewalks. Cars double park over night. There really should be a night parking enforcement. There would be so many violations and you can use that money to pay for other East LA city improvements. Treat us like we live on the westside and get this situation in order.
29	Parking enforcement should cruise in the evenings also
30	There are some businesses primary from mechanics that leave the cars they're working on, on residential parking
31	People who don't live in the neighborhood park here, making it harder for the residents that live in the neighborhood to find parking once coming home. Although we do have neighbors who don't use their driveway instead they prefer to park on the street. They usually hold their most prized cars or cars they don't use in their driveway.

32	I have lived in East LA for over 25 years. I am a homeowner with 2 garage spaces for our cars. However, despite having parking off street, it is almost impossible to find a parking space close by. If we have get togethers with family members, we have to encourage them to Uber because of this huge problem. Please help us with this problem.....it's long overdue.
33	Cars are left from local body shops
34	Illegal parking in alley is a big problem
35	There are too many houses that are converted to apartments and do not provide sufficient parking for all those tenants. There should be dedicated handicap parking that is assigned to the households that need it, too many people have handicap placards that take up all the handicap parking with a few blocks of the area for those who actually live there and need them.
36	One households have to many cars. That’s why it’s hard to fine parking and broken down cars.people always double park too.
37	North Bonnie Beach is primarily single home residents, it is in recent years that parking has become an issue. Possibly reasons beyond the scope of what the County can do, for example almost anyone can finance a car so we face too many cars on the road.
38	We have a lot of renters in the community and renters do not often have control over parking, especially when the property lots have been jam packed with housing stock and no parking. Additionally, the persistent economic disparities have continued to force many adults to live with their parents or other family members, thus increasing the number of vehicles in the area. Any parking solution must focus first on getting individuals with access to parking off-street to utilize it. Then we must focus on viable solutions that do not further punish those at the lowest income bracket which includes parking structures off site offered at no cost. Make it easy for people to offload their non-working vehicles in order to make room for working vehicles in their driveways and on street. Increase the number of building inspectors to ensure that when new housimg stock is being constructed it includes adecquate parking.

39	Lots of people parking Their cars in the middle of the street making it very dangerous For drivers... the round abouts took away many parking spots as well
40	There are some landlords that rent out homes to people that aren't immediate family and there may be more than five adults in a small home but everybody has cars to park . Parking was fine in my neighborhood up until a couple years ago when it started to increase and more recently when Herbert Circle was closed off, which is understandable especially when city workers need to drive through in the circle was overcrowded or double parked. also some kids are still living at home but they own more than one car at their age and it's not for work purposes. I think we need a parking lot nearby or what would really be helpful is a shuttle bus that would come up the hill by Herbert Circle if that's possible... That would make it easier to jump on the L soul bus and go downtown.
41	Feel free to call me with any questions at 626 533 0044. I have lived in City Terrace for 52 years. My name is Donna. I am glad that the County has recognized this problem. I hope it can be remedied.
42	Please do something about it. We have big metal collection trucks that are getting bigger, heavier, and unsafe taking over the streets.
43	Please do something. It feels like just talk and nothing gets done.
44	McDonnell Ave, between Telegraph Rd. and Olympic Blvd, lacks residential parking because of the car repair shops in the area take all the street parking spaces. Their cars are only moved when on street sweeping days.
45	We shouldn't have to pay for parking within our community. Please ensure there is rent control so families do not have to live together in order to afford rent in this area. Also, multiple homes in the area have been converted to apartments that has also effected our parking situation on the street. Majority of our neighbors respect one another's space in front of our homes. Also, it should be noted this area has older style homes where the driveways are too narrow for us to fit cars down them.
46	I strongly suggest Parking Enforcement pick up their slack and enforce parking restrictions. I guarantee you they would enforce it if we were in Beverly Hills or some rich neighborhood. Start with getting on the Sheriff's ass about doing a no tolerance enforcement for the rest of the year

	and see if that works. We shouldn't have to be begging our public servants (Sheriff/Parking Enforcement) to do their job. And it shouldn't be like trying to pull teeth to get complaint addressed right away. It's ridiculous! DPW also needs to update the infrastructure to fix the parking issue. This
47	On the call it was mentioned that driveways were found not being used. Couldn't that be because someone was on vacation (like my roommate for 2 1/2 weeks) or they don't have a car, their car is too large to fit in their driveway, or they work later or earlier than when the observation was made? I think the residents with more cars than drivers in their household should be addressed. On our street one household has 7 cars and 4 drivers - unfortunately they are the most vocal when the street parking spot they claim is theirs is taken and their argument is that they pay taxes so it's their space.
48	Parking becomes hard to find after 5pm, I have to plan my day to not go out after that time to avoid losing my parking spot, and at times it is inevitable that I must move my car and when I come back home I have to park 3 to 5 blocks away from home which is dangerous because I have been followed and I practically have to run home because I feel so unsafe, my son works night shift and same issue, no parking which at times we have no choice but to park on the red spots close to the intersection because of the lack of parking and for personal security
49	parking wars!!!
50	Many mechanics leaving cars out on the street to fix that take up space
51	Most households have more cars than licensed drivers.
52	It's completely unfair that so many people have cars parked on the street that are never used and or for sale as a business taking up parking on the streets. some people take advantage that street parking is free. A parking permit might be a way for people to get rid of unused cars.
53	We recently lost 50% of our street parking & our street parking was already tough. Now when I return home I regularly have to park 3 blocks or more from home. I have to walk on streets without sidewalks at night with my kids hauling groceries. I got a ticket for parking in front of my

	own garage. My neighbors car windows were broken & he was sad he was parked so far from home bc he doesn't know who did it. Now people are speeding down my street bc it's a wide hill. We want our parking back. Sending the sherriff thru at 4am to give out tickets was not OK. Permits are not going to work. We pay a lot in taxes & rent - we can't afford to pay for parking like that. Please understand. Stop ticketing us to death. It's a lot. Maximize parking & minimize excess charges, this is not Beverly Hills & these fees add up.
54	Get rid of unused vehicles
55	The infrastructure in City Terrace has not been updated since 1962; and today residents have more cars per family, apart. units, on Miller Street, have no parking and struggle everyday to fine parking. We have homeowners that prefer to park on the street and not used their driveway, homeowners that have tenants that literally block their tenants from using their parking space and last homeowner selling used cars from his house.
56	Owners are renting homes to tenants with multiple families and vehicles that causes the parking problems on the streets..
57	Our home unfortunately doesnt have a driveway, we are the only home without one. Appliance store (La Segunda) located on City Terrace Dr. takes prk from residents that live on Hazard Ave, in addition to an illegal taco stand that creates a gridlock. Also neighbor selling cars from his home easily takes parking from residents.
58	We need to hold residents accountable who have multiple cars (such as 20) that are inoperable and take up as much as two blocks of space. These are violators and they need to be prosecuted.
59	Charging should be last consideration. Some renters would have no where to go. I recommend innovative parking instead of traditional parking. How about adding marked parking spot. Horizontally and vertically
60	not enough enforcement. Cars sit for days pre and during pandemic. residential streets should not be the provider of overnight parking for businesses on Atlantic and Olympic that are lacking their own parking space on their property.

61	There is an abundant parking behind dollar tree, numero uno market and 99cents store. The county should build parking structures there. There is no need to create a permit system, especially if you will be charging for it. It is the county's responsibility for the amount of development they have approved in East LA.Also, why will you be adding an extra cost to an already low-income renter community? Be considerate of the existing socio-economic conditions.
62	Appliance Junk Yard and Illegal taco street vendor on the corner of City Terrace Dr. and N. Hazard Ave. are a big cause of our parking situation. Also, neighbors who have car sales business and take up all the parking for their cars to be sold.
63	LA residents shouldnt have to pay a fee to have parking for their cars. You cannot survive in socal without a car and you need parking for those cars. A parking structure is a horrible idea , this just means more cars are going park there for shops and dining & it will not center the residents
64	There is plenty of revenue being generated from citations, therefore, I see no reason to have to pay for parking. In addition, I am not a proponent of parking permit districts. While conducting your study, you must see that we have many businesses, schools, churches and residents, and parking is an extreme problem. I am also concerned about the cars that are parked for sale in front of Anthony Queen Library on Hazard Avenue. Another thing is NO MORE BUILDING if you cannot provide ample parking for the new building development! Thank you.
65	We are not sure if all of the 'ice cream trucks' are operable that are parked at what seems to be a parking lot for these suspicious vehicles that are like 'food trucks'. The trucks are not only noise nuisances and air pollutants, but they also are not up to health code and seem to be a front for other shady exchanges of 'things' in and out of the trucks. I attached a photo of one of the trucks, that very clearly has an address for an Ice Cream company (Huerta Ice Cream) based in Montebello. We saw the ice cream truck block a street for some time, as it backed up into a driveway of a residential home on Bonnie Beach Place, near the William R. Anton Elementary School, where we noticed another supposed 'ice cream truck' parked. These trucks often have very odd, creepy art and images on them, as well as graffiti. They look rusted, beat up and definitely condemned. We have also noticed neighbors of ours, visit the trucks on the street, for extended periods of time (sometimes an excess of 20 mins), not buy any ice cream, but instead exchange

	something else (often bags that come from inside the homes, and the people pass off to the truck drivers).
66	We need more street parking enforcement
67	I live down around the corner from Floral Drive, and I notice many vehicles that are abandoned or inoperable. Rodents nest in these vehicles and chew the electrical wires, further detracting from the vehicle's capabilities thereby placing more financial strain on its owner.
68	make officers keep track of vehicle abandonment
69	I live in the hills and it is very difficult to navigate here due to visability issues when making left turns. There are many accidents on both Rowan and Gage Avenues due to this problem. Cars obstruct the drivers' view and the speed at which cars are driving also impact the safety of both vehicle drivers and pedestrians alike.
70	I think before they built the new middle school on Kern/whittier blvd they should have built a parking structure. There is not enough parking and the school will really impact the parking issues. Also many cars park on the corner of a street blocking the sidewalk making it difficult to cross the street. In the evenings it is impossible to find parking. Many broken down cars are on the street and need to be towed. Landlords need to allow residents to park inside also. My landlord does not allow us to park inside, so I rent a garage for $75. My vehicle does not fit in the garage, but it saves me a parking. At times someone would be in my parking spot, I have called the police on occasion. More parking enforcement on weekends and in the evenings is needed.
71	how to encourage those that have driveways or land on property to park there.
72	Every neighbor in this block has more than 2 vehicles per household.
73	where practical driveways can be expanded sideways to create additional parking. These are called driveway aprons. It will make the front yard lightly smaller but it week ease the parking. Perhaps the county can offer a property tax break equal to the cost of the apron.
74	I completely disagree with East LA having a parking enforcement fee. Why is this information not going around to our spanish speaking neighbors? Many of the decisions that have been taking

	place are only accounted for those that have access to internet. many of our spanish speaking community don't have access to a computer so I feel it is highly irresponsible to create a survey that is only limited to a few individuals.
75	permits won't solve the parking issue...the issue is too many cars to a home and not enough off street parking available
76	Street parking in our residential area specifically where I live 1226 Van Pelt Ave is dangerous. Cars speed down on our street, putting in danger children that live near by, cars are parked on the sidewalk, double parked next to each other, making the streets narrow with limited space for cars to drive through. My house hold as experienced two instances where our cars have been side swiped by speeding cars. In addition to a parking solution, our neighborhood/ street need speeding signs and should consider the option of speed bumps. Our neighborhood deservers a safer living environment. With our narrow streets, I don't see how emergency vehicles like ambulances or fire trucks could make it through our streets. This seems to be developing as a bigger problem than I realized. We need a solution. Thanks.
77	People aren't respecting driveways anymore, always blocking residents. I really encourage Parking Permits.
78	Permits will be the only thing that will solve parking, as well as getting junk cars off the streets, there are so many of them that haven't moved in months
79	There needs to be some sanctions for funeraria Latino Americana on Whittier Blvd/Alma Ave bc they park their funeral vehicles on my Alma between Whittier and Verona, plus tell their patrons to park at Salazar Park
80	We need parking enforcement officers to make regular rounds in the hills of City Terrace. You make great plans but people do not follow the rules after 5pm or on weekends. Also, please encourage people to clear out their garages and to park in them. Dumping is also a huge issue. People cannot park because there are mattress and dumped furniture throughout N Gage and City Terrace Dr.

81	More street cleaning.
82	None
83	Parking in East LA is an uncontrolled nightmare. Residents and visitors alike, know very well that parking enforcement is virtually non-existent and thus there is little to no regard for posted parking restrictions. Parking enforcement, itself, needs to be enforced.
84	Too many apartments are being built with not enough parking spaces. A lot of landlords do not allow their tenants to park in the property.
85	People double park, and those who have space in their driveways prefer to use street parking, cannot understand why
86	It's getting infested with unused vehicles.
87	N/a
88	To many people with to many cars that are not being used at all an don't get moved.
89	double parking is starting to occur and has been causing traffic and small accidents due to no parking
90	Too many illegal rental units that do not provide parking for their tenants. Extreme problem with double parking, literally empty cars running, while dropping off kids at a home daycare that offers no parking. People using disabled spots as reserved parking, sharing a disabled plaque, telling neighbors door to door not to park on disabled, and keying and spraying cars that park in the disabled.
91	Many homes have been converted into apartments, which now include homes holding more than three adults, and with each adult that is at least one car. Perhaps there is a way to make a rule where property owners have to provide one parking per adult living on the property. Figure out a way to reduce illegal room additions/ without permit which is probably why there is an influx of vehicles, and less parking on the streets.

92	1. Owners/tenants should be enforced and encouraged to use all the available space they have within their driveways or garages to minimize the over crowded street parking for those that do not 2. Over sized trucks such as produce, ice cream, trailers trucks should not be allowed to use regular street parking especially if it's not in use 3. Towing should be enforced for street cars/trucks parked with expired tags
93	Not enough parking should do paid permit parking , fully support that as some people have way too many vehicles and constantly block driveways
94	Parking is really bad something needs to be done with people who have big business trucks they should find parking somewhere else as far as other tenants should only be allowed one parking space per car and not take other peoples parking space and leave car for days is ridiculous that you could not even park on your own street parking because you have tenants who have more than 6 cars per house hold member and occupied entire street
95	Biggest issue for me is non operating vehicles left on street and similarly, people with multiple cars leaving their excess cars outside.
96	Parking in East LA is bad . The cars are always blocking cross walks or sometimes even the curb ramp and that's something the city should really enforce because of a handicap person falls because the ramp was blocked that would be a lawsuit . And sometimes you can't even see on coming cars . That's why there's so many accidents now in residential streets because you can't see on coming traffic. On my street some residents just show up and double parked and leave there cars all night till next morning . And they never get ticketed. I recommendation is to implement parking permits and that will open up parking . Cuz many persons use the street parking as storage.
97	I believe part of the problem is multiple families living in a single family home. Also too much population density. The building of apartments and/or condos where single family homes once stood is a big part of the problem. I'm seeing three and four unit buildings in R-2 zoned areas.

98	I understand it’s their job but parking enforcement give out so many tickets way too often. It’s dangerous for women to park so far and walk to their house if they work night shifts. I have struggled with being followed and harassed because of lack of parking
99	Many people are selfish with parking, taking up whole blocks (moving cars to tighten space for parallel parking, not allowing others to park)
100	Stop these used car dealerships from parking their cars on the Streets and you will solve a big chunk of the parking problem. CHARGE them for parking permits. And apartment renters- charge them for permits if their building doesn't have parking. 6 people in one apartment and each one has a car, and there's 25 + apartment buildings with 20+ units - you fo the math!!!! So between the apartments and the used car dealerships home owner s have no extra parking!!! I've lived here over 50 years - my mom more than 70 years so we know what its become. Check out West Hollywoods permit parking!
101	No RV parking in residential neighborhoods
102	Double parked vehicles and ice cream trucks create a hazard by forcing other cars to go around them and into on coming traffic. I would like to see CHP involved in this survey in addition to parking enforcement and LASD.
103	Paid parking
104	There’s no enforcement of the no parking zones so people continually park there blocking my in my drive way
105	Most households around me have more cars than licensed drivers.
106	The City should cut down on people operating Mechanic shops out of their homes
107	The ongoing issue on parking is due to neighbors double parking. There is parking spaces that can fit up to 3 or 4 (depending on car size) cars. Instead neighbors double park in spaces purposely occupying just the right amount of space that doesnt allow another car to fit. I must add that moat of the neighbors that double park also have they're driveway unoccupied which would make more parking available.

	Also there are commercial trucks and tow trucks that are parked in residential areas. Many cars that are unused and Non Operating Vehicles have been parked for months
108	There is too many cars, too many houses/ residents in one house/ per block. I believe it's a density issue and the lack of efficient public transportation. Many residents have cars that don't operate and take up space. Many vehicles park blocking the intersections and pedestrian walkways/ curbs.
109	We limit ourselves to leaving due to losing parking, no one likes to visit due to parking, there's a lot of car non-operated parked, a lot of auto mechanic activity going on and cars left for days.
110	Painted lines on street would help with parking, so people don't park midway to "save" stops, or be in the shade.
111	People just don't care, they park in red, they block other people's driveway. They block fire hydrants, they park on sidewalks
112	Neighbors purposely park many cars on the street even when having driveway also residents from 2 blocks away park their cars and dont move them for days as well as some neighbors double park to save parking and some neighbors get upset if you park in front of their home on public street and they proceed to throw dirt or trash on your cars or stick nails in your tires.
113	I would like to have my own designated space in front of the property, I do not mind paying for my spot. This would help with trash day and provide at least 1 space for the tenant that has 3 cars. I provide my tenants at least 2 parking spaces and inform them that if they need parking, to put in their car in the property. Some of the property owners never provide their tenants parking. I fight with people that live a block away coming to our block to park their car, the issue is them moving my trash cans when I have them outside my home (1 space). This is a huge issue in our block!!
114	On my street there is a neighbor who owns an auto body shop down on Eastern & Floral but he parks all of his Vehicles that need repair on the street. He has taken up at least 5-6 spaces on the street. If he would store his vehicle that need repair at his shop there would be so much more room on the street.

115	I don't support paying for permits, the problem is the area has a lot of renters vs. homeowners now and these people have like 4-5 cars per house. It's ridiculous, especially the people who's business is metal pick up or junk removal services. They have big trucks that take up more parking space.
116	Na
117	non operational vehicles up to 5 , same spot. Doub
118	Previous tenants that have junk collecting trucks leave them parked here overnight then come and park their car during the day to take junk truck during the day.
119	Need more parking
120	too many people from other block away Park a vehicle taking 2 spaces so that they have a space for their second vehicle.
121	no permits needed, ban trash can placeholders and double parking.
122	Too much dangerous overcrowded housing causing parking wars.
123	Lots of non operational cars both on the streets and peoples driveways .i find this behavior very ignorant.
124	There should be a parking structure built on the large chunk of land that contains pure empty field. Specifically, between Hay St. and Brady St.
125	I don't understand why you think that charging me for public Street parking is the solution. You are taking away my right and charging me to take it back. Unheard of and ridiculous.
126	N/a
127	Neighbors having more than 4 vehicles and Parking them on the street when they have a driveway available to them. Local mechanics or repair business' parking their clients vehicles on the street.

128	people having multi cars that doesn't have tags. Cars not working.
129	Several RVs set up as permanent residences by Evergreen Cemetery, Superior Grocers, and one RV has been parked on Michigan & Eastman for over 15-20 years.
130	Our neighbor has two cars which he rotates in the spot in front of our home so it's never available. People double park all the time. Our driveway is blocked at least once a week. It's ridiculous! Something needs to be done about it. INSTALL SPEED BUMPS TOO! So much speeding!
131	We need something done about the motorhomes being parked on the streets in the area, they take up too much space.
132	Broken down vehicles, businesses vehicles should NOT be allowed on residential streets.
133	I really think parking permits are needed. I sometimes have RVs parked in front of my house. Also many people rent their garages and have multiple cars parked on the street when they are never driven. Or too many cars for 1 household. Parking permits should really be given based on house size. There's no need for 6 cars for a 2 bedroom house. People also need to utilise their own garages.
134	Neighbors only move car for sweep and then park the rest of week
135	Too many cars on the street
136	I do not believe that residents paying any additional fees is wanted or necessary. There is already city/county money for this. Do not make residents pay!!
137	I hope this survey actually helps and fixes all the problems that the police and parking enforcement ignore because this is not the west side
138	People have like 4 or even more cars that they never move! I don't know if the cars don't work but they've been parked in the same spot for 6 months now since this COVID situation started

139	If permit parking went into effect, I would support being able to buy an overnight pass or weekly pass.
140	Parking in East LA is horrible. There are many people living in these homes. They don’t use their driveways at all.
141	Car dealers need to move there cars onto there lots homeless in tailers living at park and sce building and schools provide parking for staff and pick up students not through residential area. Residents deserve peace and quiet throughout the day. Kipp uses speaker at 745 am shouting at students have many seniors and people who sleep in the moringa due to working graveyard shifts. And be woken up to hearing " Whos in the house" and kids screaming cheering the teacher on , Hear nothing from Garfield,St. Alphonsus or 4th street school.
142	This issue needs to be resolve ASAP
143	It's harder for elderly because we can't be walking at night alone when we have to park a block or more away because we can't find parking on our street. Property owners should be made to supply parking spaces to all their tenants, should be a law.
144	To many families park on the street instead of in their driveways
145	Parking issue needs to be resolved ASAP
146	Need permit for gold line users park in the neighborhood to avoid parking structure fees for parking
147	To look at parking in isolation is scary. The earlier move that has allowed for increased units has resulted in tremendous paving of front yards to make parking. We cannot sustain that effect. It is ugly, bad for our neighborhood, and the environment. No one cares - we need to start educating and enforcing the code on hardscape.
148	Illegal added housing adds more cars and they do not provide on property parking
149	Parking is EXTREMELY 👎 we definitely need help

150	A lot of the issue in my community is homeless people who are living in their vehicles and spreading out to other parking slots and onto the street.
151	Parking closest to my residence is only option for me. If this cannot be met then I am not interested in parking permits and rather take my chances.
152	There are way to many cars on the streets. Especially at corners. Making it very difficult to see cars coming in either direction when trying to cross an intersection.
153	Parking on Sydney is way out of control ever since they started parking on both sides of Sydney.
154	For many years we have asked for permit parking and it has never been addressed. My owns a triplex that has its own driveway and at times we cannot access our own driveway since other cars will block it. We have lives here since 1962 and it is a pitty that street services are provided only with the bare minimum. We have requested speed bumps since my father was murdered in front of this residence due to a gang initiation. We were denied that since the street didn't qualify for it. A murder did not justify speed bumps. Parking is TERRIBLE on our street people stalk the street sweeper and if we wait until 3, the proper time to put a car on the street we will have no parking. Woods avenue between telegraph and Atlantic is terrible. Help us reclaim our neighborhood, the place we love and call home.
155	A lot car park on the street use them for storage or not move them for days
156	I 'm worried about the growing number of loitering on Escuela St. Cars come and go and leave food container trash, marijuana dispensary containers, alcohol bottles, used condoms, etc. My block wall gets vandalized often. Parking should be okay but not to hang around and trash the street. I once witnessed a couple park and have sex in the back of their vehicle. Grocery carts are left on the street or sidewalk.
157	house hold have 5-8 cars, some do not use driveways some hold spots. I work 8 hrs drive in some time traffic to get home and not parking

158	Although I have a driveway, I strongly feel I am entitled to street parking. As a homeowner, I pay taxes for the repair and maintenance of the street. Landlords and developers should be required to provide parking for tenants.
159	Constant monitoring by Parking Services to ticket vehicles blocking Fire Hydrants, Street Corners painted red (limiting turning visibility) and double parking will make large revenue for the community if performed correctly. Part of the problem why people are inclined to repeat this behavior is most likely because there are zero consequences to this behavior. Also, neighboring businesses might need to allow 'permited' parking in their parking lots if they are walking distance to nearby households that are impacted by family/car size. Permits may allow easy enforcement for after-hours monitoring. Thank you.
160	Because there isn’t any restrictions with the Parking other than during street sweeping days, people take advantage of the parking.
161	Please enforced abandoned vehicles, fixing vehicles, and RV on residential blocks. Huge problem on 400 N. Alma Ave
162	Too many run down cars and illegally parked trailers are the biggest problem.
163	It should be control as to how many vehicles are own per household not more than 3 vehicles
164	The biggest issue we have with parking is people not using their drive ways, ppl parking from other housing units and currently people home because of the pandemic and parking enforcement still issuing tickets with no place to park!!

165	I just want to be able to park in front of my own house and not have to worry about my neighbor taking my spot.
166	If permits are required, what would happen when we have family gatherings. Parking would be a nightmare and for my guest to get temporary parking permits would be a nightmare. What is suggested in those cases. I would recommend an online permitting app
167	There's way to my cars per residency !
168	People are over crowding houses with adults that drive. Adults have more than one car and use the street as a used car lot to fix, wash and store unused cars.
169	So many cars not enough parking
170	Having something like this will help fix parking issues especially because many vehicles that are parked there aren't moved at all.
171	Parking enforcement needs to remove all abandoned vehicles and give tickets for double parking. Also, there are 10 cars to a household which makes me hard for everyone to find parking. Tickets for people who double park.
172	A lot of people own more than 4 cars and only two people drive also homeowners should have more privileges than renters on the parking situation
173	we have to reduce the amount cars on streets. There are way too many families living under the same house hold so their for they all have cars and its not fair! start strict permits and fees you will see how quickly it cleans up
174	Using empty land as a parking lot
175	I think my biggest gripe is just that people will park a car for 2-3 days even more without moving it. When authorities are called...nothing gets done.
176	The parking in East LA sucks ! So after 3pm you have cars parked on red, or on fire hydrants double parked as well on some streets And on the intersection corners you sometimes can even

	turn or see on coming traffic cuz there's cars parked there as well . And seems like everyone knows that parking enforcement doesn't operate from 5pm to 4:30am everyday and off on weekends cuz that's when it's completely worse . I think 2 permits for home will be great cuz it will also get people to put there cars inside . For example there's neighbors that have like 6 cars and don't put none inside .
177	Parking permits I believe are not the answer. This will only cause financial hardship on certain residents, and with so many residents living in converted living spaces, they will only start to park on the properties lawns etc...there is just not enough space provided anymore on residential lots to park cars and precious space is taken up and cars are no longer viable to park on properties.
178	Too many people per house. Too many homeless people living in RVs.
179	It's not always safe. There isn't good lighting. Too many residents per household is the main issue. Not enough room for everyone.
180	No Rv parking
181	Crack down on people living in unpermitted garages.
182	There are cars parked on the street for month. There is no patrol of parking or enforcement.
183	enforce regulation of large vehicle parking
184	Saving parking by double parking.
185	Some people have more than 3 cars taking up street parking they never move them , or most double park
186	Too many properties with mechanic shops in their homes, taking parking spaces. My neighbor parks 4 cars in a 2 space street parking. 1 blocking sidewalk the other at the entrance to the street. Clearly a citation!!!

187	Households have plenty of parking and hardly anyone parks inside also most neighbors will double park to save a spot and only move at their convenience!!!😡😡
188	Something has to be done about the parking situation here. Parking enforcement is a joke. I have had problems with people parking in front of my driveway and I have had about half dozen cars towed away in the 10 years I have lived here
189	Cars parked on corners or red zones make it dangerous for cars to make right and/or left turns. Cars double parked on the street overnight
190	It is very hard to find parking at any time
191	Vehicles that are being used as a business, for example pick-up trucks that have been modified to be used as metal collecting or gardening, should not be allowed to park on residential streets.
192	The safety of our residents is vital. There are to many cars that make it very hard to enjoy the neighborhood safely.
193	I SEE A LOT OF RESIDENT THAT HAVE DRIVE WAYS AND INSTEAD OF PARKING THEIR VEHICLES IN THEIR DRIVER WAYS THEY HAVE CLUTTER OR TABLES AND THE FAMILY HAS 4 TO 6 CARS AND THEY ALL PARK IN THE STREET WHICH TAKE SPACE FROM HOMES WITH NO DRIVE WAY OR LIMITED DRIVE WAY SPACE.
194	Too many cars in one household and they take up 2 spots and dont consideration for anyone. Cars are often broken into
195	Cross walks are blocked making street crossing dangerous. People double park.
196	It affects the quality of life in City Terrace. It makes our streets unsafe for pedestrians and drivers because the cars are so full of cars. On numerous occasions, the fire dept hasn't been able to get up here for emergencies. A car ran into 3 vehicles.

197	Too many disabled (ADA) parking spots not in use from no longer living residents, causes issues such as illegal use of parking spot or no use of parking at all.
198	To the planning staff, please please please recommend at the top of your recommended interventions for residential parking permits!
199	I would recommend marking out the parking spaces. Any car taken two spaces should be fined or towed.
200	Create a permit system to allow parking in Belvedere park between 8pm-8am. Charge a fee per month or per year, use the fees to pay a security person, even though its next to sheriff's Station. And use the rest of the fees to fund other parking issues
201	Mostly concerned with an unnecessary amount of street sweeping and non operational cars
202	I would love a permit based parking. Also, we should not be allowing RVs/Motorhomes to park on the street over night. They take up multiple spaces, and when parked close to an intersection makes it impossible to see oncoming traffic. Similarly, vehicles that are primarily used for business should not be allowed to park overnight. We need to save the spaces for resident and their guests.
203	To many cars per household and some are non operating. 10 plus cars per household at times. You even see people doing mechanics to cars on streets. I would be happy with permit parking and road humps. We live in the hills and people drive so fast up here. Not safe for our kids.
204	This parking situation is ridiculous. People park 5 or 6 vehicles per home. and they don't use their off site parking
205	Residential buildings should not be given a construction permit if enough parking spaces are not part of the construction. Too many apartments around my neighborhood and not enough parking.
206	Parking not the issue for me as much being able to leave in the morning and evening from my driveway. Of course once we get back to normal again it will become a problem again.
207	Parking is an ongoing and chronicle problem in Unincorporated East LA. There are several cars per household and many do no use their driveways or garages - many times because they've used it for

	storage purposed. I do not believe parking permits are the answer and if selected areas opt in, it will only push the problem out to surrounding areas/neighboring blocks. I am in favor of STRICTER parking enforcement to begin setting a precedent of parking etiquette, such as NO double parking, no parking in the red zone or blocking water hydrants.
208	Limiting multi-car households taking all street parking is essential. Neighbors have 5 cars!
209	Lots of cars parking in their driveways which block pedestrian, wheelchair and stroller access to the sidewalk, you have to go into the street with your wheelchair and strollers (on trash days you have to go out more into the street) making it very dangerous but I've reported it many times and it just keeps happening. Cars are constantly in their driveway blocking pedestrian sidewalk
210	Red curbs are never respected.
211	There are too many households with multiple cars in them , and many, many people have junk cars stored on the streets (that they only move once a week for street cleaning) . This clearly shouldn't be allowed. People park illegally on corners and block sight at intersections . Also there are lots of abandoned vehicles.... and people living in vehicles. If everyone were made to get permits it would be a much better story for the people living and working in the area . We know of one household With 7 cars- and they don't even use their own garage because they use that for storage!!
212	Parking is a nightmare in our area. It's outrageously dangerous and unregulated. Parking is allowed on both sides of the street which makes the roads one way. It's so ridiculous and a obvious hazard. To get onto a Main Street we have to back up multiple times for other cars to pass. Many in the area have several cars, my neighbor has over 10. This takes up all the street parking from those who need it. There are cars sitting around that are clearly abandoned and the city does NOTHING. What do we pay taxes for exactly? Oh that's right to fund payroll for corrupt politicians. The streets are an eye sore, dangerous, and clearly neglected. We cannot even access our electrical box because the city won't designate the area no parking. Not that anyone follows the parking signs anymore I have never one seen parking enforcement or street sweeping on my block.

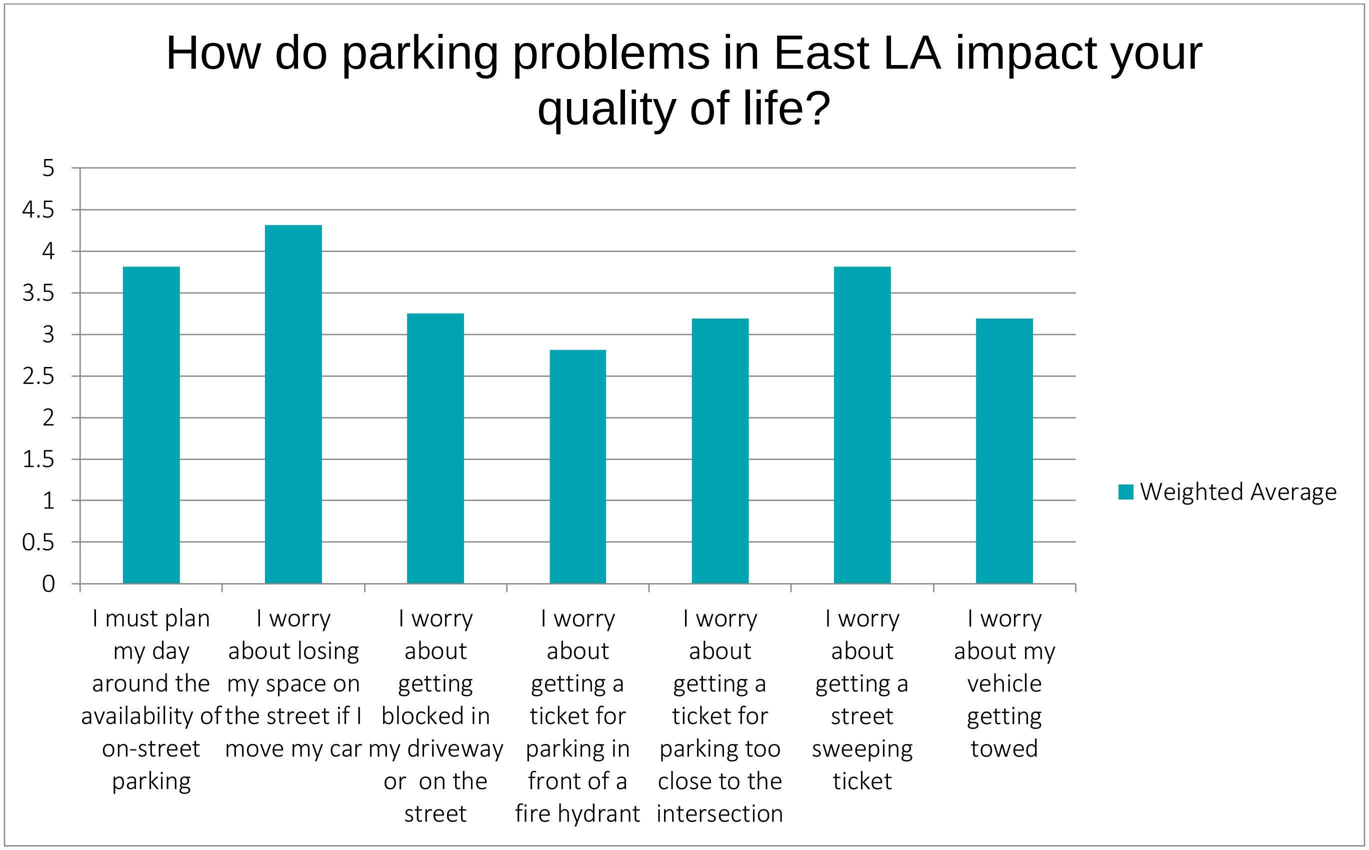
213	There are to many cars parked on the street that are inoperable ,I received a ticket for being in the Red ,and the car in front tags were from 2018 there are work vehicles and trailers parked on the street people are starting to block spaces with cones ,and trashcans ,Hilda Solis is garbage,tell her there will be a photo op on my street if she can address this ,and I bet she will be all over this
214	A lot more has to be done with people living in their cars, I’ve seen many moments of public urination and defication. It creates health hazards and public safety concerns. Perhaps create a space where folks who live in their cars can park and stay and have resources for them.
215	Not enough parking on street
216	Start regulating mechanics (home and business) that use all spaces to store their cars.
217	There are way too many “junk” trucks that park on my residential street. 5-7 each night. Full of metal and washing machines. Since Covid began, cars sit abandoned for months. Lots of inoperable cars. Lots of business on Atlantic during daytime think 1200 block of Amalia is their personal parking lot.
218	There are way too many ilegal units on properties that are being rented which creates this parking overflow onto the streets. Many many residents have enough space in their driveways but decide to saturate the street because it's easier to come and go. Also, many households have adult kids still living at home or the kid's entire family living with their parents which creates more cars on the street. I have seen many cars parked on the street that residents move back and forth to use as storage when they can park in their own property/driveway. Many are older classic cars. Time to get rid of them.
219	The parking is East LA is ridiculous. There is no enforcement and the residents know it. There are many cars parked illegally and they block driveways, sidewalks and crosswalks. This makes it impossible for people with disabilities to travel safely on sidewalks. People also park where there are clearly "NO Parking" signs, in front of fire hydrants and on the corners of intersections. It is very dangerous to drive in East LA because of the cars that are parked on the corners of intersections. You cant see cars coming or people crossing the street. People also have multiple cars with expired tags and they use these cars to save parking spots. I grew up in the city of Los Angeles and never have I been somewhere where the parking laws are ignored. It is really shocking that there is a lack of parking enforcement. When my wife and I drive in the neighborhood we play a game where we

	spot illegally parked cars and they are worth $25 dollar tickets, who ever issues the most tickets wins. Sadly there are times when one of us wins with over $1000 dollars worth of tickets in the span of 10-15 minutes. The parking enforcement needs to be implemented in East LA and using the pandemic as an excuse is not valid because parking was not being enforced to begin with.

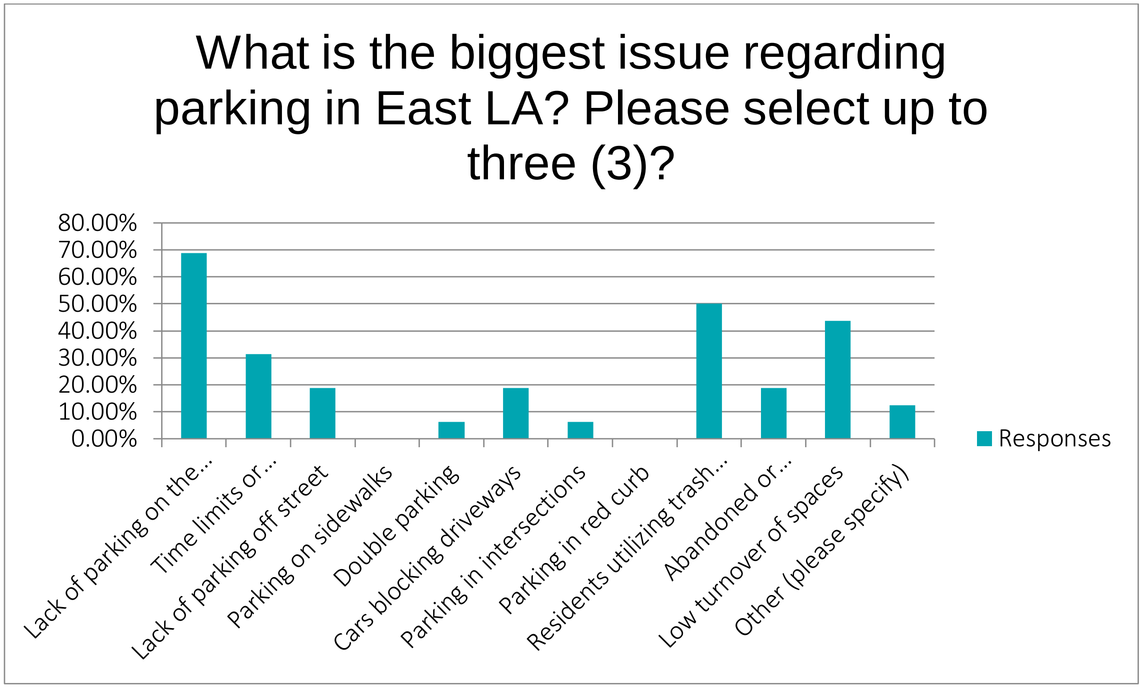
Questions 25 – 38

No charts provided as there were no respondents that answered these questions. These questions were directed toward business owners in East LA.

Question 39

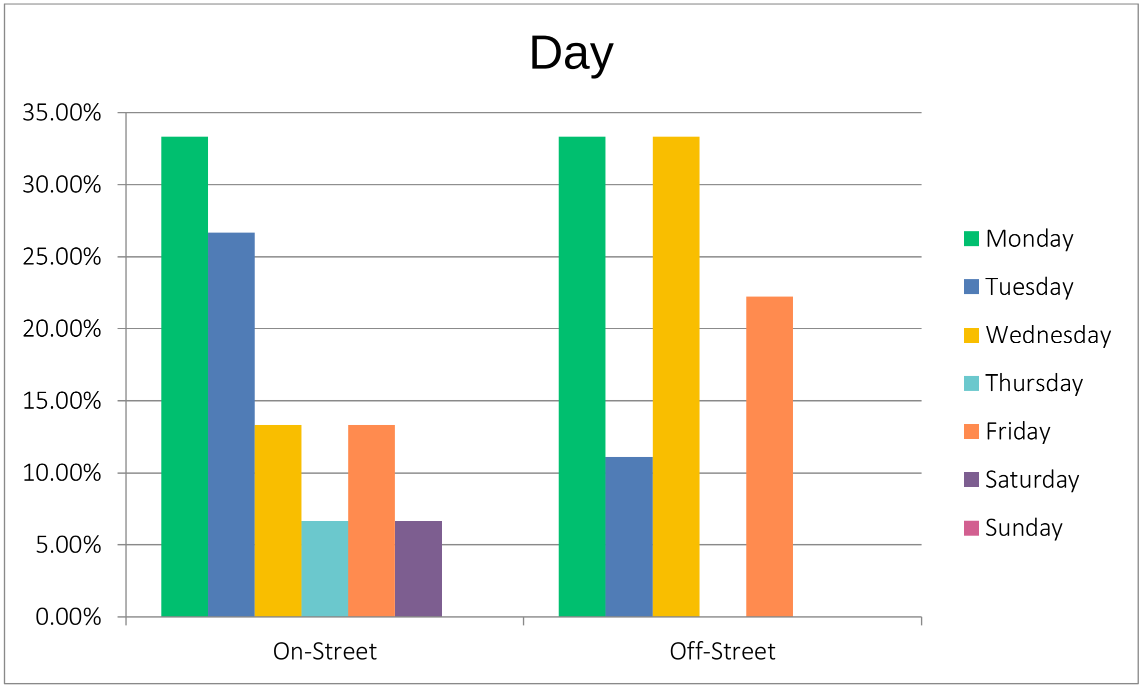

How do parking problems in East LA impact your quality of life?
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
I must plan my day around the availability of on-street parking
I worry about losing my space on the street if I move my car
I worry about getting blocked in my driveway or on the street
I worry about getting a ticket for parking in front of a fire hydrant
I worry about getting a ticket for parking too close to the intersection
I worry about getting a street sweeping ticket
I worry about my vehicle getting towed
Weighted Average

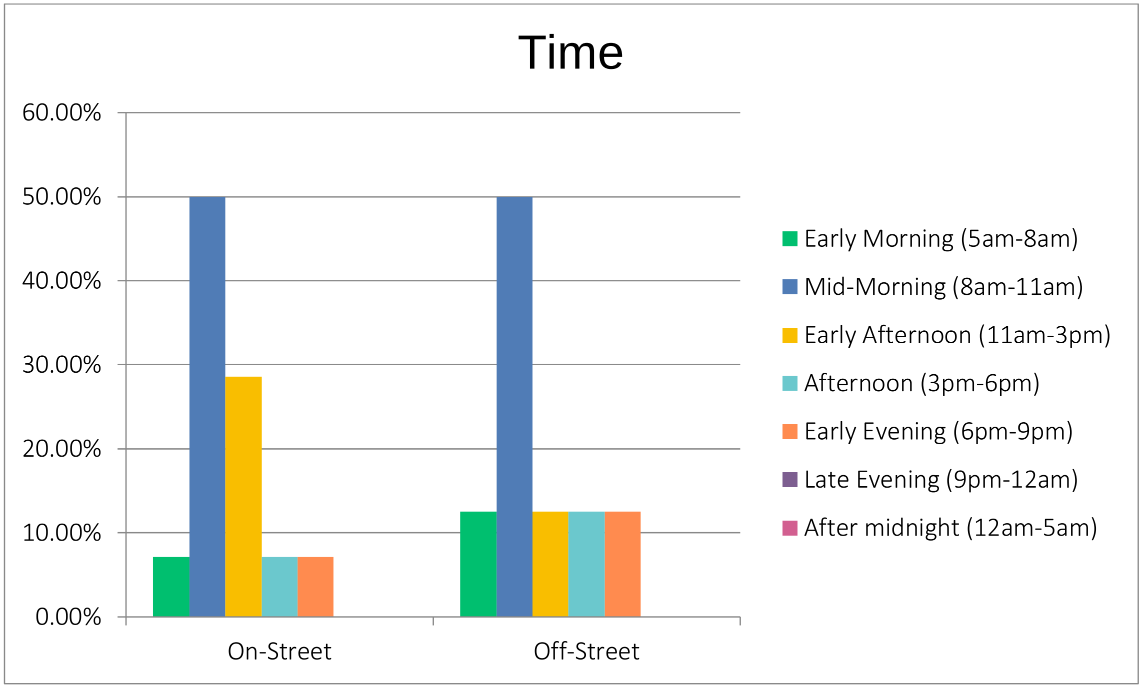
Question 40



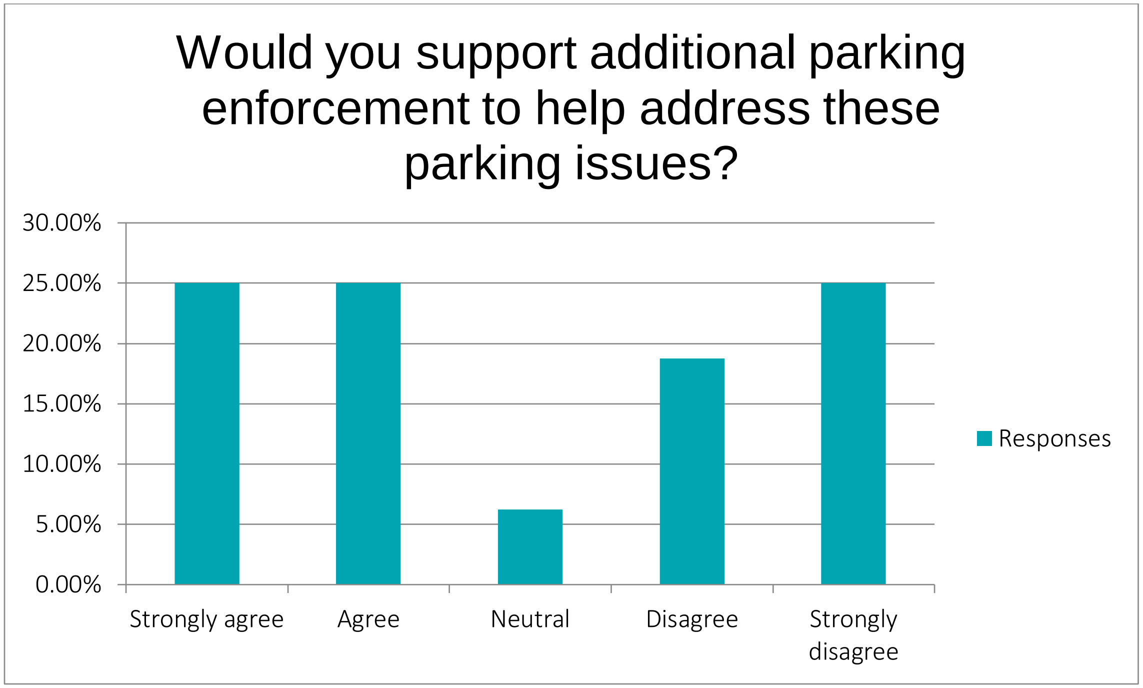
Respondents	Other (please specify)
1	Lack of available ADA parking, lack of safe sidewalks, lack of enforcement for ADA violations
2	Lack of parking on street-sweeping days

Question 41 - What day and time is it most difficult to find parking in East LA?

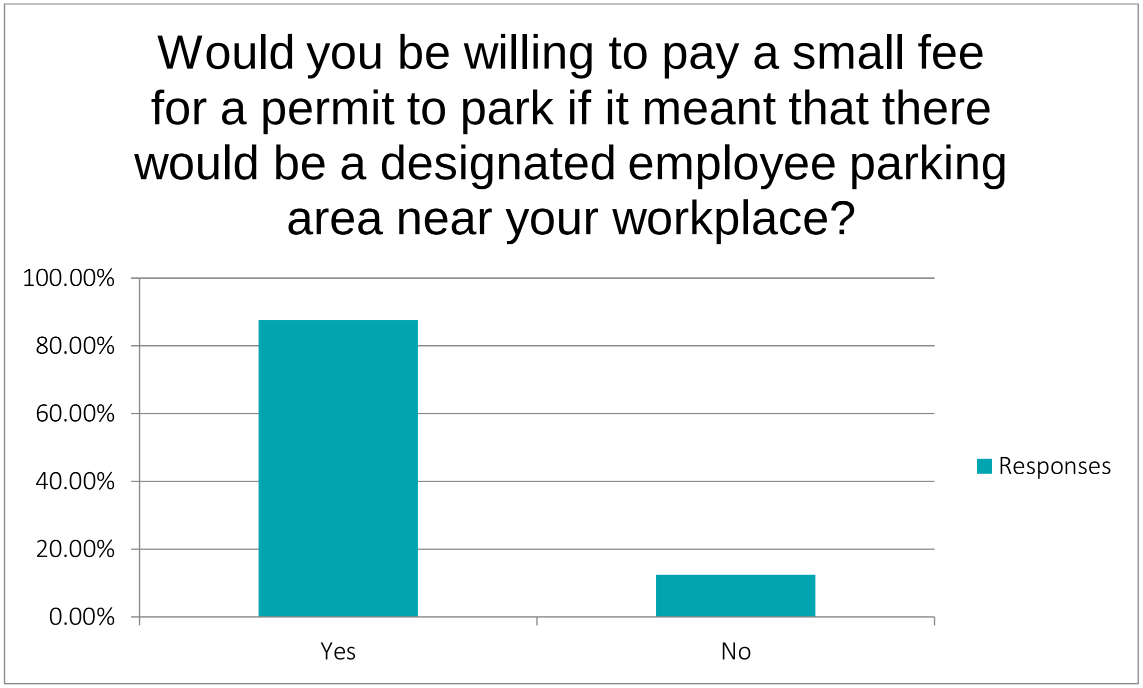



Time
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
On-Street
Off-Street
Early Morning (5am-8am)
Mid-Morning (8am-11am)
Early Afternoon (11am-3pm)
Afternoon (3pm-6pm)
Early Evening (6pm-9pm)
Late Evening (9pm-12am)
After midnight (12am-5am)

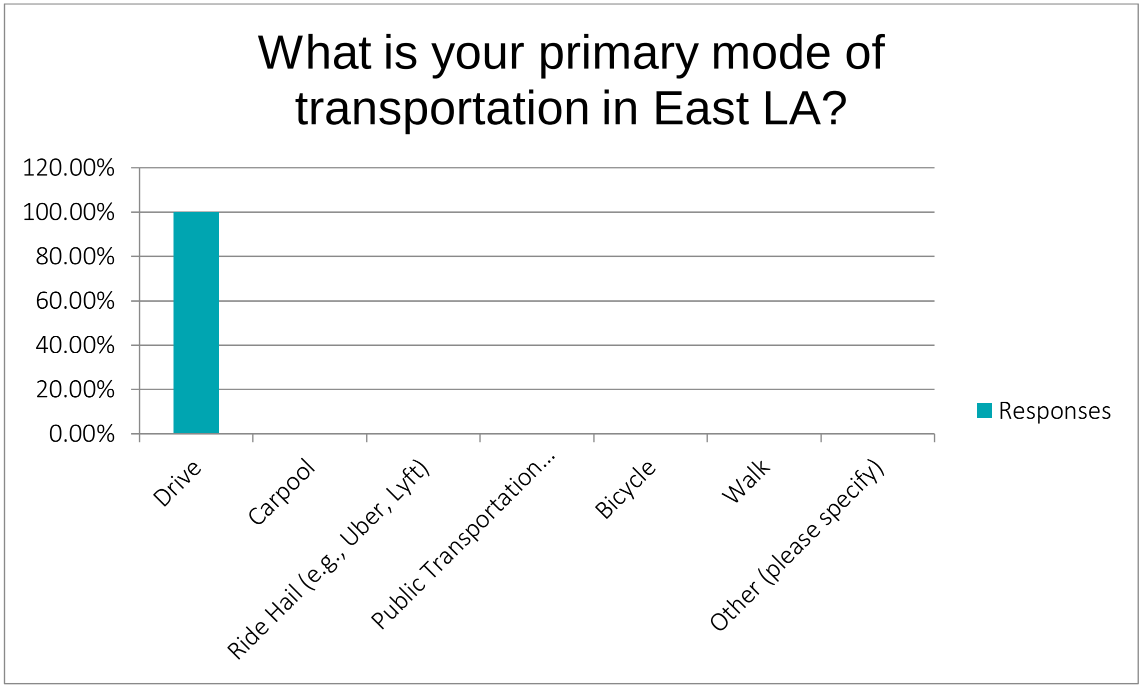
Question 42


Would you support additional parking enforcement to help address these parking issues?
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Strongly agree
Agree
Neutral
Disagree
Strongly disagree
Responses

Question 43


Would you be willing to pay a small fee for a permit to park if it meant that there would be a designated employee parking area near your workplace?
100.00%
80.00%
60.00%
40.00%
20.00%
0.00%
Yes
No
Responses

Question 44

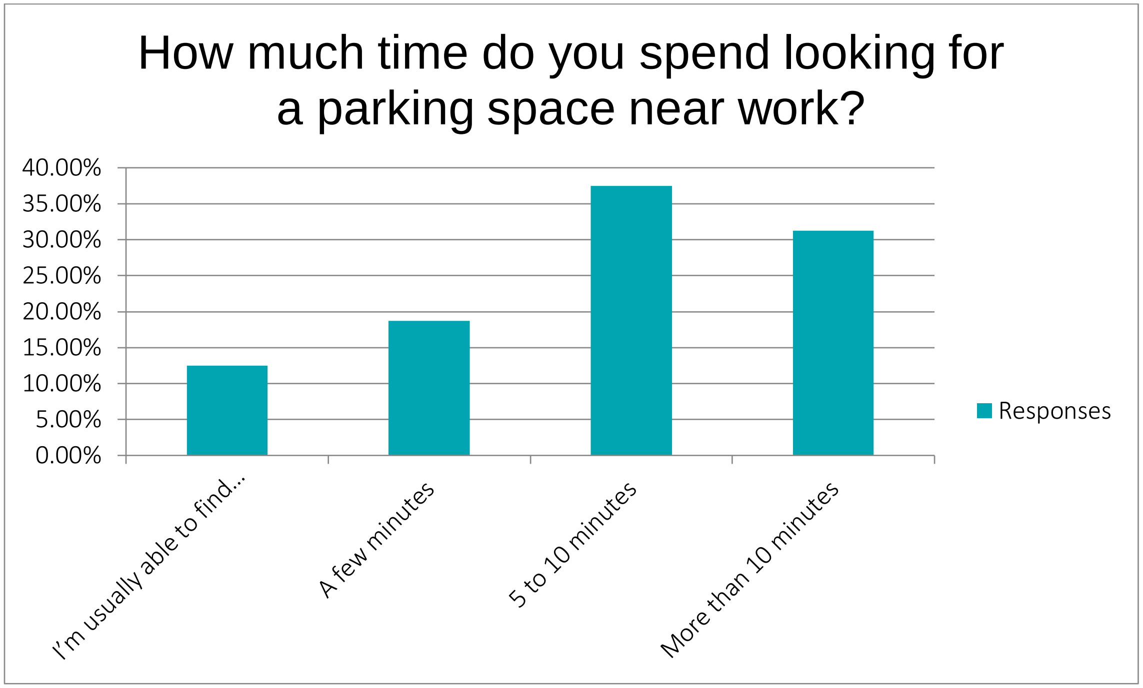

What is your primary mode of transportation in East LA?
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
0.00%
Drive
Carpool
Ride Hail (e.g., Uber, Lyft)
Public Transportation...
Bicycle
Walk
Other (please specify)
Responses

Question 45 - If you drive, where do you typically park?

Respondents	Responses
1	In the site parking lot if not full.
2	Park, street, building-specific parking
3	Street
4	On the street.
5	In residential area next to business
6	Street Parking on Amalia
7	Residential street
8	Structure
9	on-site at employment or on street
10	Street
11	Street
12	Private parking for work and family drive way parking
13	Parking lot, but when I am meeting members of the community I face the same challenges as the residents. Lack of parking is the main reason I left ELA
14	Street
15	Street

16	Street

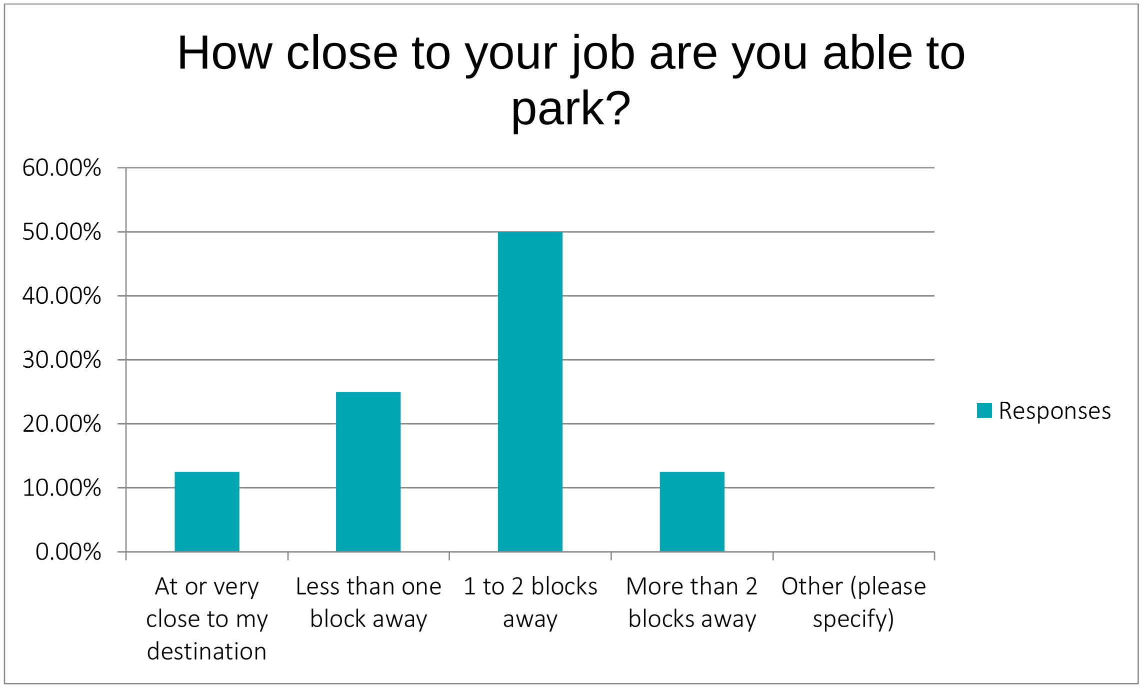
Question 46


How much time do you spend looking for a parking space near work?
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
I'm usually able to find...
A few minutes
5 to 10 minutes
More than 10 minutes
Responses

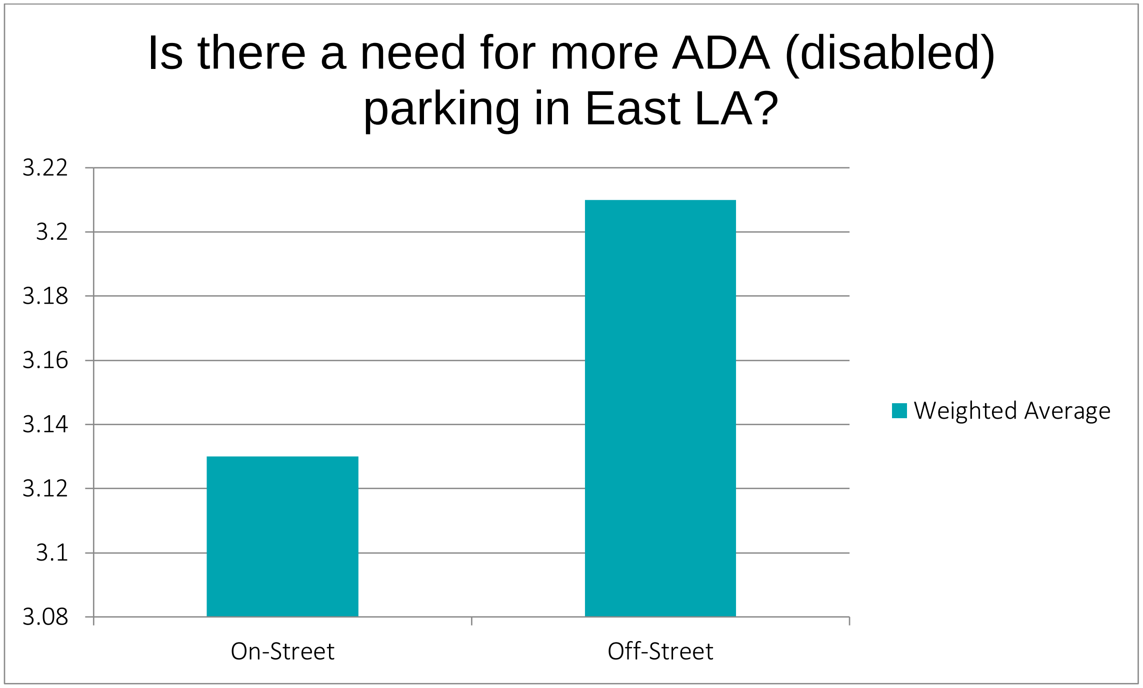
Question 47


How long do you typically leave your car parked at work?
50.00%
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
2 hours or less
2 to 4 hours
4 to 8 hours
More than 8 hours
Responses

Question 48


How close to your job are you able to park?
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
At or very close to my destination
Less than one block away
1 to 2 blocks away
More than 2 blocks away
Other (please specify)
Responses

Question 49


Is there a need for more ADA (disabled) parking in East LA?
3.22
3.2
3.18
3.16
3.14
3.12
3.1
3.08
On-Street
Off-Street
Weighted Average

Question 50 - Please provide address or closest cross-streets to your workplace.

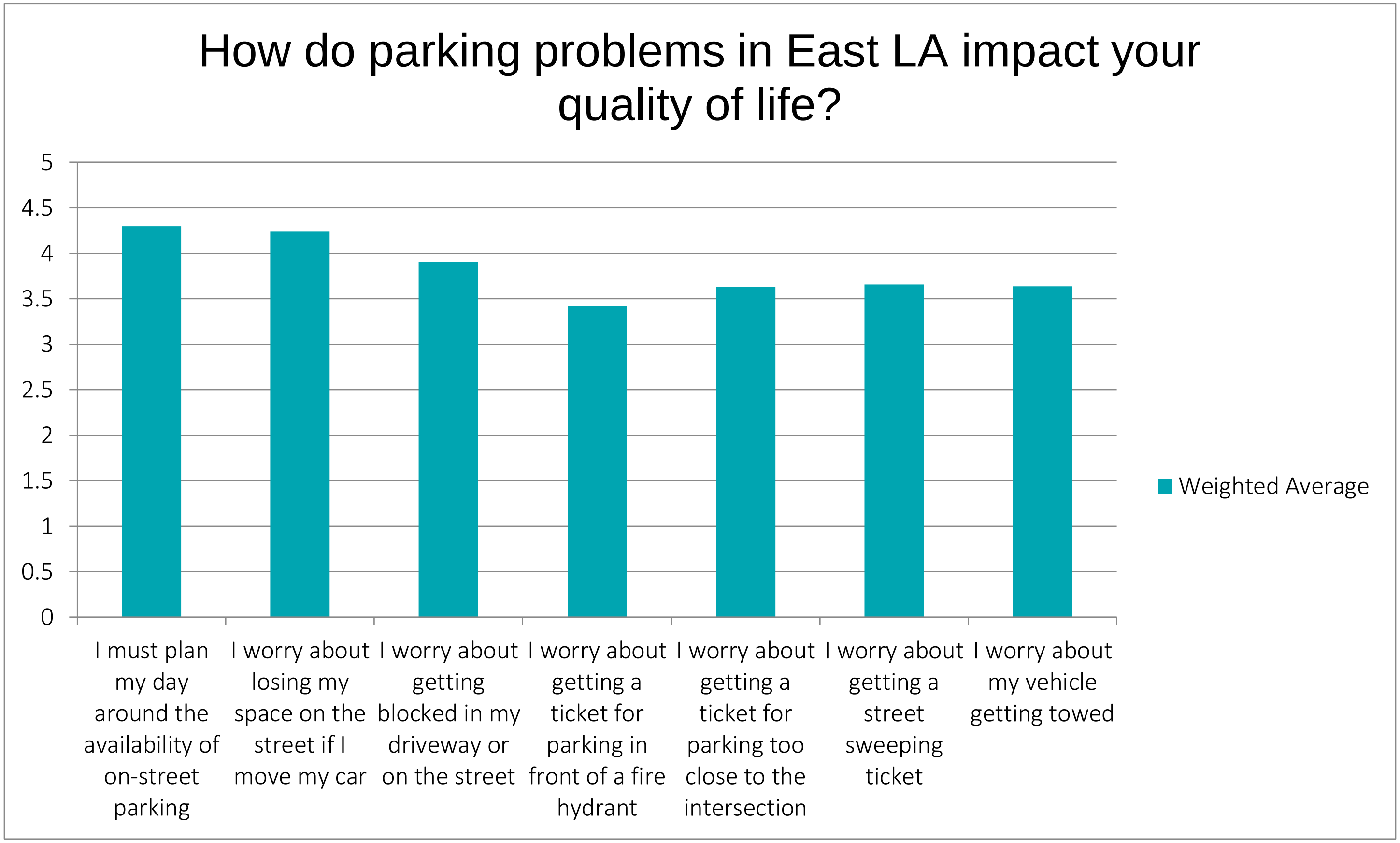
Refer to Figure 20 for a reference map. Actual addresses not shown for the privacy of respondents.

Question 51 - Please provide any additional comments that you may have regarding parking in East Los Angeles.

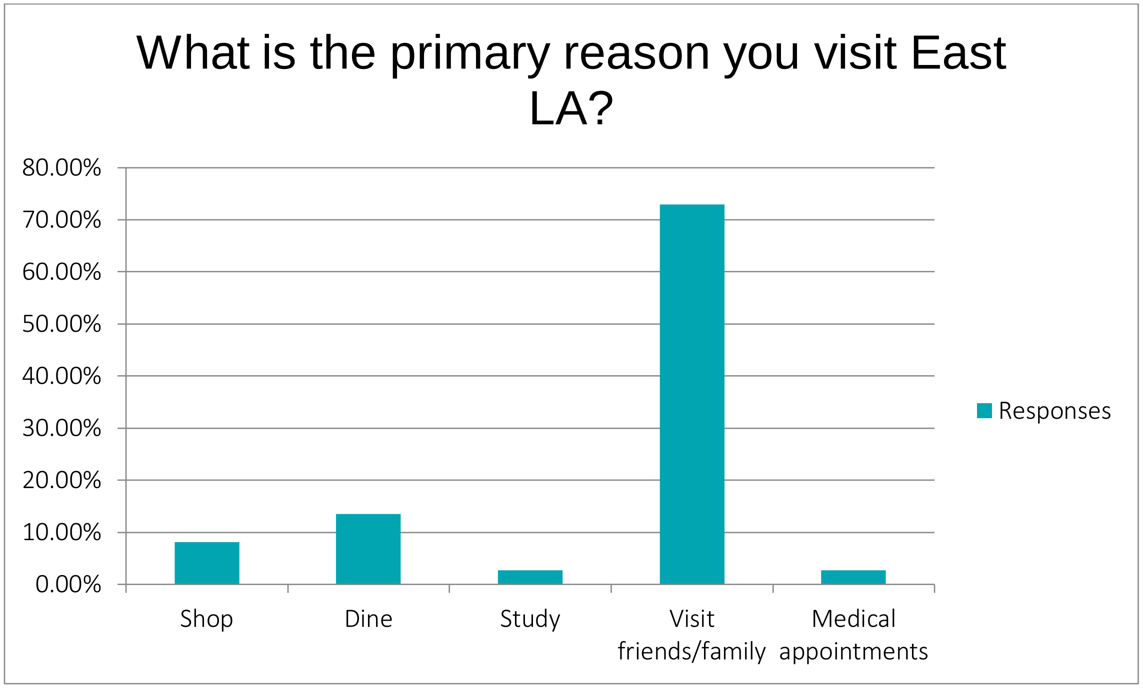
Respondents	Responses
1	As people are aging / acquiring disability / abuse of disabled placards, lack of ADA parking is a big concern
2	Need off-street parking.
3	Residents in the neighborhood often park in the middle of the space so that only one car may park in a space that could accommodate two cars. They also block spaces with trash bins. The street sweeping restrictions are set for the beginning and middle of the work day which make on street parking unavailable on one whole side of the block for too long a period. Other neighborhoods in LA County have no street sweeping restrictions. One hour parking limits on Whittier Boulevard are too restrictive. Parking permits would just make the parking problem more critical and would not be helpful as residents have too many cars on the street.
4	The main problem for me is the street sweeping restrictions and the 1 hour parking on busy streets (whittier and atlantic).
5	Residents try to impede parking for teaching staff by blocking spots. Parents dropping off students also take parking spots and will not leave until after school begins, making it difficult for staff to find parking.
6	I believe that too many people have more than one care and they take up all the street parking... I also see people playing musical cars - might be friends of relatives, that when they move their car, they save it for that one friend or relative to get that parking. Currently, since the street sweeper is not actually working like before COVID-19, people are leaving their cars for a week or more and they do not get tickets when the street sweeper passes by.

7	Again, lack of parking space is the primary reason I left ELA, had it not been for that, I would have purchased my home here
8	Hate it

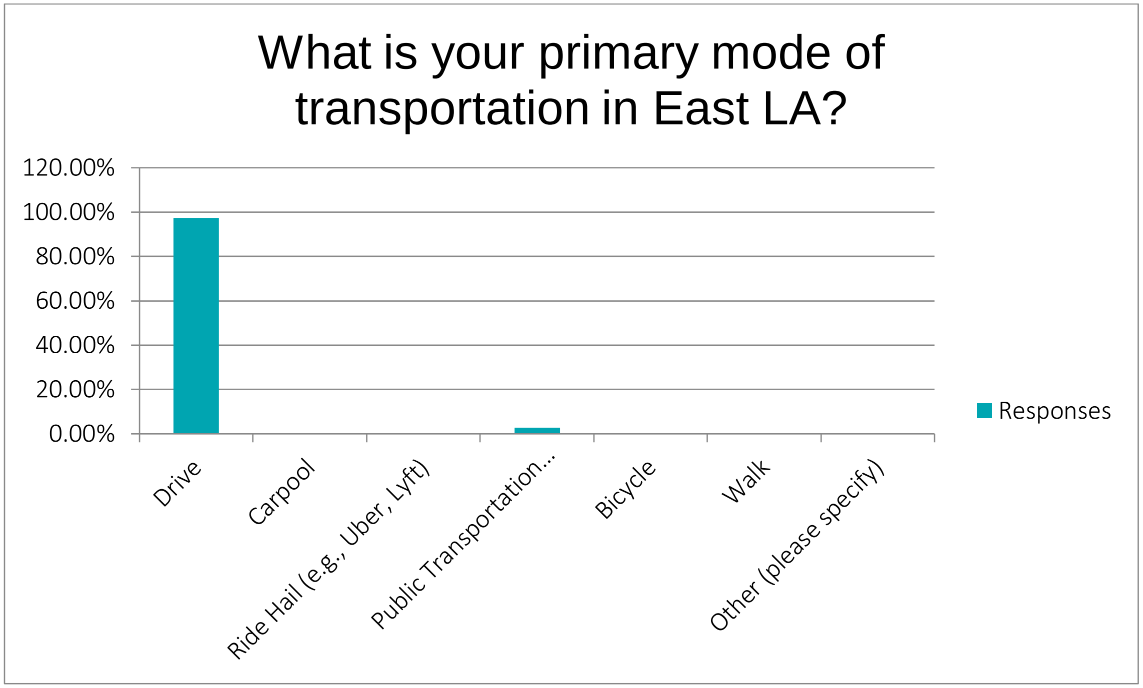
Question 52


How do parking problems in East LA impact your quality of life?
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
I must plan my day around the availability of on-street parking
I worry about losing my space on the street if I move my car
I worry about getting blocked in my driveway or on the street
I worry about getting a ticket for parking in front of a fire hydrant
I worry about getting a ticket for parking too close to the intersection
I worry about getting a street sweeping ticket
I worry about my vehicle getting towed
Weighted Average

Question 53


What is the primary reason you visit East LA?
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Shop
Dine
Study
Visit friends/family
Medical appointments
Responses

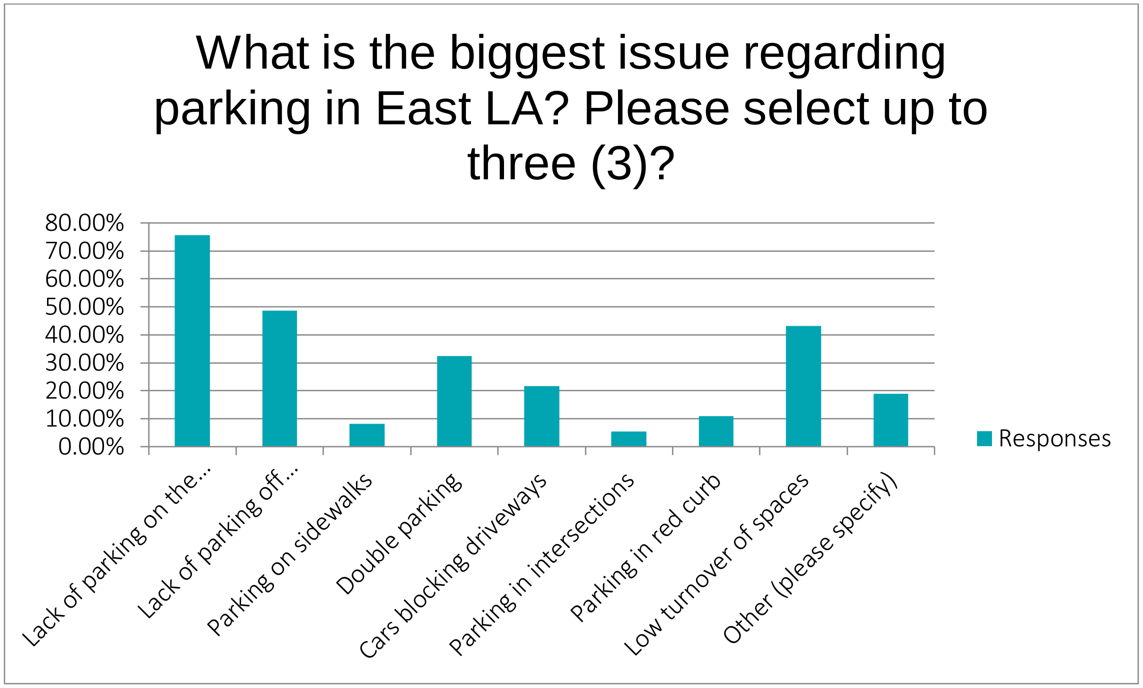
Question 54


What is your primary mode of transportation in East LA?
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
0.00%
Drive
Carpool
Ride Hail (e.g., Uber, Lyft)
Public Transportation...
Bicycle
Walk
Other (please specify)
Responses

Question 55 - Which areas of East LA do you visit most often?

Refer to Figure 20 for a reference map. Actual addresses not shown for the privacy of respondents.

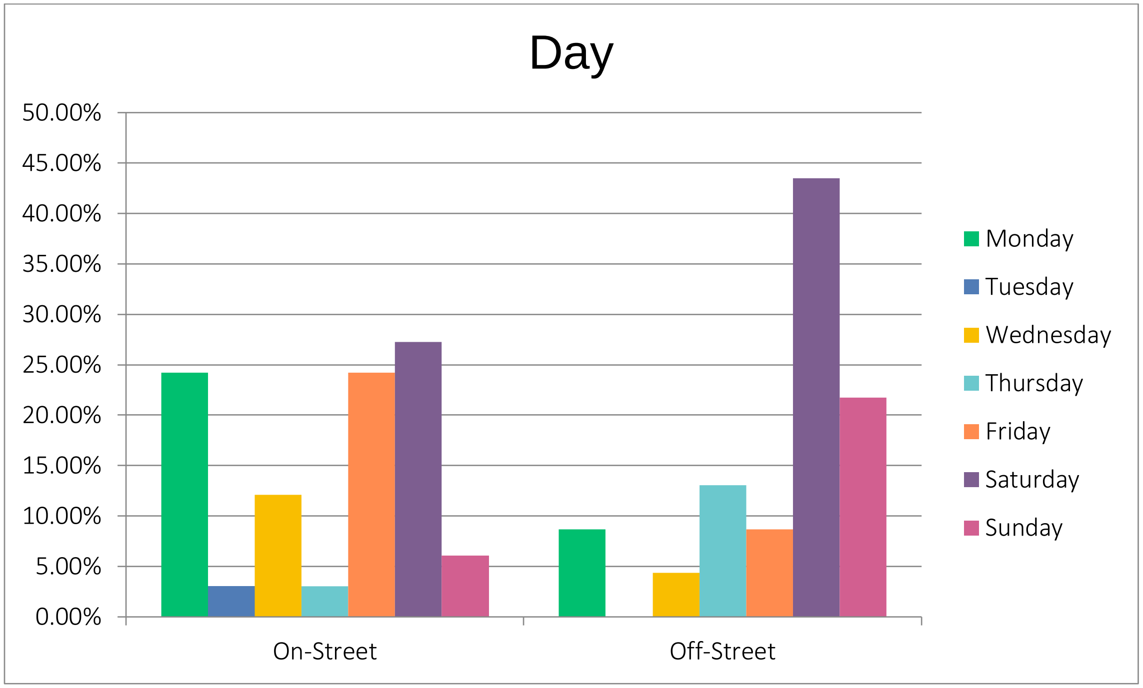
Question 56

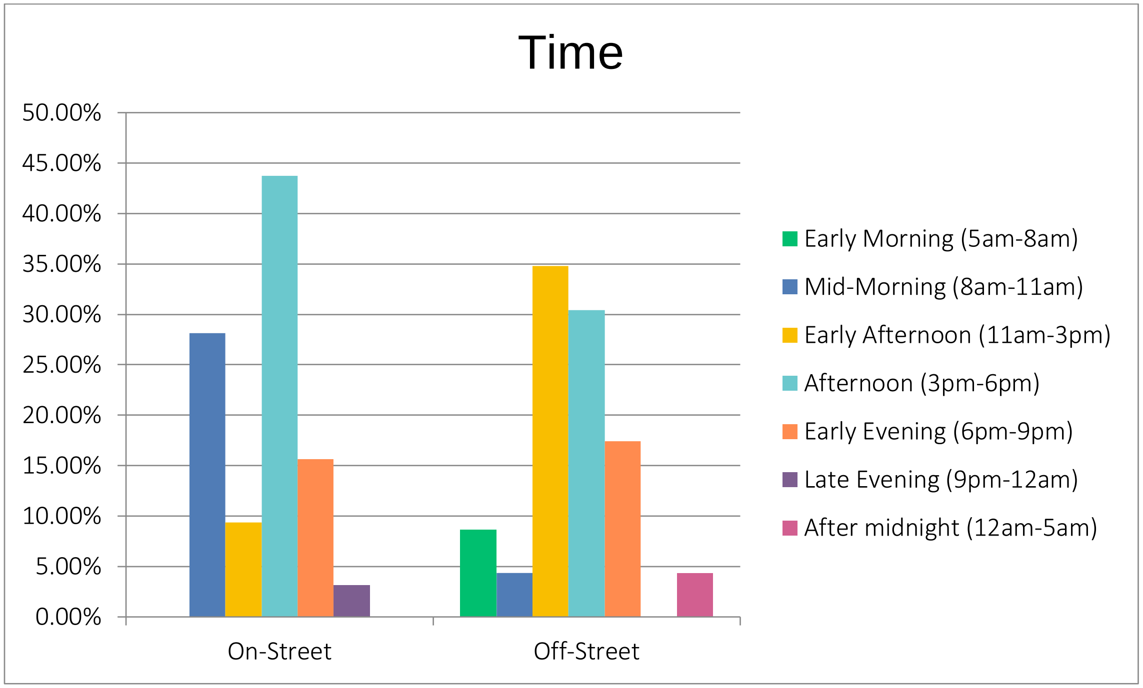


Respondents	Other (please specify)
1	people park in my parents neighborhood to take the gold line
2	Driveways don't get used for parking
3	Too many cars per household; people not leaving enough room for other cars to save space for another car in their home.
4	increase in oversized RV parking in residential areas

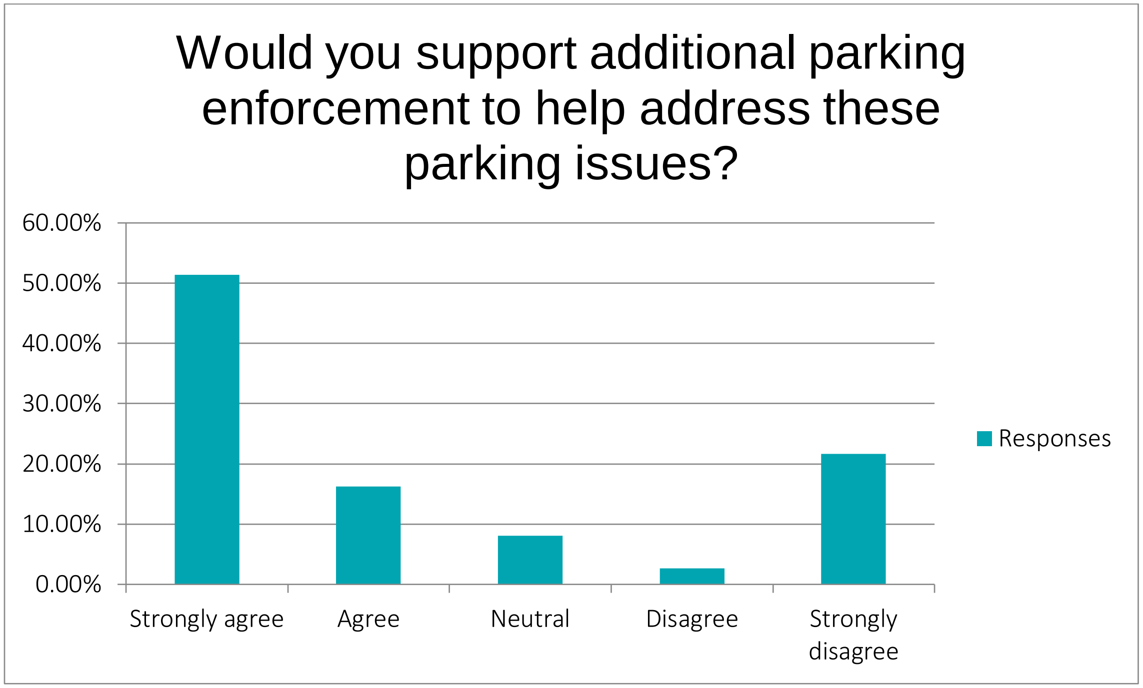
5	Oversized RV Parking in residential area
6	Mobile homes/RV of individuals who don’t live in the area taking up street parking
7	Big trucks that are overloaded with junk take up all the parking and make the street dangerous

Question 57 - What day and time is it most difficult to find parking in East LA?




Time
50.00%
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
On-Street
Off-Street
Early Morning (5am-8am)
Mid-Morning (8am-11am)
Early Afternoon (11am-3pm)
Afternoon (3pm-6pm)
Early Evening (6pm-9pm)
Late Evening (9pm-12am)
After midnight (12am-5am)

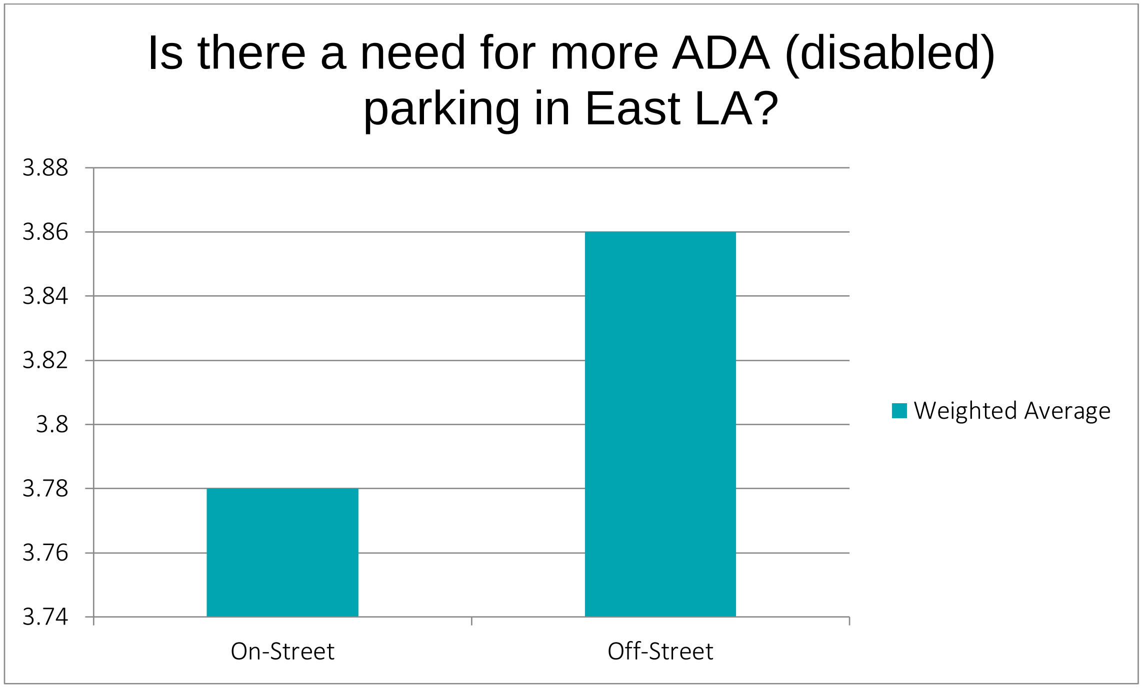
Question 58


Would you support additional parking enforcement to help address these parking issues?
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Strongly agree
Agree
Neutral
Disagree
Strongly disagree
Responses

Question 59


Would you support paying a small fee for parking, if it made it easier for you to find a parking space?
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
Yes
No
Responses

Question 60


Is there a need for more ADA (disabled) parking in East LA?
3.88
3.86
3.84
3.82
3.8
3.78
3.76
3.74
On-Street
Off-Street
Weighted Average

Question 61

Respondents	Responses
1	Parking by permit
2	People should use their driveway instead of the spots on the street. It makes it very difficult when they park their cars on the street just to have an extra spot.
3	Mandate all housing has sufficient parking for renters
4	Looking for parking in east la is always a hassle. Makes me think of visiting family.
5	A lot of people have more than one car and it takes away the chance for other people to park
6	homes exceed occupancy limits - hence too many drivers with cars. new buildings should not be approved without 3 off street parking spaces per unit
7	What is this survey considering ELA?
8	East Los Ángeles /City Terrace parking enforcement department is NOT available EVER to enforce parking and abandon car violators. Do NOT use ELA Sheriff's department for parking enforcement. They are needed for public safety NOT parking enforcement. The problem with parking is due to the LACK of Enforcement by East Los Ángeles parking enforcement department. Parking supervisor needs to do the job and personally tow away all the abandoned cars. The parking enforcement supervisor does not respond to the community. Supervisor Hilda Solis' office is aware of the parking problems in East Los Ángeles/City Terrace. Stop the survey & do your jobs!!! Ticket & Tow violators!!! While your add it pickup the abandon debris and dumped items at bus stops and intersections. PERMIT parking needed in City Terrace/East Los Ángeles just like Pasadena, Alhambra, San Gabriel. Increased revenue for LA County.
9	Neighbors who have multiple cars and take up all street parking.

10	I feel that the biggest issue about parking difficulties is caused by street sweeping. The street sweeper has not operated for 6 months . May i add that the streets are filthy and full if trash. Some areas of Los Angeles still has debris from 4th of july laying in the streets. When the street sweeper is operating weekly not only does it help against the pandemic but also it forces neighbors to actually move they're vehicles. Which enables all neighbors a equall chance of parking theyre vehicle. Instead of a zero chance when vehicles stay in place.
11	Parking enforcement is ruthless..
12	houses using trash cans to save parking, cars parked for a long period in the middle of the street with hazard lights on
13	It's bad but there are a lot of people living in single households. The economy is not at a point where you can start charging people to park
14	to many cars per household
15	Stop ticketing low income people for parking issues.
16	My property is the only one on my block without a driveway, due to a fire hydrant placement and alleyway. My neighbors double park on street and leave their driveways empty! I'm little frustrated! It's a daily struggle that my entire family deals with.
17	Follow the example of the city of Maywood and have marked street parking.
18	Just simply congested area
19	it really bad, especially the double parking of cars
20	I support on-Street parking permits and creating preferential parking districts across East L.A.
21	Parking brackets on the street/curb would be helpful to maximize the number of cars that fit on a street. Many people park in a way as to make it impossible for another car to fit, mostly because

	they are saving space for other cars in the household and in some instances disregard for neighbors.
22	There has been an increase in oversized RV parking in residential areas which dramatically decreases the number of available spots for residents. This has caused an increase in trash dumped on the street causing a lower quality of life for residents in East LA.
23	There has been an increase in oversized RV parking in residential areas which dramatically increases the number of available spots for residents. This has caused an increase in trash dumped on the street causing a lower quality of life for residents in East LA.
24	Designated parking for RV/ mobile homes should be moved off of residential streets and into a secured structure (especially if the RV/mobile homes do not belong to the residents in the area).
25	Not sure what's the solutions to the parking issue too many people and too many cars.
26	A big problem on Humphreys and Sydney is that these trucks that collect metal and junk take up a large amount of parking on Sydney and Humphreys. A second problem is that some residents have too many cars.

East Los Angeles Parking Availability Improvement Study

Current Parking Restrictions and Enforcement Practices

County of Los Angeles, CA

September 24, 2021

Prepared for:
Chief Executive Office Budget and Operations
Community Services

WALKER
CONSULTANTS

Contents

Appendix

Exhibits

Executive Summary

The primary mission of Los Angeles County's ("LA County" or "County") parking enforcement program is to ensure that residents, visitors, and other community stakeholders adhere to the county's parking regulations.

The Parking Enforcement Detail (PED) of the Los Angeles County Sheriff's Department provides centralized administration of parking violation enforcement and parking citation processing in the unincorporated areas of LA County. PED also provides the administrative review of contested citations and schedules administrative hearings conducted by civilian hearing officers. The PED unit provides services for other County departments, police agencies, and some Contract Cities. PED is comprised of 1 Manager, 8 headquarters staff members, 55 Parking Control Officers, and 11 Supervisor Parking Control Officers deployed throughout 16 patrol stations. Through regular patrol, parking control officers issue citations to vehicles that are parked in violation of the law, identify abandoned vehicles, and recover stolen vehicles. They also respond to community complaints regarding parking violations.

The Parking Enforcement Detail issues over 225,000 citations annually. Once parking citations are issued, the Parking Violations Bureau handles collection management. Motorists can pay tickets online by credit card, telephone, U.S. mail, or in-person at any of the LA County payment centers. The Administrative Adjudication process provides for the hearing and disposition of all contested cases involving parking violations of the California Vehicle Code, the Los Angeles County Codes, and participating City Municipal Codes.

Unincorporated Community of East Los Angeles

In the unincorporated community of East Los Angeles (East LA), the PED is comprised of 8 Parking Control Officers, and 1 Supervisor Parking Control Officer reporting to the East Los Angeles Station.

On average, the East Los Angeles Parking Enforcement Detail issues over 49,000 citations annually, representing over $3.25 million citation fine dollars, with an average citation fine amount of $66.56 per citation. Only 2,500 (5%) of these citations are contested on an annual basis and approximately 13,726 (28%) of the citations issued have not been paid.

Overview of Findings

Walker reviewed the current parking restrictions and enforcement practices in unincorporated East LA. As we will discuss throughout the body of this report, we recognize that some parking restrictions may create additional challenges for parking enforcement to enforce with a high degree of consistency, such as short-term, time limited parking durations and the growing concern that food vendor trucks and mobile kitchens have taken over the valuable curbside parking inventory in many of the commercial corridors.

Additionally, East LA parking enforcement personnel resources are limited to a number of encumbered positions making it difficult to increase enforcement efforts and consistently enforce all parking related aspects of unincorporated East Los Angeles. To effectively meet the needs of the community, we believe more enforcement officer positions should be staffed throughout the day and, in the case of the residential neighborhoods, into the early evening hours and weekends.

The following details a listing of our findings of the current practices and restrictions, recommendations for organizational analysis, and best practice concepts.

Street Sweeping Hours Parking restrictions allow for street sweeping of commercial corridors during early morning hours (5:00 a.m. to 8:00 a.m.) and residential streets between the hours of 8:00 a.m. and 12:00 p.m. and from 11:00 a.m. to 3:00 p.m.

On-Street Time Limits Extend on-street parking permissions on commercial corridors to 2-hour limits to allow for maximum commercial access and appropriate enforcement behaviors. The reality of enforcing a 1-hour time limit is not conducive to commercial needs and enforcement resources.

- **Commercial and Vehicles for Sale Restrictions** Posted restrictions for parking commercial vehicles over 5 tons and vehicles for sale on commercial corridors add to additional posted regulatory information. Commercial vehicles and vehicles for sale are permissible in the areas without posted signage per County Code. Posting this regulatory information on some roadway corridors and not all corridors confuse the public.

Coin-Only Parking Meters The parking meters located in the East 1st Street neighborhood are coin-only, which limits the ability for motorists to pay for parking, creating a program whereby compliance becomes a barrier and not the solution.

Sign Restriction Conflicts Early morning street sweeping restrictions were found to conflict with time-limited parking permissions in several commercial areas on certain days of the week. A typical example of this conflict is when on-street parking is restricted between the hours of 5:00 a.m. and 8:00 a.m. while commercial on-street permissions allow for time-limited parking between the hours of 7:00 a.m. and 4:00 p.m.

Mobile Vendors During the current conditions analysis, community stakeholders expressed that food vendor trucks, mobile kitchens, and pickup trucks pulling food kitchen trailers often park longer than the posted time restriction, which limits curbside access and commercial turnover throughout the permissible parking times of day.

Parking Violation Types Walker requested and received copies of the parking citations issued in unincorporated East LA over the past three years, to include records from calendar years 2017 through 2019. On average, the PED issued sixty-four (64) different categories of parking citations. The list of most commonly issued citations represent forty-six percent (46%) of the total violation categories shown in the County's parking citation database system. As authorized by LA County parking ordinance codes and the California Vehicle Code, the PED has the ability to issue as many as 140 different types of parking violations within the County.

Parking Violation Percentages Of the sixty-four (64) violation categories, six (6) citation categories comprise ninety percent (90%) of the citations issued in unincorporated East LA. Approximately 53% of the parking citations issued in the East LA County neighborhoods are for street sweeping violations, an indication that many residents do not have options for parking their vehicle in designated off-street locations.

Enforcement Best Practice The County should have consistent enforcement practices on all violation types to include time-limited and metered parking in commercial corridors, commercial vehicle parking in residential neighborhoods, and parking vehicles for sale in commercial corridors.

Parking Enforcement Detail Allocation During the stakeholder intake interview with the Parking Enforcement Detail team, Walker learned street sweeping enforcement responsibilities determine how enforcement resources are allocated each day. Street sweeping schedules are generally Mondays through Fridays from 5:00 a.m. to 7:00 a.m., 8:00 a.m. to 12:00 p.m., and 11:00 a.m. to 3:00 p.m. To meet the scheduled enforcement times, the PED allocates a minimum of four to seven parking control officers to the designated areas each day. Current staff coverage and assigned shifts are as follows.

#	Rank	Day of Week	Time of Day	Work Cycle
1	SPCO	Monday through Friday	6: 00 AM to 2:00 PM	Five (8-hour tour)
1	PCO	Tuesday through Friday	5: 00 AM to 3:00 PM	Four (10-hour tour)
2	PCO	Tuesday through Friday	7:00 AM to 5:00 PM	Four (10-hour tour)
3	PCO	Monday through Friday	6:30 AM to 2:30 PM	Five (8-hour tour)
4	PCO	Sunday	3:00 AM to 1:00 PM	One (10-hour tour)
		Monday through Wednesday	5:00 AM to 3:00 PM	Three (10-hour tour)
5	PCO	Monday through Friday	4:00 AM to 12:00 PM	Five (8-hour tour)
6	PCO	Monday through Thursday	5:00 AM to 3:00 PM	Four (10-hour tour)
7	PCO	Monday through Friday	5:00 AM to 1:00 PM	Five (8-hour tour)
8	PCO	Thursday and Friday	9:00 AM to 7:00 PM	Two (10-hour tour)
		Saturday and Sunday	5:00 AM to 3:00 PM	Two (10-hour tour)

Source: LA County Sheriff Department; May 2020

Parking Enforcement Detail Salaries We requested and received the salary information for the PED and received the 2018-2021 salary schedule with step increases for the position of Supervisor Parking Control Officer and Parking Control Officer. The graphic below has been provided to demonstrate the salary ranges for each of these positions.

Parking Enforcement Detail 2018-2021 Salary Schedule							
Position	Year	Step 1 Annual	Step 2 Annual	Step 3 Annual	Step 4 Annual	Step 5 Annual	Step 6 Annual
Supervisor Parking Control Officer	10/1/18	$46,579	$49,155	$51,886	$54,785	$57,840	$59,424
	10/1/19	$47,724	$50,376	$53,184	$56,148	$59,280	$60,912
	1/1/20	$48,199	$50,877	$53,716	$56,710	$59,873	$61,523
	10/1/20	**$49,399**	**$52,146**	**$55,058**	**$58,128**	**$61,371**	**$63,060**
	1/1/21	$49,399	$52,146	$55,058	$58,128	$61,371	$63,060
Parking Control Officer	10/1/18	$40,350	$42,566	$44,910	$47,381	$50,010	$51,380
	10/1/19	$41,340	$43,610	$46,019	$48,557	$51,255	$52,665
	1/1/20	$41,736	$44,028	$46,464	$49,032	$51,756	$53,184
	10/1/20	**$44,911**	**$47,381**	**$50,010**	**$52,795**	**$55,739**	**$57,267**
	1/1/21	$44,911	$47,381	$50,010	$52,795	$55,739	$57,267

Source: LA County Sheriff; 2020

For salary comparison purpose, Walker referenced the U.S. Bureau of Labor Statistics website for parking enforcement workers. As of May 2019, the occupational employment and wages provided the following:

			(Median)		
Percentile	10%	25%	50%	75%	90%
Hourly Wage	$12.80	$15.48	$19.67	$25.50	$30.87
Annual Wage	$26,610	$32,200	$40,920	$43,040	$64,210

Source: www.bls.gov 33-3041 Parking Enforcement Workers; 2020

Limited Parking Enforcement Coverage As identified in the public survey responses and further supported through comments made during the community stakeholder sessions, both residents and business merchants believe enforcement coverage is not substantial or consistent enough to meet the needs of the community. A number of stakeholders shared that enforcement officers are seldom seen enforcing matters on their community streets, especially during the afternoon and early evening hours. On days when street sweeping is scheduled in specific neighborhoods, as few as 2-3 parking control officers are available to cover the non-street sweeping restricted areas of the East LA district. Considering conditions that effect scheduled and unscheduled paid time off (PTO) or medical leave of absence (MLA), it can become increasingly difficult to meet the coverage needs, not only each day, but in the early evening hours too.

Mobile LPR Enforcement Consider the use of mobile license plate recognition (LPR) to help PED maintain the timeliness of district-wide enforcement practices and discourage scofflaw behavior.

Parking Enforcement Training and Experience LA County Parking Control Officers are required to have a minimum of six months of experience in the public or private sector involving contact with the public, customer relations, or service to the community. A valid California Class C Driver License is required to perform job related essential functions. The minimum training and experience requirements for a Supervising Parking Control Officer specify at least two years' experience as a Parking Control Officer.

Enforcement Tours Establish regular enforcement tours for the assignment of Parking Control Officers each day. Require the Parking Enforcement Officers to rotate through the enforcement tours every two weeks to reduce the perception of targeting and promote best practice enforcement behaviors.

Organizational Analysis Should the PED remain an in-house service of the County, the LA County Sheriff's Department remains the clear choice to provide parking enforcement services in unincorporated East Los Angeles. The training and ability to shift personnel resources remains adequate to provide minimal coverage in the event of temporary employment vacancies.

Parking District Programs Best Practices Residential Parking Permit (RPP) programs or Preferential Parking District (PPD) programs are tools that help communities manage on-street parking in residential areas by limiting spillover of non-residential parking in residential areas.

- When RPP or PPD permits are free of charge, cities are not generating fee revenue from the programs, thus limiting funding available for administering the programs.
- For RPP and PPD programs, cities need to provide consistent enforcement, which in turn requires sufficient staffing, which can be costly.

- When RPP or PPD programs allow for an unlimited or large number of permits to be issued to each resident, the programs do not necessarily manage parking demand, as there can be numerous resident or guest vehicles parked on the street.
- When RPPs or PPDs have varying hours of enforcement or time restrictions throughout a community, it can be difficult for cities to administer the program. An alternative approach is to designate an entire community as an RPP or PPD and allow for areas to opt-in to the program, if desired.

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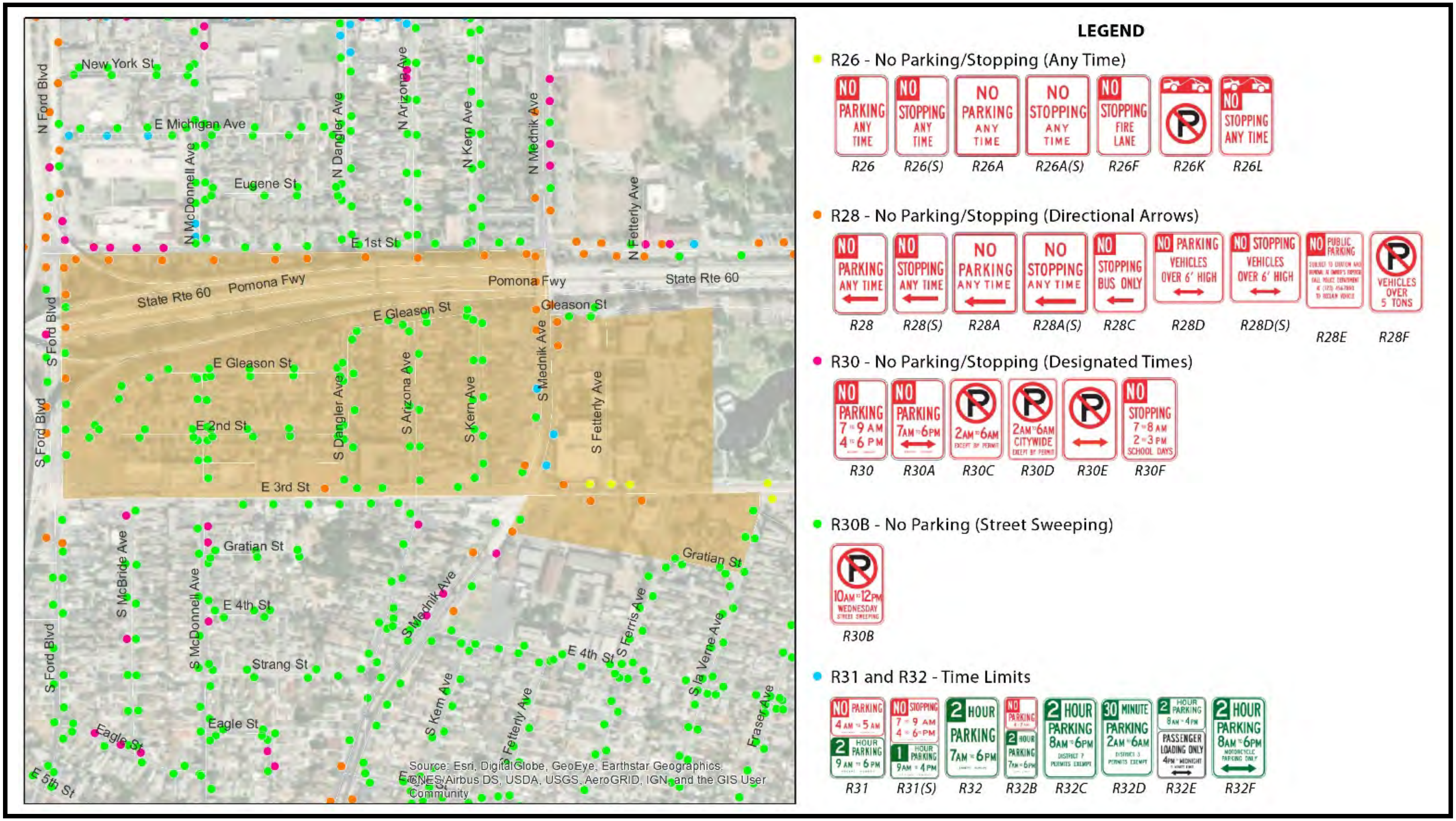
Current Parking Restrictions and Enforcement Practices

Current Parking Restrictions

Walker received parking restriction data from the County's Department of Public Works. Upon initial review of the data, Walker determined that the East Los Angeles study area has 11,929± street signs designed to permit and restrict parking on neighborhood streets and alleys. To analyze the data, Walker created the following exhibits using a geographic information system (GIS) framework designed to visualize the location of parking signs throughout the East Los Angeles neighborhoods. A brief analysis of the restriction data is provided before each exhibit.

Exhibit 1. The majority of the parking restriction signs in this neighborhood have been designed to restrict parking between 10:00 a.m. and 12:00 p.m. on Wednesdays for street sweeping purposes. Signs posted along primary roadway corridors to include East 3rd Street and South Mednik Avenue appear to be more restrictive with permissible limited duration parking along portions of South Mednik, north of East 3rd Street. Signs permitting 2-hour parking are acceptable for commercial business patrons in this neighborhood. The Metro Gold Line is supported by the Maravilla Station and the East LA Civic Center Station located along the East 3rd Street corridor of this area.

Exhibit 1: East 3rd Street/South Ford Boulevard/South Mednik Avenue and Dangler



*Signs shown are examples of signage provided by the California Department of Transportation for each category. Signs do not represent actual signs posted in East LA.

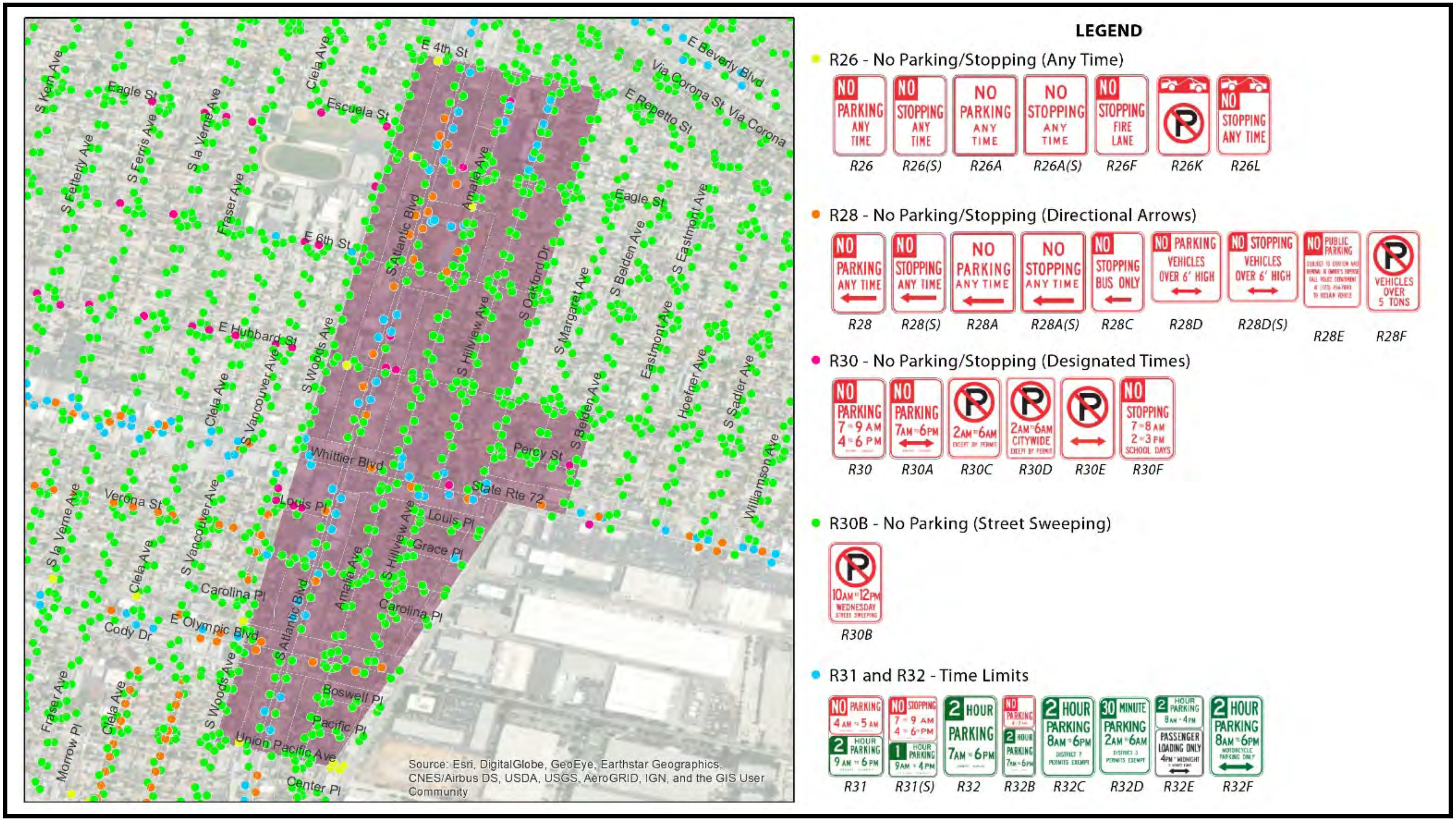
Source: Public Works Department and Walker Consultants; 2020

Exhibit 2. Similar to the previous exhibit, the vast majority of the signs for this neighborhood restrict parking from 10:00 a.m. to 12:00 p.m. on Wednesdays for street sweeping purposes. Street sweeping times for commercial corridors, to include Whittier Boulevard/SR 72, restrict all parking from 5:00 a.m. to 8:00 a.m. on designated days.

A number of designated areas throughout the Whittier/SR 72 and South Atlantic corridors have multiple restrictive signs, to include "no parking commercial vehicles over 5 tons" and "no parking of vehicles for sale entire block". The addition of these restrictive signs to commercial areas tend to create unnecessary sign clutter and potential confusion, often creating a menu of signs on a single light pole. These restrictive signs should be removed and remain a function of County ordinance and enforced district wide. During field observations, Walker observed that food vendor trucks, mobile kitchens, and pickup trucks pulling food kitchen trailers often parked longer than the posted time restriction, which limits curbside access and commercial turnover throughout the permissible parking times of day. The County should work with food truck and mobile kitchen vendors to create designated areas where these services may be offered to the public without affecting commercial access and traffic conflicts.

Overnight and weekend parking in this area could be supported by the parking structure serving the LA County Department of Social Services. The facility is located at 759 South Belden Avenue.

Exhibit 2: South Atlantic Boulevard

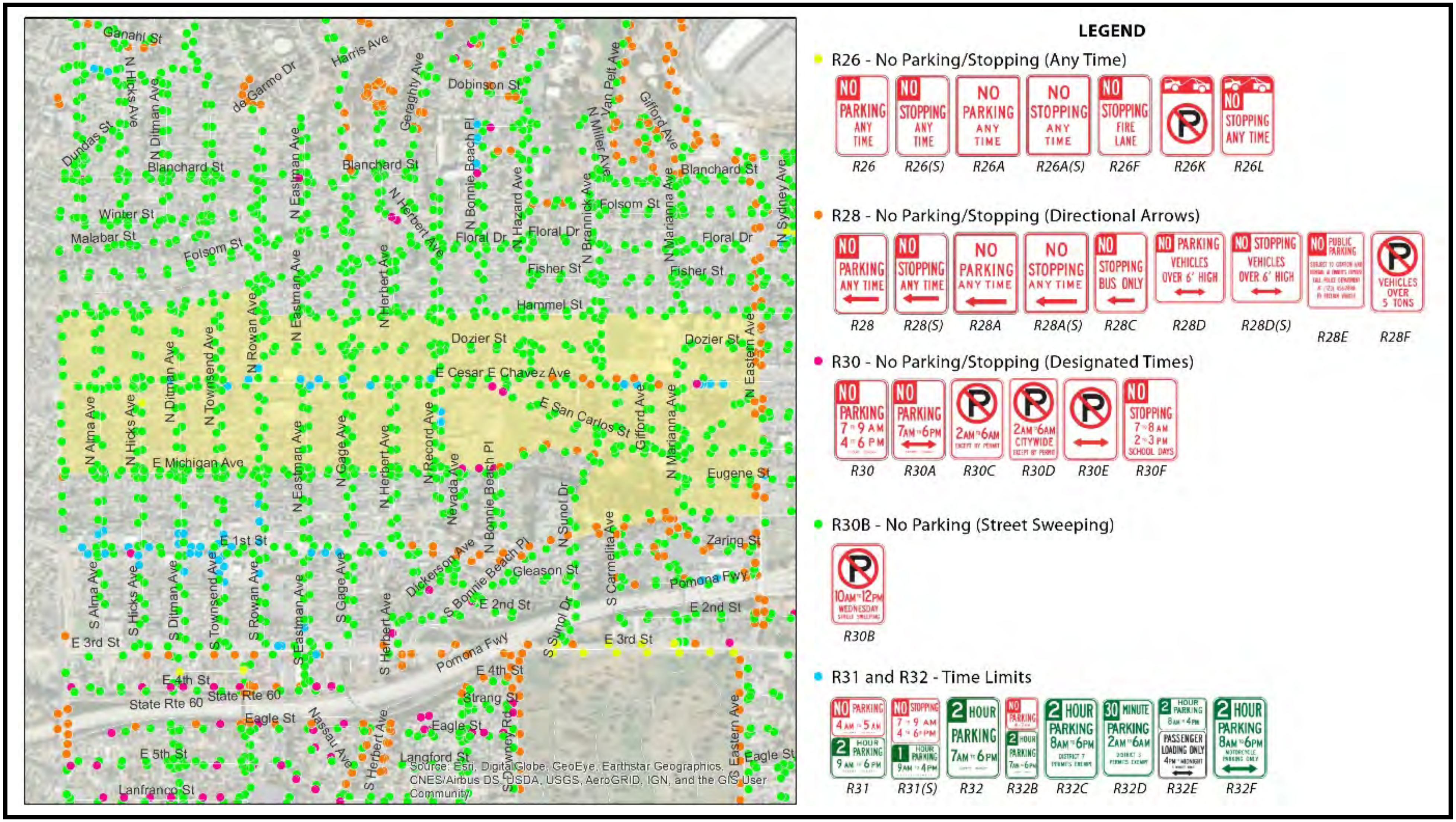


*Signs shown are examples of signage provided by the California Department of Transportation for each category. Signs do not represent actual signs posted in East LA.

Source: Public Works Department and Walker Consultants; 2020

Exhibit 3. East Cesar Chavez Avenue corridor operates in much of the same way as the other commercial corridors within the district, permitting short-term parking and restricting parking for early morning street sweeping on certain days.

Exhibit 3: East Cesar E. Chavez Avenue



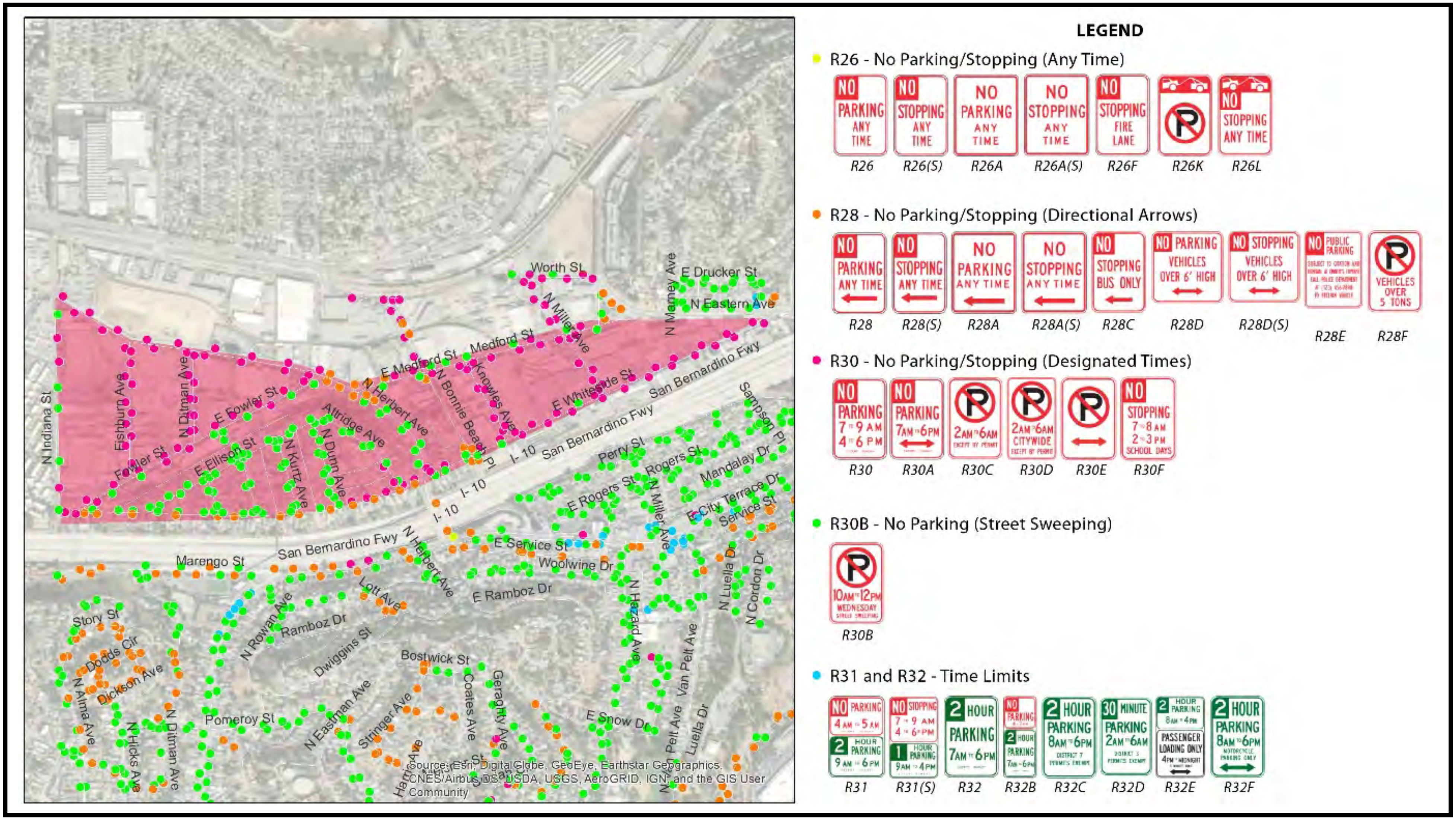
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

*Signs shown are examples of signage provided by the California Department of Transportation for each category. Signs do not represent actual signs posted in East LA.

Source: Public Works Department and Walker Consultants; 2020

Exhibit 4. Much of the light industrial portions of this City Terrace neighborhood have signs restricting parking from 7:00 p.m. to 5:00 a.m. each day with street sweeping restrictions on Mondays from 11:00 a.m. to 3:00 p.m. There are no commercial corridors or need to limit curbside parking to short-term duration limits.

Exhibit 4: City Terrace North

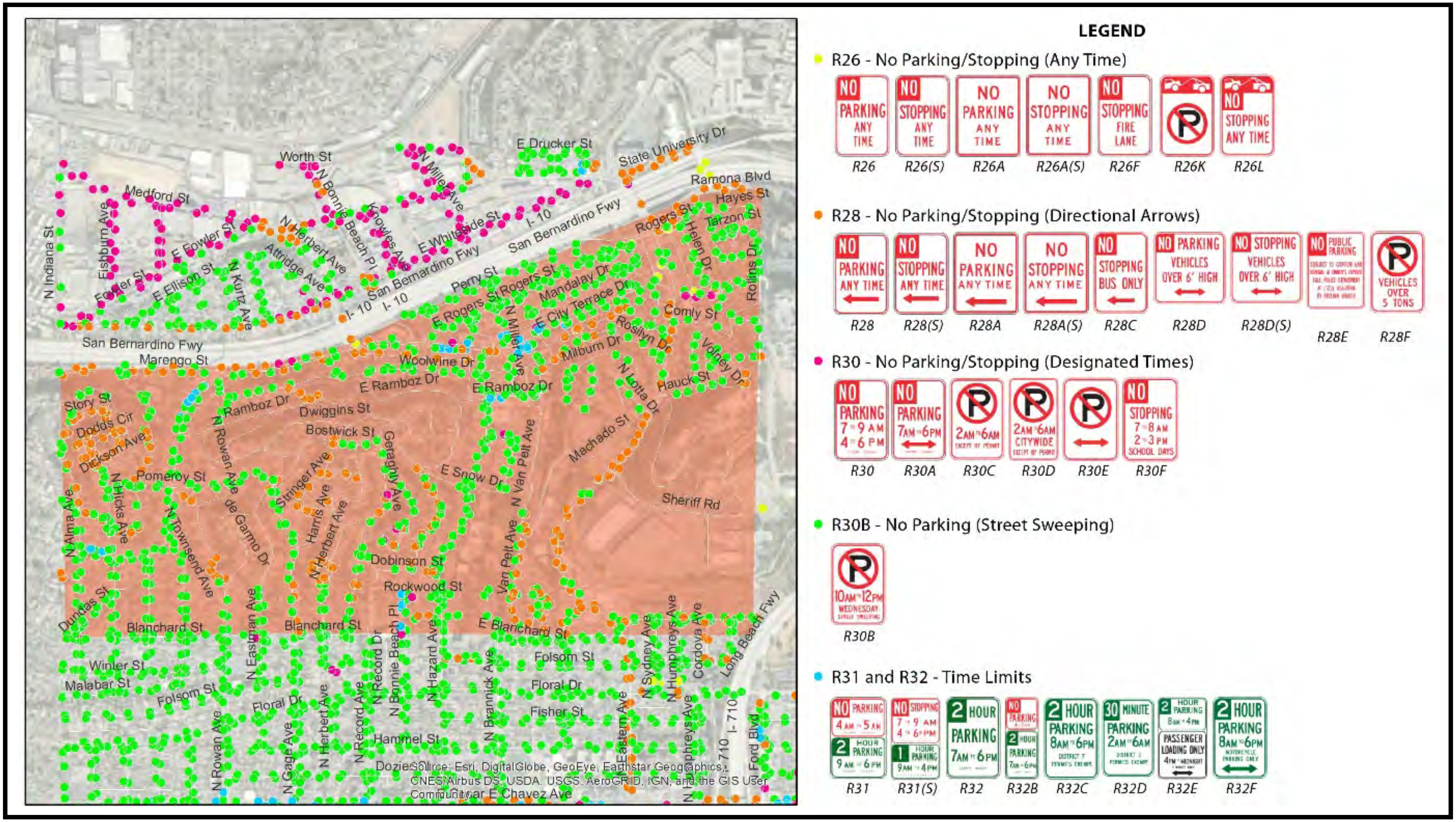


*Signs shown are examples of signage provided by the California Department of Transportation for each category. Signs do not represent actual signs posted in East LA.

Source: Public Works Department and Walker Consultants; 2020

Exhibit 5. Residential dwellings within the City Terrace South designation must adhere to Monday and Tuesday street sweeping schedules requiring the removal of vehicles from 11:00 a.m. to 3:00 p.m. each week. Parking restrictions are generally located around the elementary schools and residential roadways where on-street parking is limited to one side of the street. To accommodate passenger loading around the schools, early morning and afternoon loading signs restrict on-street parking, however, time limited parking is permitted between the two loading periods.

Exhibit 5: City Terrace South



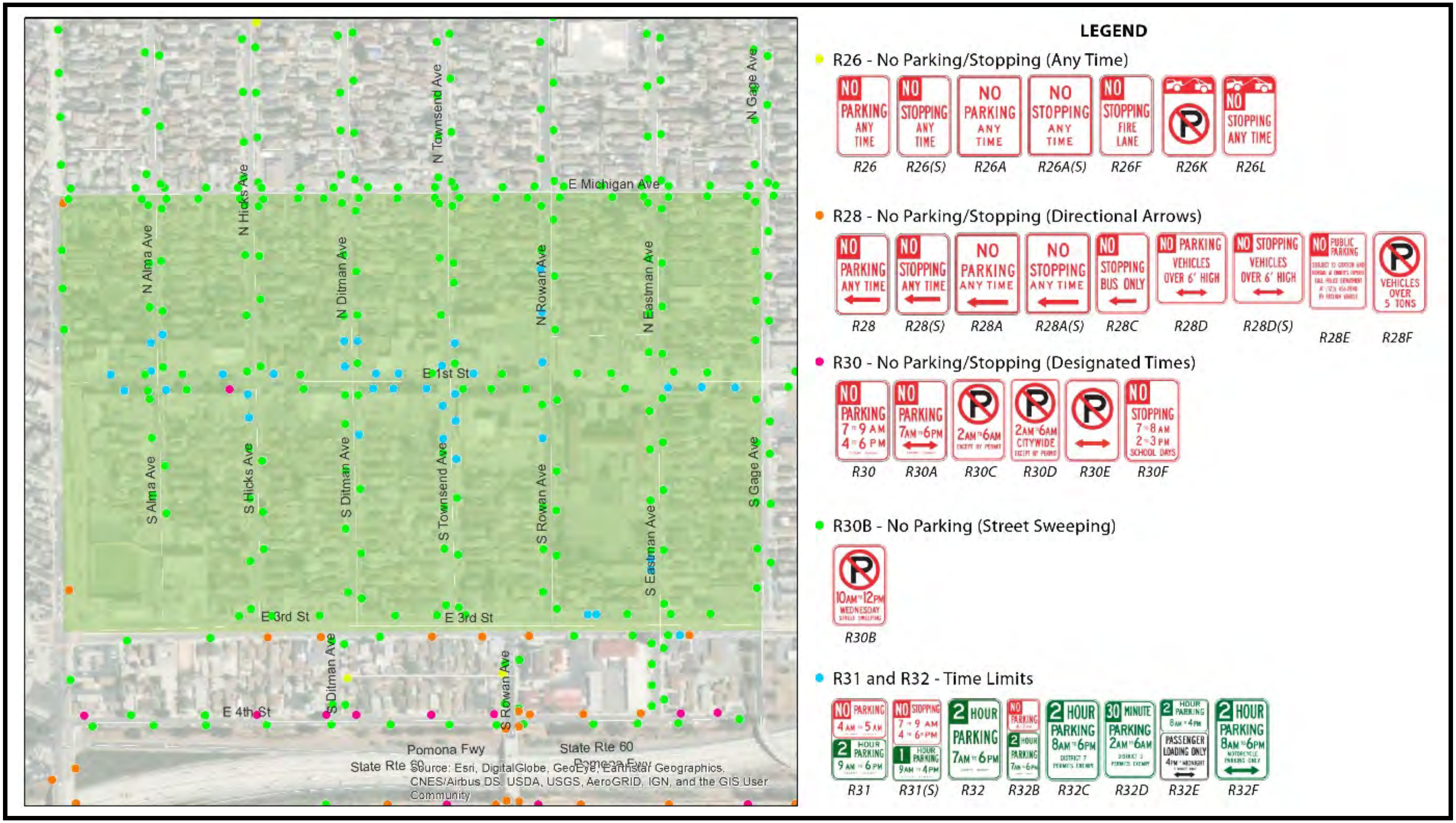
*Signs shown are examples of signage provided by the California Department of Transportation for each category. Signs do not represent actual signs posted in East LA.

Source: Public Works Department and Walker Consultants; 2020

Exhibit 6. Time limited and metered parking is prevalent throughout this area from 7:00 a.m. to 6:00 p.m. daily. Coin only, single space meters limit payment methods for motorists. Commercial parking restrictions on 1st Street from 5:00 a.m. through 8:00 a.m. on Mondays and Fridays conflict with one hour parking permissions from 7:00 a.m. to 6:00 p.m. Street sweeping restrictions prohibit on-street parking on Wednesdays and Thursdays from 8:00 a.m. to 12:00 p.m. The Metro Gold Line is supported by the Indiana Station located at the western end of this area on South Indianan Street.

There is one off-street parking facility located in this area at 124 North Ditman Avenue. The location is secured by a gated system and supports administrative parking privileges for the KIPP (Knowledge is Power Program) SoCal Public Schools. KIPP SoCal Public Schools is an independent nonprofit organization that operates 20 tuition-free, open-enrollment charter public schools educating more than 8,800 students and supporting 5,100 alumni to and through college.

Exhibit 6: East 1st Street

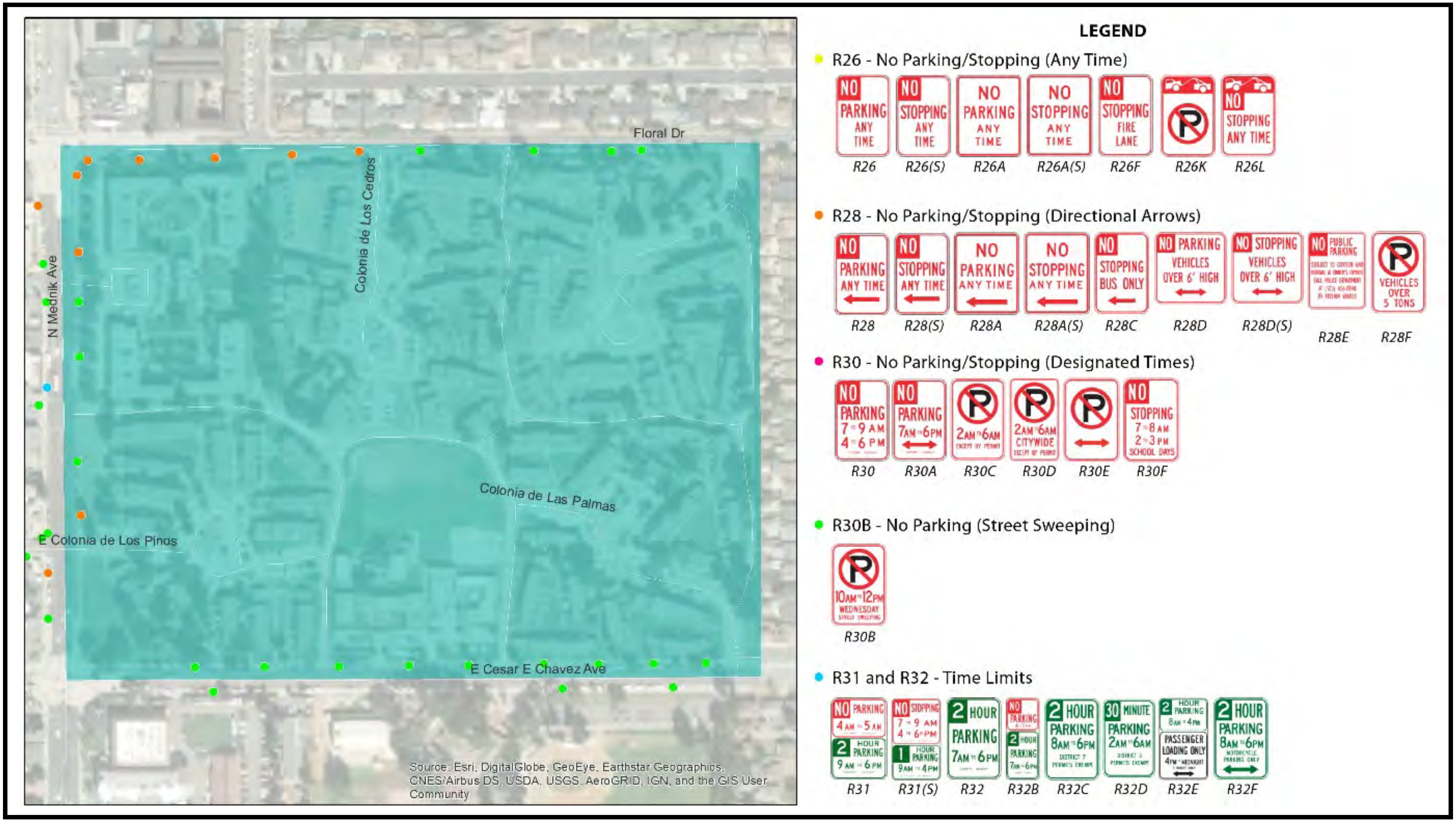


*Signs shown are examples of signage provided by the California Department of Transportation for each category. Signs do not represent actual signs posted in East LA.

Source: Public Works Department and Walker Consultants; 2020

Exhibit 7. Parking restrictions around the Nueva Maravilla Community appear to be the least restrictive with the exception of early morning Friday street sweeping restrictions from 5:00 a.m. to 8:00 a.m. Parking restrictions appear most prevalent along the Floral Drive corridor to the north of the area. There are no designated off-street county parking facilities in this area.

Exhibit 7: Nueva Maravilla

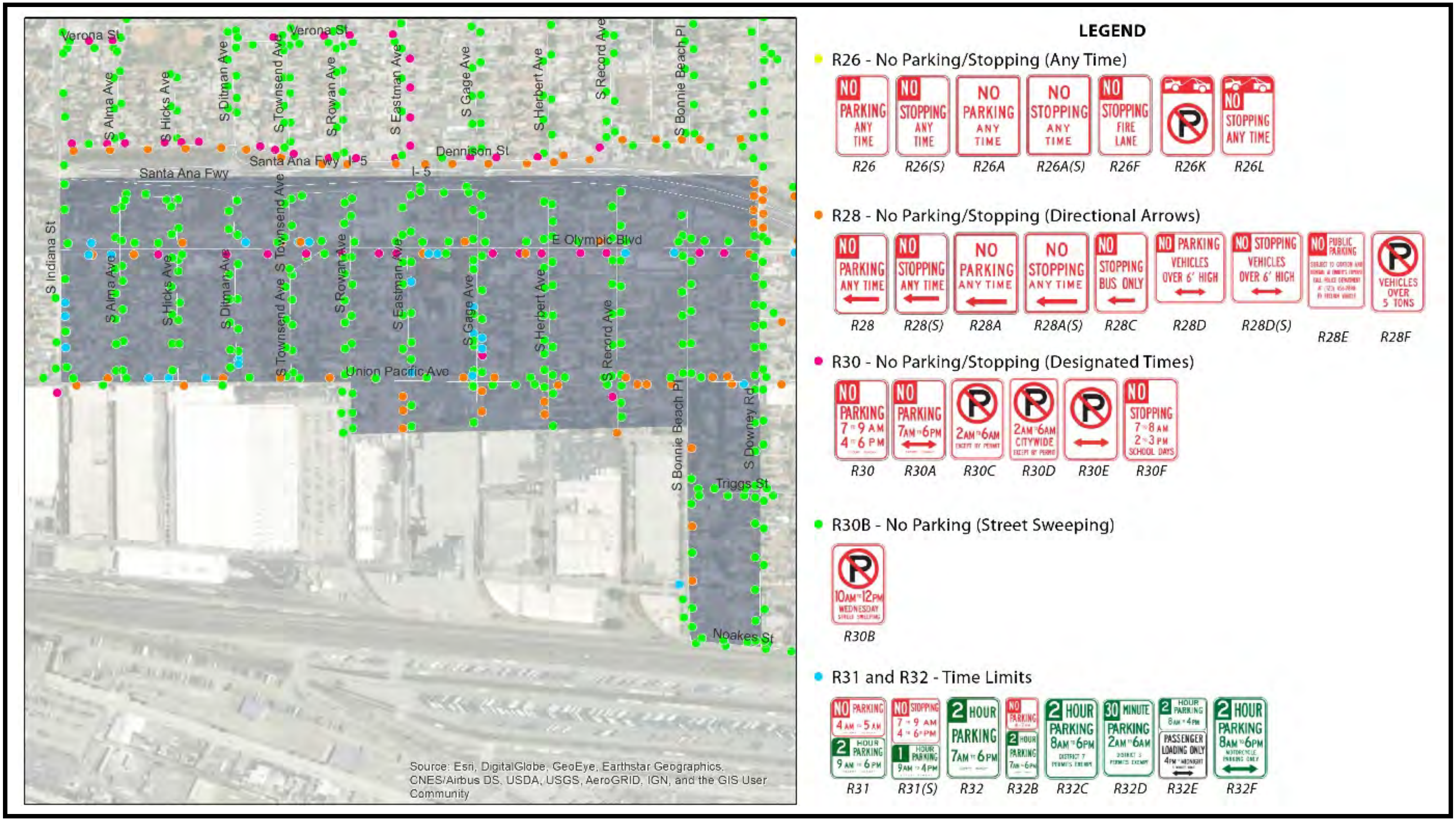


*Signs shown are examples of signage provided by the California Department of Transportation for each category. Signs do not represent actual signs posted in East LA.

Source: Public Works Department and Walker Consultants; 2020

Exhibit 8. The East Olympic Boulevard corridor operates in much of the same fashion as the Whittier/SR 72 and South Atlantic Boulevard corridors. Street sweeping restrictions occur in the early morning hours and no parking signs are posted restricting vehicles for sale within entire blocks and restricting commercial vehicles over 5 tons from 10:00 p.m. to 6:00 a.m. Typical restrictions are found to be prevalent around the Eastman Avenue elementary school. Residential street sweeping areas restrict parking on Thursday mornings from 8:00 a.m. to 12:00 p.m. and Friday afternoons from 11:00 a.m. to 3:00 p.m. There are no designated off-street county parking facilities in this area.

Exhibit 8: East Olympic Boulevard

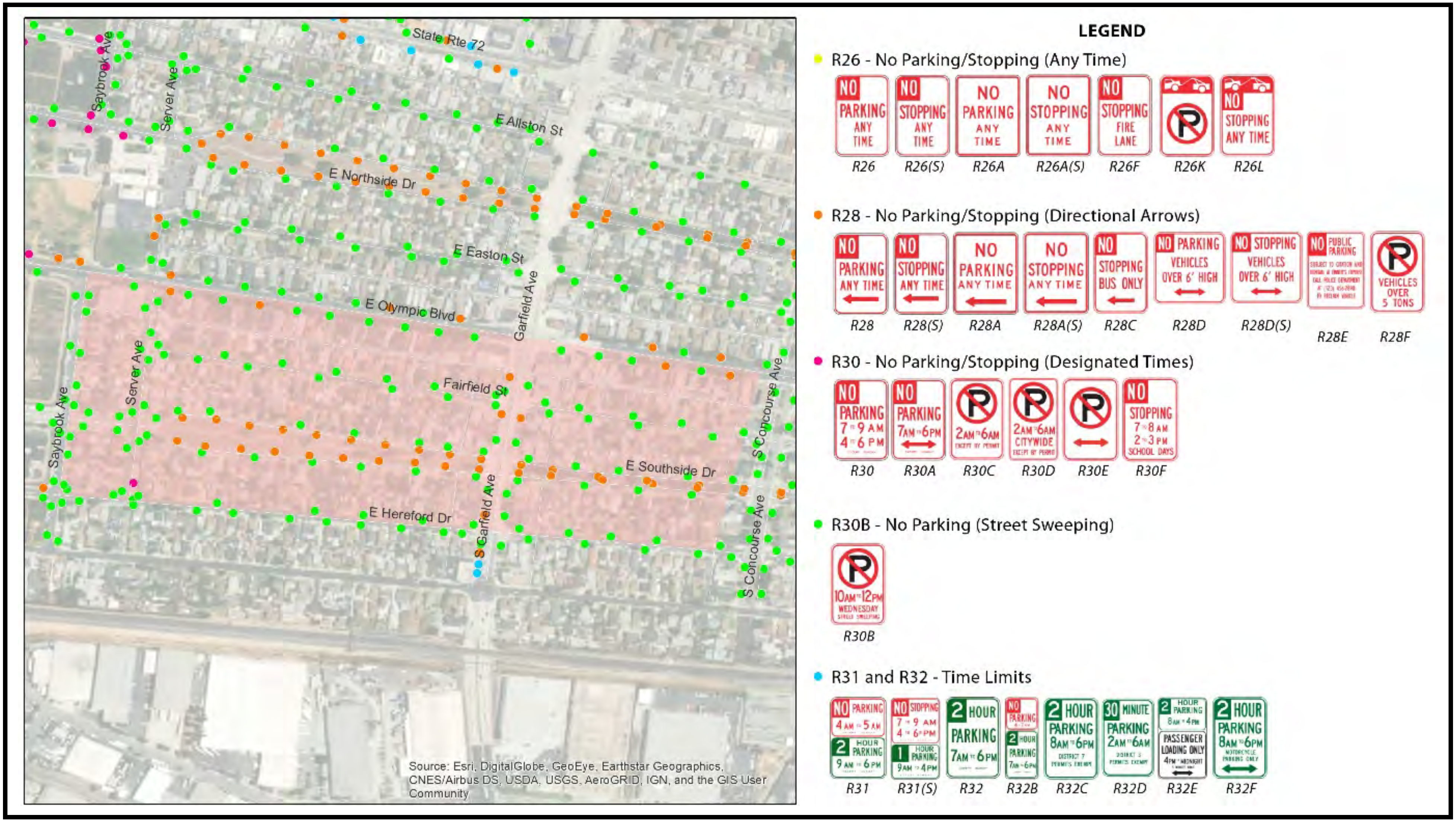


*Signs shown are examples of signage provided by the California Department of Transportation for each category. Signs do not represent actual signs posted in East LA.

Source: Public Works Department and Walker Consultants; 2020

Exhibit 9. The Saybrook neighborhood is just south of East Olympic Boulevard and runs from Saybrook Avenue on the west to Garfield Avenue on the east. The East Southside Drive corridor runs through the center of the residential area, restricting parking to only one side of the roadway. Residential street sweeping occurs on Tuesdays and Wednesdays from 11:00 a.m. to 3:00 p.m. There are no designated off-street county parking facilities in this area.

Exhibit 9: Saybrook Avenue



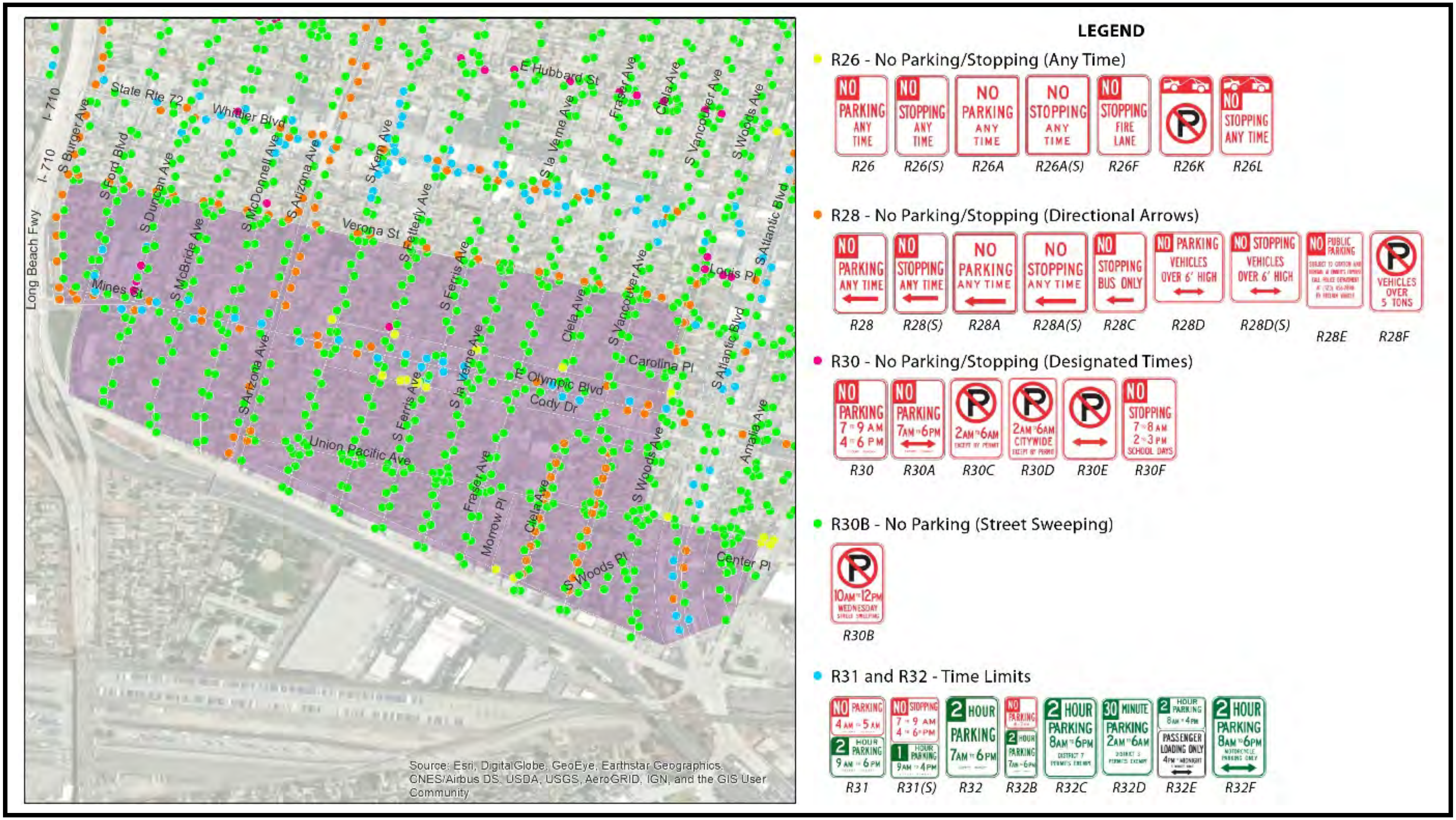
*Signs shown are examples of signage provided by the California Department of Transportation for each category. Signs do not represent actual signs posted in East LA.

Source: Public Works Department and Walker Consultants; 2020

Exhibit 10. The Telegraph and East Olympic Boulevard area is defined by each of these commercial corridors, although the neighborhood actually extends north to Verona Street. Areas east of South Woods Avenue and South Woods Place support extensions of the South Atlantic Boulevard commercial corridor. Winter Gardens Elementary School and Ford Boulevard Elementary School restrict street parking during early morning and afternoon passengers loading times. Neighborhood street sweeping occurs on Monday and Friday afternoons from 11:00 a.m. to 3:00 p.m. Parking along South Vancouver Avenue and Clela Avenue is limited to the residential sides of the roads and not permitted along the median.

Commercial vehicle parking over 5 tons is restricted along primary commercial corridors. As previously recognized, East Olympic Boulevard has a conflicting message for permissible and restrictive parking between 7:00 a.m. and 8:00 a.m. on street sweeping days. There are no designated off-street county parking facilities in this area.

Exhibit 10: Telegraph and East Olympic Boulevard



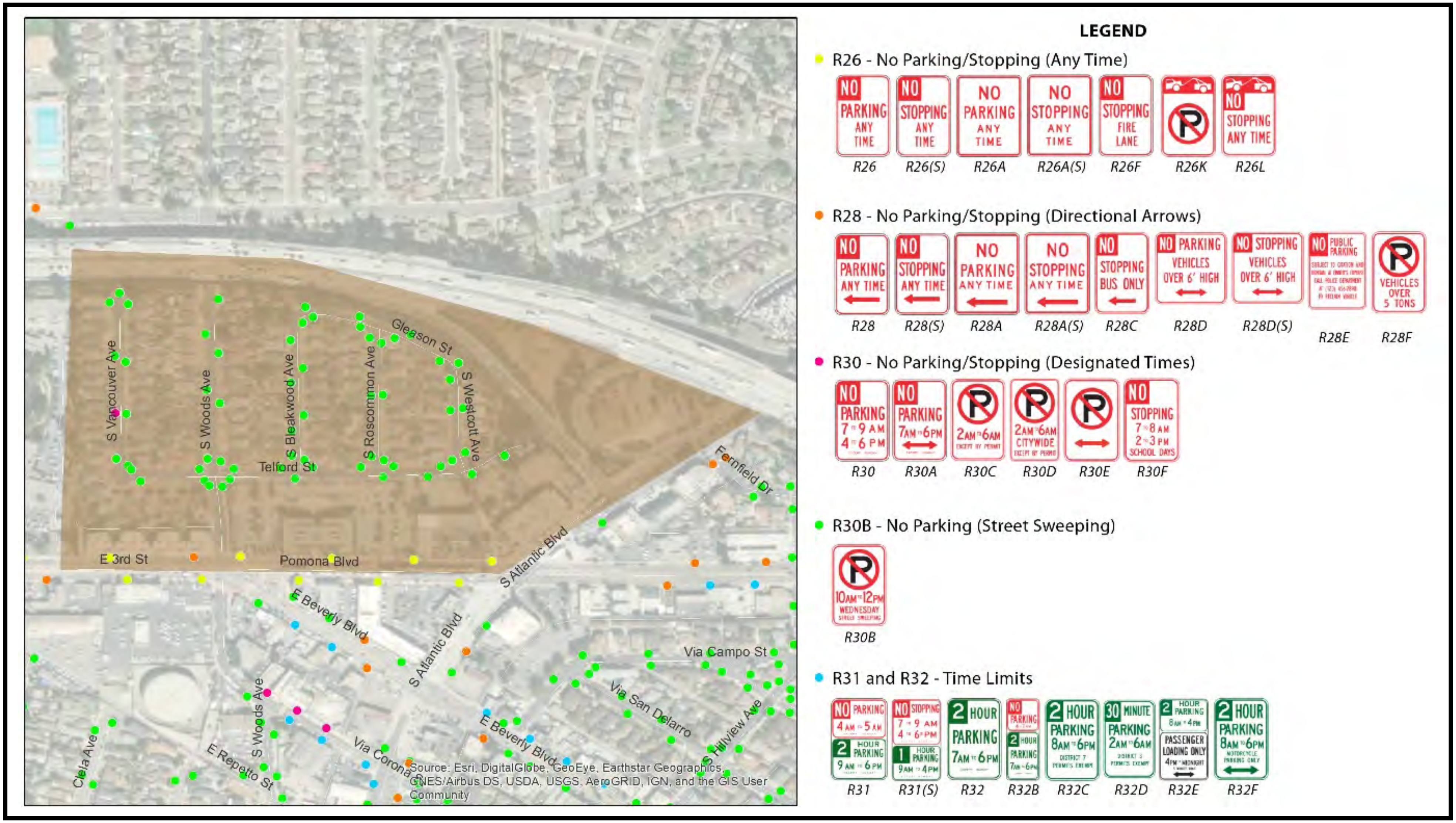
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

*Signs shown are examples of signage provided by the California Department of Transportation for each category. Signs do not represent actual signs posted in East LA.

Source: Public Works Department and Walker Consultants; 2020

Exhibit 11. The Telford Street area is bordered by East 3rd Street/Pomona Boulevard and the Pomona Freeway with limited access to the neighborhood from South Woods Avenue. Unique to this neighborhood is the Kaiser Permanente East Los Angeles Medical Offices. Parking during weekday business hours and Saturday mornings is limited to the needs of the medical offices, primarily restricting park and ride needs of the Metro Gold Line Atlantic Station. The nearby Atlantic Station Metro Gold Line parking facility restricts public parking from 4:00 a.m. to 11:00 a.m. each day and permits public parking after 11:00 a.m. for $3 for 3 hours. 24-hour transit parking is available for $2 per day. Neighborhood street sweeping occurs on Thursdays and Fridays.

Exhibit 11: Telford Street



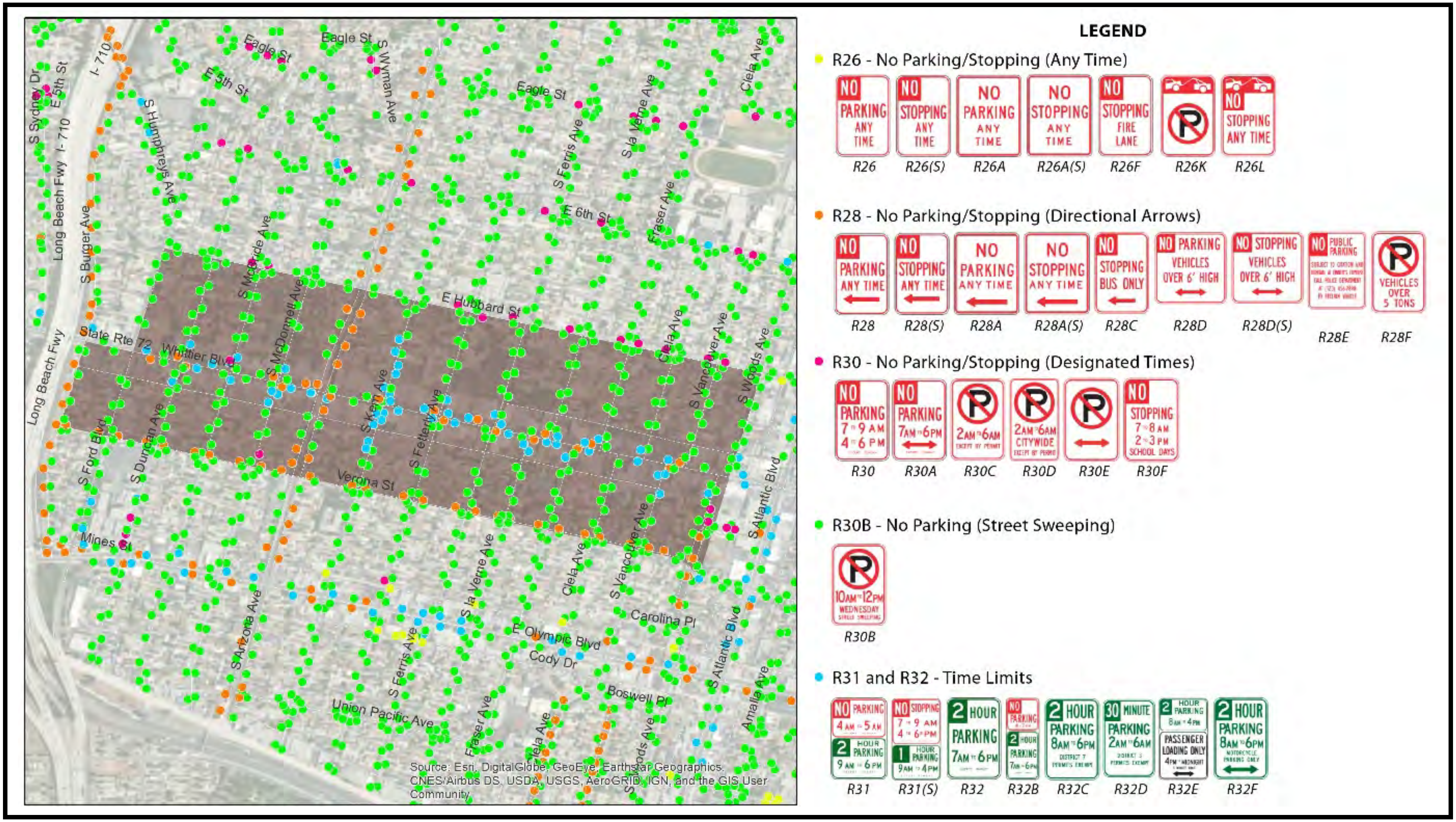
*Signs shown are examples of signage provided by the California Department of Transportation for each category. Signs do not represent actual signs posted in East LA.

Source: Public Works Department and Walker Consultants; 2020

Exhibit 12. The Whittier Boulevard/SR 72 serves a significant level of commercial activity between East Hubbard Street on the north and Verona Street on the south. Street sweeping on Whittier Boulevard has a similar conflicting message for permissible and restrictive parking between 7:00 a.m. and 8:00 a.m. on street sweeping days. Parking along Verona Street is limited to one side of the street due to the limited rights of way along this corridor.

The County offers off-street public parking inventory at 922 South Fetterly Avenue, which prohibits parking from midnight to 6:00 a.m. and public parking inventory at 753 South La Verne Avenue. Parking is free of charge at these locations.

Exhibit 12: Whittier Boulevard/SR 72 East of I-710

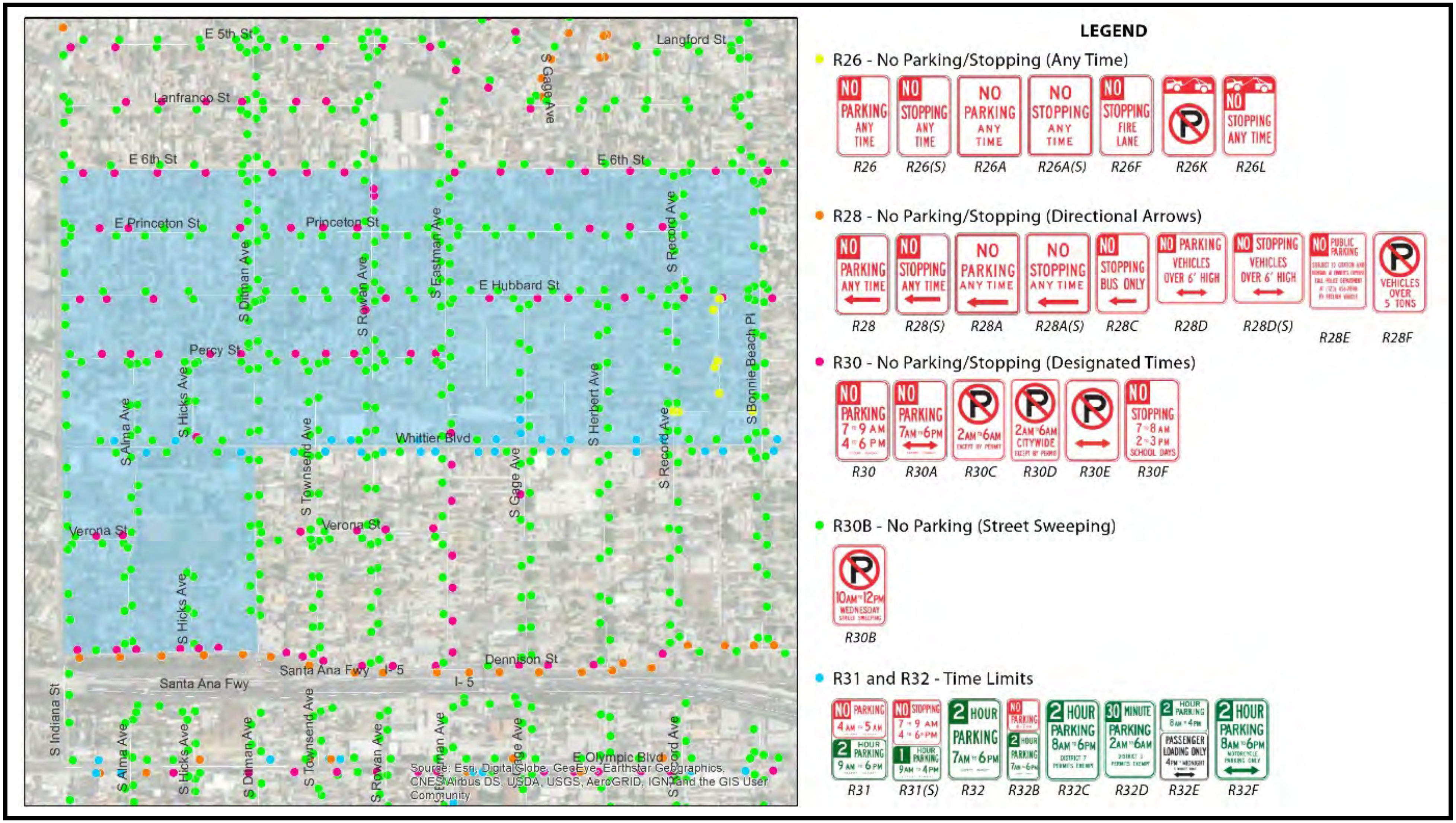


*Signs shown are examples of signage provided by the California Department of Transportation for each category. Signs do not represent actual signs posted in East LA.

Source: Public Works Department and Walker Consultants; 2020

Exhibit 13. Whittier Boulevard/SR 72, west of the I-710 supports additional commercial activity between South Downey Road and South Indiana Street. County provided parking at Salazar Park suggests the only county-owned public parking in the neighborhood. Residential street sweeping restrictions limit parking in neighborhoods on Thursdays between 8:00 a.m. and 12:00 p.m. and Fridays between 11:00 a.m. and 3:00 p.m. Parking along the Dennison Street corridor to the south is limited to parking on the residential side of the street only.

Exhibit 13: Whittier Boulevard West



*Signs shown are examples of signage provided by the California Department of Transportation for each category. Signs do not represent actual signs posted in East LA.

Source: Public Works Department and Walker Consultants; 2020

Walker Recommendation

Based on our general observations of the parking restrictions in East Los Angeles, Walker recommends that the County continue to focus on the following areas:

- Street sweeping of commercial corridors should remain the focus during the early morning hours before 7:00 a.m. Neighborhood street sweeping in residential corridors should continue to allow for street sweeping restrictions on one side of the street during opposing and separate days of the week.
- Consider extending on-street parking permissions on commercial corridors from a 1-hour limit to a 2-hour limit to allow for maximum commercial access and appropriate enforcement behaviors. The reality of enforcing a 1-hour time limit is not conducive to commercial needs and enforcement resources.
- The removal of multiple restrictive signs, to include “no parking commercial vehicles over 5 tons” and “no parking of vehicles for sale entire block.” These restrictions should remain a function of County ordinance and enforced district wide.
- During the current conditions analysis, community stakeholders expressed that food vendor trucks, mobile kitchens, and pickup trucks pulling food kitchen trailers often park longer than the posted time restriction, which limits curbside access and commercial turnover throughout the permissible parking times of day. The County should work with food truck and mobile kitchen vendors to create designated areas where these services may be offered to the public without affecting commercial access and traffic conflicts.

Parking Violation Categories

Los Angeles County is a legal subdivision of the state of California charged with governmental powers. Under the powers established within the county’s charter, Title 15 – VEHICLES AND TRAFFIC provides three specific divisions defining 1) traffic, 2) miscellaneous traffic regulations, and 3) penalties and fees related to violations of standing and parking laws. Within the three divisions, specific ordinances have been developed for laws governing traffic signs and signals; stopping, standing, and parking; abandoned and inoperable vehicles; and a schedule of civil penalties and additional assessments for parking violations.

Walker requested and received copies of the parking citations issued in Unincorporated East LA over the past three years, including records from calendar years 2017 through 2019. On average, the Parking Enforcement Detail issued sixty-four (64) different categories of parking citations. The citation categories and fines are as follows:

Exhibit 14: Unincorporated East LA Most Common Parking Citation Categories

#	Parking Citation	California Vehicle Code	LA County Ordinance	Fine Amount
1	Abandonment Prohibited	22523 (a)(b)		$100
2	Parking in Fire lane	22500.1		$65
3	Parking Disabled Access Ramp	22500(l)		$250
4	Blocking Street		15.64.300	$40
5	Parking in Bus Loading Zone		15.64.110	$250

#	Parking Citation	California Vehicle Code	LA County Ordinance	Fine Amount
6	Double Parking	22500(h)		$40
7	Failure to Apply for Registration	4152.5		$25
8	Failure to Obey Sign/Curb Markings		15.200.703	$50
9	Failure to Obey Sign/Curb Markings		15.200.70	$50
10	Failure to Obey Sign/Curb Markings		15.200.701	$50
11	Parks - Unauthorized Parking		17.04.370M	$40
12	Parking in Front Yard		15.64.271	$55
13	Disabled Parking	22507.8		
14	Disabled No Visible Placard or Plate	22507.8(a)		$330
15	Obstruction of Disabled Parking Space	22507.8(b)		$330
16	Parking Disabled Crosshatched Boundary Lines	22507.8(c)		$330
17	Identification Plate	5017		
18	Key in Ignition, Unattended Vehicle		15.64.210	$35
19	Position of License Plate	5201		$25
20	Mutilated of Illegal License Plate	4457		$25
21	No Commercial Parking, Residential District (more than 10,000lbs.)		15.64.052	$65
22	Commercial Vehicle (More than 6,000 lbs.) Parked in Violation of Posted Limits		15.64.055	$65
23	Display of License Plate	5200		$25
24	No Front Plates	5200(a)		$25
25	Period of Display	5202		$25
26	No Parking at Anytime		15.64.260	$40
27	No Violation Code		No VIOL	
28	Parking in Intersection	22500(a)		$40
29	Parked on Lawn	2220025		
30	Parked over 18" from Curb		15.76.230	$40
31	Parking in Alley	1048060		$40
32	Parking/Safety and Curb	22500(c)		$40
33	Parking Commercial Vehicle		15.64.050	
34	Parking, Disconnected Trailer		15.64.100	$40
35	Parking - Fire Hydrant		15.64.370	$55
36	No Parking – Alleys		15.64.130	$40
37	Parking in Bus Zone	22500(i)		$250
38	Housing Authority - Occupying More than One Parking Space		15.44.140	$35
39	Blocking Driveway	22500(e)		$40
40	Parking on Grades		15.64.220	$35
41	Unlawful Parking - Public Grounds	21113(a)		$40
42	Parking in Private or Public Property without Consent		15.64.270	$40
43	Parking Time Limits		15.200.10	$35

#	Parking Citation	California Vehicle Code	LA County Ordinance	Fine Amount
44	Parking in Intersection	22500(a)		$40
45	Parking on Wrong Side of Street		15.64.280	$40
46	Parking Near (3') Sidewalk Access Ramp	22522		$280
47	Blocking Driveway on Private Street		15.64.320	$40
48	Plate Clearly Visible	5201(f)		$25
49	With Proof of Correction	5201(g)		$10
50	Preferential Parking District-Unauthorized Parking		15.64.700	$40
51	15' of Fire Hydrants	22514		$55
52	Parking 18" from Curb	22502(a)		$40
53	Parking Fire Station Entrance	22500(d)		$55
54	Parking on Crosswalk	22500(b)		$40
55	Parking on Sidewalk	22500(f)		$40
56	Parking Lot - Street and Alley Parking	22951		$35
57	Repairing Vehicles on Street		15.76.120	$40
58	Stopping Prohibited		15.64.180	
59	Street Sweeping		15.200.702	$50
60	No Tabs Displayed	5204		$60
61	No Tabs Displayed	5204(a)		$60
62	Temporary No Parking		15.64.140	$40
63	Registration Required	4000(a)		$60
64	Registration Required	4000(a)1		$60

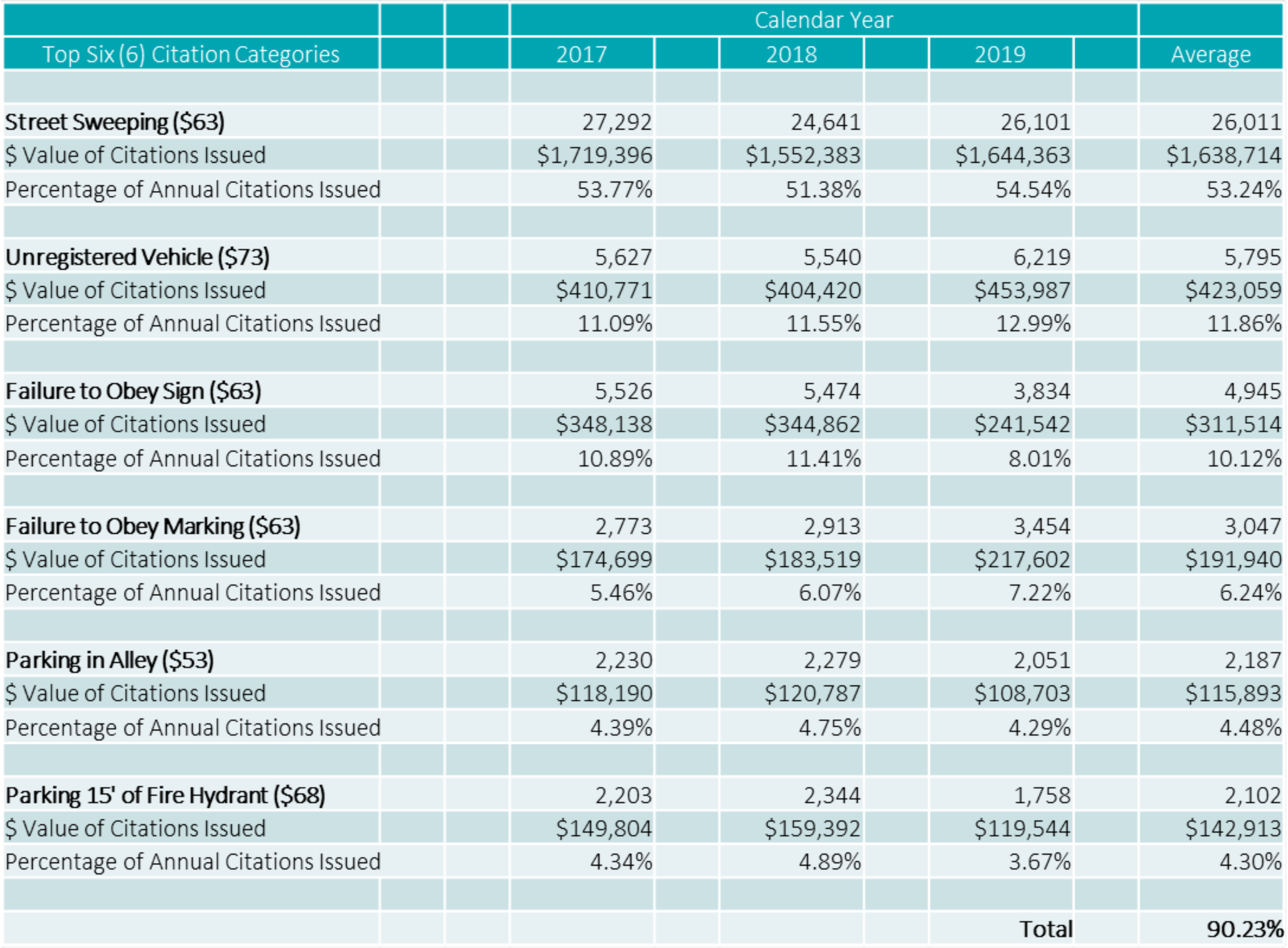
Source: LA County Sheriff; Conduent; 2020

The list of most commonly issued citations shown above represent forty-six percent (46%) of the total violation categories shown in the County's parking citation database system. Between LA County parking ordinance codes and the California Vehicle Code, the Parking Enforcement Detail has the ability to issue as many as 140 different types of parking violations within the county. A complete list of LA County parking violation descriptions with violation code and fine amount has been provided in the Appendix section at the end of this report. The violation list includes applicable California Vehicle Code and LA County Ordinance descriptions.

Of the sixty-four (64) violation categories shown in the previous exhibit, six (6) citation categories comprise ninety percent (90%) of the citations issued in East LA County. This data for these six categories are shown in **Exhibit 15**.

Approximately 53% of the parking citations issued in the East LA County neighborhoods are for street sweeping violations, an indication that many residents do not have options for parking their vehicle in designated off-street locations or other on-street locations.

Exhibit 15: Unincorporated East LA Top Six Citation Categories



	Calendar Year			
Top Six (6) Citation Categories	2017	2018	2019	Average
Street Sweeping ($63)	27,292	24,641	26,101	26,011
$ Value of Citations Issued	$1,719,396	$1,552,383	$1,644,363	$1,638,714
Percentage of Annual Citations Issued	53.77%	51.38%	54.54%	53.24%
Unregistered Vehicle ($73)	5,627	5,540	6,219	5,795
$ Value of Citations Issued	$410,771	$404,420	$453,987	$423,059
Percentage of Annual Citations Issued	11.09%	11.55%	12.99%	11.86%
Failure to Obey Sign ($63)	5,526	5,474	3,834	4,945
$ Value of Citations Issued	$348,138	$344,862	$241,542	$311,514
Percentage of Annual Citations Issued	10.89%	11.41%	8.01%	10.12%
Failure to Obey Marking ($63)	2,773	2,913	3,454	3,047
$ Value of Citations Issued	$174,699	$183,519	$217,602	$191,940
Percentage of Annual Citations Issued	5.46%	6.07%	7.22%	6.24%
Parking in Alley ($53)	2,230	2,279	2,051	2,187
$ Value of Citations Issued	$118,190	$120,787	$108,703	$115,893
Percentage of Annual Citations Issued	4.39%	4.75%	4.29%	4.48%
Parking 15' of Fire Hydrant ($68)	2,203	2,344	1,758	2,102
$ Value of Citations Issued	$149,804	$159,392	$119,544	$142,913
Percentage of Annual Citations Issued	4.34%	4.89%	3.67%	4.30%
			Total	**90.23%**

Source: LA County Sheriff Department; 2020 (Fine amounts include additional penalties and related costs)

Walker Recommendation

Based on our general observation notes of the parking violation categories for unincorporated East Los Angeles, Walker recommends that the Parking Enforcement Detail focus on the following areas:

- Focus consistent enforcement practices on all violation types to include time-limited and metered parking in commercial corridors, commercial vehicle parking in residential neighborhoods, and parking vehicles for sale in commercial corridors.

Enforcement Practices

Walker evaluated a number of parking enforcement data outputs including citations issued, cost of citations, fees and penalties, average cost of citation, annual revenue collected, annual delinquency rates, average total cost of outstanding citations, as well as total number and amount of outstanding citations. A summary of this information has been provided in this section with our evaluation comments provided accordingly.

Parking Enforcement Data

Through a data request to the Parking Enforcement Detail, Walker received the following parking enforcement data from Conduent, the agency's parking citation management vendor. The data provided in the following exhibit details the number of citations issued and paid with their associated dollar amount. The exhibit also reflects the number of unpaid citations with the associated revenues for the amount of outstanding citations. Lastly, a percentage of calendar year paid versus issued citations is reflected in the last line.

Exhibit 16: East Los Angeles Parking Citation Data – Recent Three-Year Historical

	CY2017	CY2018	CY2019
Citations Issued	50,757	47,690	47,860
Citations Paid*	34,868	35,515	35,015
Total PAID AMT	$3,390,374	$3,300,673	$2,918,807
Citations Unpaid	15,889	12,175	12,845
Total AMT Due (Unpaid)	$2,363,122	$2,196,682	$2,566,571
Percentage Paid	68.70%	74.50%	73.20%

*By Process Date

Source: Conduent; August 2020

Countywide, Conduent's records reflect a three-year average of 239,236± citations issued. Of the issued citations, an average of 84,028± were paid without collection measures, while an additional 79,686± (approximately 50% of the total citations noticed) citations were paid through collection efforts. Countywide citation payment percentages average 68.43% per year. By comparison of the same three-year period, annual citations solely issued in East Los Angeles have a slightly greater percentage (72.13%) of payment on record.[1]

There are two types of citations of parking citations that are uploaded into Conduent's citation database.

1. Electronic – Citation issued via parking control officer handheld docked at the individual Sheriff's stations and uploaded to the database in a nightly batch process.
2. Handwritten – Batched by County Parking Enforcement Detail and sent to Conduent via third party courier services for data entry and also uploaded to the database in a nightly batch process. These may take a little

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[1] Conduent Business Services, LLC; LA County Grand Totals Extract Report; July 2020

longer to update depending on the time it takes for Conduent to receive citations from Parking Enforcement Detail (currently it's estimated Conduent is receiving a few 100 handwritten citations daily).

The timeline and communication to the violator is dictated by a pre-programmed citation lifecycle shown in **Exhibit 17**. The citation database is programmed with next action logic so that each citation follows this flow from issuance through closure via dismissal or payment. When a citation is contested the lifecycle stops (is suspended) while the citation is under review.

The primary issue when paying a citation in-person relates to the violator's need to pay the citation immediately after issuance. Electronic citations generally get uploaded quicker; however there is still a potential for delay depending on the day and specific time the citation was issued. Handwritten citations may take as many as 4 to 6 calendar days for the citation record to appear in the database if the citation was issued on a Friday.

Conduent has recommended a conversion to real-time upload and processing using one of their newer proprietary enforcement applications to address this issue. The following exhibit has been provided to detail the digitized rules governing the County's citation lifecycle.

Exhibit 17: LA County Parking Citation Lifecycle

Date	Action/Event	Description
Day 0	Issue Date	Citation issued to citizen
Day 1	Registered Owner Update	Name/address requested from DMV: requests done (INSTATE 4 times every 30 days | OUT of STATE 4 times every 90 days)
Day 21	Notice 1	Notice of Delinquent Parking: mailed 21 days after issue date
Day 36	Penalty 1	Assessed 15 days after Notice 1 mail date
Day 51	Penalty 2	Assessed 15 days after Penalty 1 is added
	Penalty 4	Assessed 15 days after Penalty 1 is added: Penalty 4 is Special Collection Fee, assessed at 30% of amount due as of January 2010 and 21% of amount due before January 2010
	Penalty 5	Assessed 15 days after Penalty 1 is added: Penalty 5 is $3 California DMV Fee for DMV hold, INSTATE only
	Notice 21	1st Special Collection Notice: mailed as soon as Penalties 2, 4, and 5 are assessed
Day 56	Registration Hold Request	California DMV hold is requested 5 days from Notice 21 mail date
Day 66	Notice 22	2nd Special Collection Notice: mailed 15 days after Notice 21 mail date
Day 96	Notice 25	3rd Special Collection Notice: mailed 30 days after Notice 22 mail date

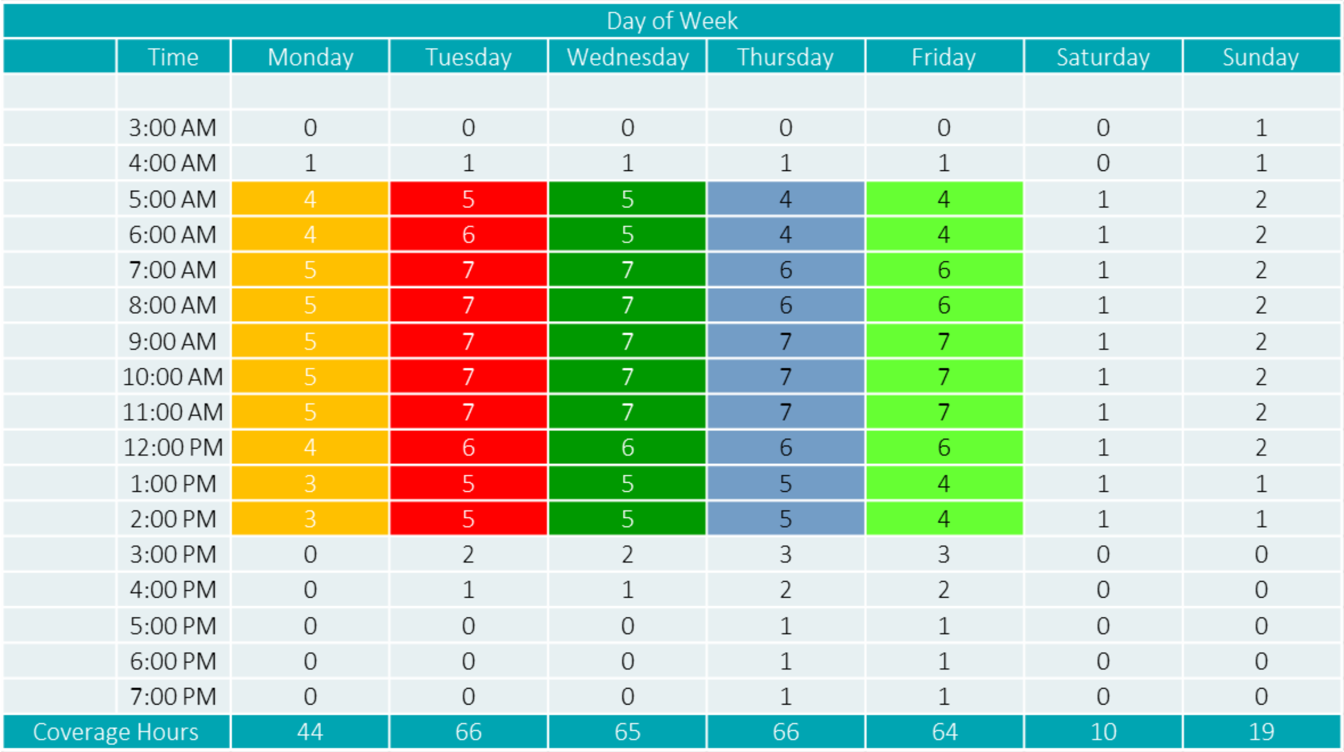
Source: Conduent; August 2020

Allowing a DMV hold to be placed on a vehicle registration within 60-days of an unpaid citation is an ideal best practice measure for citation collection. Some states require three or more outstanding citations, or in some cases, a significant dollar amount threshold to place a vehicle registration on hold. Introducing a graduating penalty schedule every 15 days is also considered a best practice measure for encouraging payment of an outstanding citation.

Parking Restrictions and Enforcement Mapping

Parking enforcement throughout East LA County is designed by time of day and day of week. During our stakeholder interview with the Parking Enforcement Detail team we learned street sweeping enforcement responsibilities determine how enforcement resources are allocated each day. Street sweeping schedules are generally designated on Mondays through Fridays from 5:00 a.m. to 7:00 a.m., 8:00 a.m. to 12:00 p.m., and 11:00 a.m. to 3:00 p.m. To meet the scheduled enforcement times, the Parking Enforcement Detail allocates a minimum of four to seven parking control officers to the designated areas each day. The following exhibit has been provided to demonstrate the coverage areas on street sweeping days.

Exhibit 18: Parking Enforcement Detail Coverage by Time of Day and Day of Week



Day of Week								
	Time	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
	3:00 AM	0	0	0	0	0	0	1
	4:00 AM	1	1	1	1	1	0	1
	5:00 AM	4	5	5	4	4	1	2
	6:00 AM	4	6	5	4	4	1	2
	7:00 AM	5	7	7	6	6	1	2
	8:00 AM	5	7	7	6	6	1	2
	9:00 AM	5	7	7	7	7	1	2
	10:00 AM	5	7	7	7	7	1	2
	11:00 AM	5	7	7	7	7	1	2
	12:00 PM	4	6	6	6	6	1	2
	1:00 PM	3	5	5	5	4	1	1
	2:00 PM	3	5	5	5	4	1	1
	3:00 PM	0	2	2	3	3	0	0
	4:00 PM	0	1	1	2	2	0	0
	5:00 PM	0	0	0	1	1	0	0
	6:00 PM	0	0	0	1	1	0	0
	7:00 PM	0	0	0	1	1	0	0
Coverage Hours		44	66	65	66	64	10	19

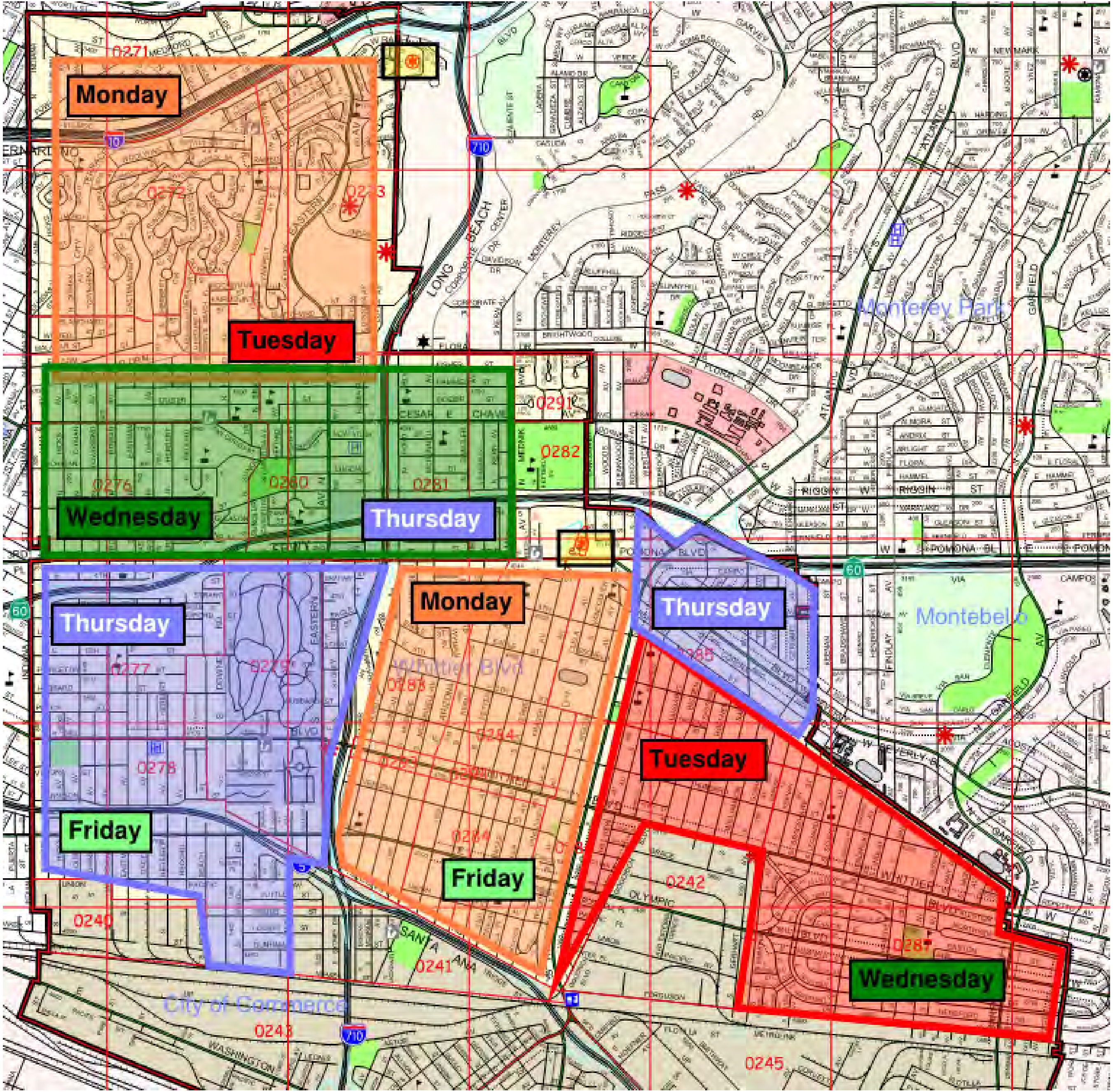
Source: LA County Sheriff Department, LA County Public Works Department and Walker Consultants; 2020

In this exhibit, each day of the week has been color coded with a color that identifies the scheduled streets within the county boundaries. For a detailed description of the street sweeping schedules by day of the week, please refer to the Appendix section at the end of this report. As shared above, street sweeping responsibilities begin at 5:00 a.m. each day and run through 3:00 p.m. A total of eight (8) parking control officers are assigned to the East LA Station, reporting to one (1) supervisor. As evidenced by the number of enforcement officers assigned to weekday enforcement times, we learned three to four officers are assigned to street sweeping responsibilities each weekday, while the remaining two to three officers handle enforcement of abandoned vehicles and neighborhood calls made to enforcement dispatch.

Mapping

To help visualize the street sweeping restrictions and the assigned allocation of parking control officers by day of the week, we designed the following exhibit to show how concentrated coverage occurs within certain areas of the community each day, while other areas may receive negligible coverage outside of their street sweeping schedule times.

Exhibit 19: Parking Enforcement Detail Coverage by Street Sweeping Schedule



Source: LA County Sheriff Department, LA County Public Works Department and Walker Consultants; 2020

As shown in the exhibit, most street sweeping areas do experience enforcement coverage more than one day of the week as street sweeping schedules provide sweeping on opposite sides of the street on different days. The exhibit has been color coded to highlight the areas where street sweeping occurs on a second day of the week. It is believed the assigned street sweeping parking control officers remain in these areas during their scheduled shift to accommodate the various street sweeping times throughout the early morning, late morning, and early afternoon. Tuesday through Friday, between 3:00 p.m. and 7:00 p.m., as few as one to three parking control officers are assigned to cover the entire community. On Mondays, Saturdays and Sundays, no enforcement coverage is provided between 3:00 p.m. and 7:00 p.m.

Walker Recommendation

Based on our general observation notes of the parking enforcement practices for unincorporated East Los Angeles, Walker recommends that the County focus on the following areas:

- Demonstrate consistent enforcement practices in all areas of unincorporated East Los Angeles County to increase parking compliance and encourage vehicle owners to take greater responsibility for their parking behavior.
- Continue to promote payment options and encourage the practice of citation payment within the first 21 days of issuance to avoid subsequent penalties.
- Consider the use of license plate recognition (LPR) for the Parking Enforcement Detail to maintain the timeliness of district-wide enforcement practices and discourage scofflaw behavior.
- Add the best practice of immobilizing vehicles for non-payment of multiple outstanding violations. Upon immobilization, vehicles should be towed at the end of the day if immobilization practice is not addressed by vehicle owner in the same day. Immobilized vehicles left on street overnight may encourage tampering of immobilization devices.

02 Parking Enforcement Operations

Parking Enforcement Operations

Walker conducted a comprehensive review of the Sheriff's Department Parking Enforcement Detail. The review included the number of staff assigned to the Parking Enforcement Detail, encumbered versus vacant positions, funding and staffing cost analysis, scheduling, workload GAP analysis, and hiring practices. The following information has been provided to demonstrate the challenges and opportunities within each of these review items. Where appropriate, we have provided best practice recommendations for improving efficiencies and maximizing the customer service experience.

Organization

The Parking Enforcement Detail remains the responsibility of the Civil Management Bureau of the Los Angeles County Sheriff's Department. Within the Bureau's organization, a Captain position oversees a Manager position, which is responsible for the oversight of sixteen (16) enforcement detail stations throughout the entire county. A single headquarter location provides administrative and technical support to the remote stations.

Staffing levels at each station range from as few as one (1) Parking Control Officer at the Santa Clara Station, to as many as eight (8) Parking Control Officers at the East Los Angeles and the Century stations. As many as eleven (11) Supervisor Parking Control Officers are responsible for overseeing enforcement activity at some individual stations. Not all stations have a dedicated supervisor. As of May 12, 2020, the Parking Enforcement Detail organization chart reflected a total of fifty-five (55) encumbered Parking Control Officer positions out of a budgeted fifty-five positions; a total of ten (10) encumbered Supervisor Parking Control Officer positions out of a budgeted eleven positions; and seven (7) encumbered office and technical support positions out of a budgeted eight positions. (See Exhibit 21 on the following page)

East Los Angeles Station

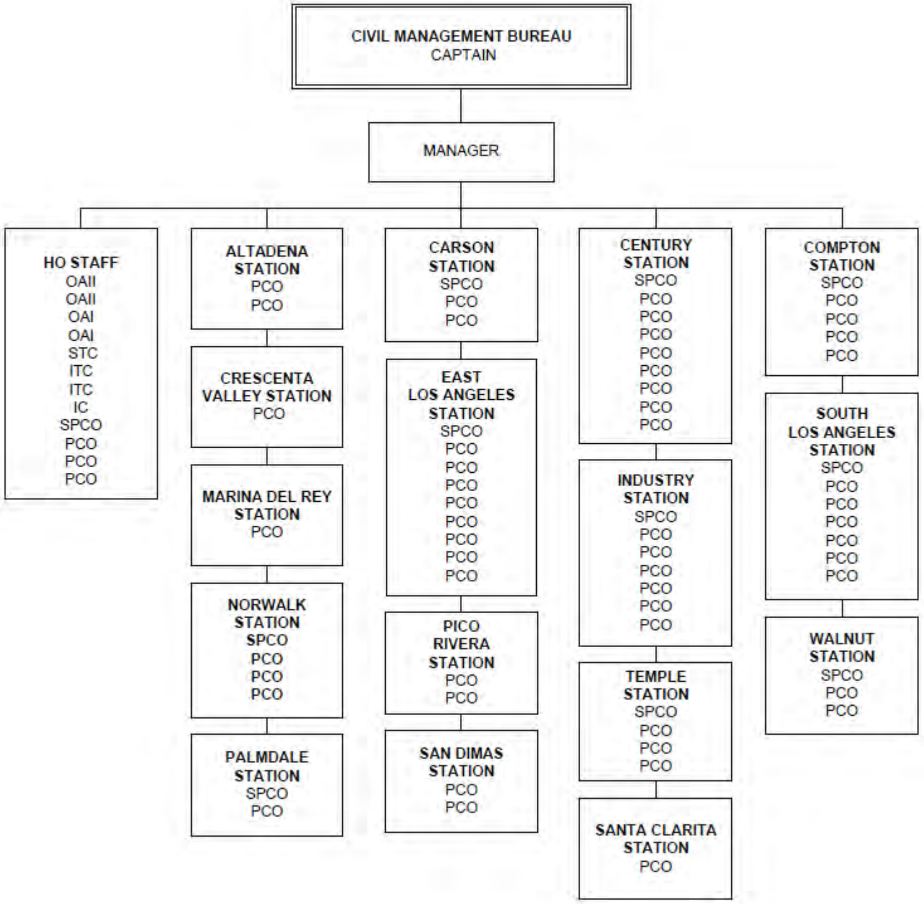
The East Los Angeles Parking Enforcement Detail station is staffed with eight Parking Control Officers (PCO) and supervised with one Supervisor Parking Control Officer (SPCO). The following exhibit has been provided to demonstrate current staff coverage and assigned shifts.

Exhibit 20: East Los Angeles Parking Enforcement Detail Staff and Assigned Shifts

#	Rank	Day of Week	Time of Day	Number of Staff (Shift Length)
1	SPCO	Monday through Friday	6: 00 AM to 2:00 PM	Five (8-hour tour)
1	PCO	Tuesday through Friday	5: 00 AM to 3:00 PM	Four (10-hour tour)
2	PCO	Tuesday through Friday	7:00 AM to 5:00 PM	Four (10-hour tour)
3	PCO	Monday through Friday	6:30 AM to 2:30 PM	Five (8-hour tour)
4	PCO	Sunday	3:00 AM to 1:00 PM	One (10-hour tour)
		Monday through Wednesday	5:00 AM to 3:00 PM	Three (10-hour tour)
5	PCO	Monday through Friday	4:00 AM to 12:00 PM	Five (8-hour tour)
6	PCO	Monday through Thursday	5:00 AM to 3:00 PM	Four (10-hour tour)
7	PCO	Monday through Friday	5:00 AM to 1:00 PM	Five (8-hour tour)
8	PCO	Thursday and Friday	9:00 AM to 7:00 PM	Two (10-hour tour)
		Saturday and Sunday	5:00 AM to 3:00 PM	Two (10-hour tour)

Source: LA County Sheriff Department; May 2020

Exhibit 21: East Los Angeles Parking Enforcement Detail – Organization Chart



Source: LA County Sheriff Department; May 2020

Encumbered Versus Budgeted Positions

As of May 2020, the Civil Management Bureau has seventy-four (74) encumbered positions of seventy-six (76) budgeted positions for a ninety-seven (97%) encumbrance rate. Only one headquarter support position and one Supervisor Parking Control Officer position are shown as unencumbered or vacant. According to these staffing metrics, the Bureau appears to be experiencing minimal vacancies and recruiting challenges.

Funding and Staffing Cost Analysis

We requested and received the salary information for the Parking Enforcement Detail and the 2018-2021 salary schedule with step increases for the position of Supervisor Parking Control Officer and Parking Control Officer. The following exhibit has been provided to demonstrate the salary ranges for each of these positions.

Exhibit 22: East Los Angeles Parking Enforcement Detail – Salary Schedule

Parking Enforcement Detail 2018-2021 Salary Schedule							
Position	Year	Step 1 Annual	Step 2 Annual	Step 3 Annual	Step 4 Annual	Step 5 Annual	Step 6 Annual
Supervisor Parking Control Officer	10/1/18	$46,579	$49,155	$51,886	$54,785	$57,840	$59,424
	10/1/19	$47,724	$50,376	$53,184	$56,148	$59,280	$60,912
	1/1/20	$48,199	$50,877	$53,716	$56,710	$59,873	$61,523
	10/1/20	**$49,399**	**$52,146**	**$55,058**	**$58,128**	**$61,371**	**$63,060**
	1/1/21	$49,399	$52,146	$55,058	$58,128	$61,371	$63,060
Parking Control Officer	10/1/18	$40,350	$42,566	$44,910	$47,381	$50,010	$51,380
	10/1/19	$41,340	$43,610	$46,019	$48,557	$51,255	$52,665
	1/1/20	$41,736	$44,028	$46,464	$49,032	$51,756	$53,184
	10/1/20	**$44,911**	**$47,381**	**$50,010**	**$52,795**	**$55,739**	**$57,267**
	1/1/21	$44,911	$47,381	$50,010	$52,795	$55,739	$57,267

Source: LA County Sheriff; 2020

As shown in red highlight and effective October 1, 2020, Supervisor Parking Control Officers are eligible for a Step 1 base salary amount of $49,399 and Parking Control Officers are eligible for a Step 1 base salary amount of $44,911. The salary amounts shown in this exhibit do not include amounts for benefits and pension contributions, nor does the amount reflect any overtime compensation or other pay amounts. The step increases provide a measure of merit pay increases dependent upon annual performance evaluation. For salary comparison purpose, the U.S. Bureau of Labor Statistics website was referenced for parking enforcement workers. As of May 2019, the occupational employment and wages provided the following breakdown:

Exhibit 23: U.S. Bureau of Labor Statistics for Parking Enforcement Workers

			(Median)		
Percentile	10%	25%	50%	75%	90%
Hourly Wage	$12.80	$15.48	$19.67	$25.50	$30.87
Annual Wage	$26,610	$32,200	$40,920	$43,040	$64,210

Source: www.bls.gov 33-3041 Parking Enforcement Workers; 2020

When compared to these national wage percentages, the Los Angeles County Parking Enforcement Detail employees fall under the 75% to 90% salary earnings range for parking enforcement workers.

Additional geographic research from this same website revealed California as the state with the highest level of employment in this position, representing 7% employment per thousand jobs. On average, California has a location quotient of 1.28, representing the ratio of the area concentration of occupational employment to the national average concentration. A location quotient greater than one indicates the occupation has a higher share of employment than average. Additionally, California has an hourly mean wage amount of $27.81 per hour and an annual mean wage amount of $57,850 per year before benefits and pension contributions. Each of these wage amounts continue to fall between the 75th and 90th percentile of the national average.

Workload Gap Analysis

As identified in the public survey responses and further supported through comments made during the community stakeholder sessions, both residents and business merchants believe enforcement coverage is not substantial or consistent enough to meet the needs of the community. A number of stakeholders shared that enforcement officers are seldom seen enforcing matters on their community streets, especially during the afternoon and early evening hours. On days when street sweeping is scheduled in specific neighborhoods, as few as 2-3 parking control officers are available to cover the remainder of the East LA district. Considering conditions that effect scheduled and unscheduled paid time off (PTO) or medical leave of absence (MLA), the challenge becomes increasingly difficult to meet the coverage needs, not only each day, but in the early evening hours as well.

Hiring Practices

During the scheduled stakeholder intake session with the management and supervision of the East LA Parking Enforcement Station, information was requested and shared with respect to the department's hiring practices. The minimum training and experience requirements for a Parking Control Officer specify six months of experience in the public or private sector involving contact with the public, customer relations, or service to the community. A valid California Class C Driver License is required to perform job related essential functions. The minimum training and experience requirements for a Supervising Parking Control Officer specify at least two years' experience as a Parking Control Officer.

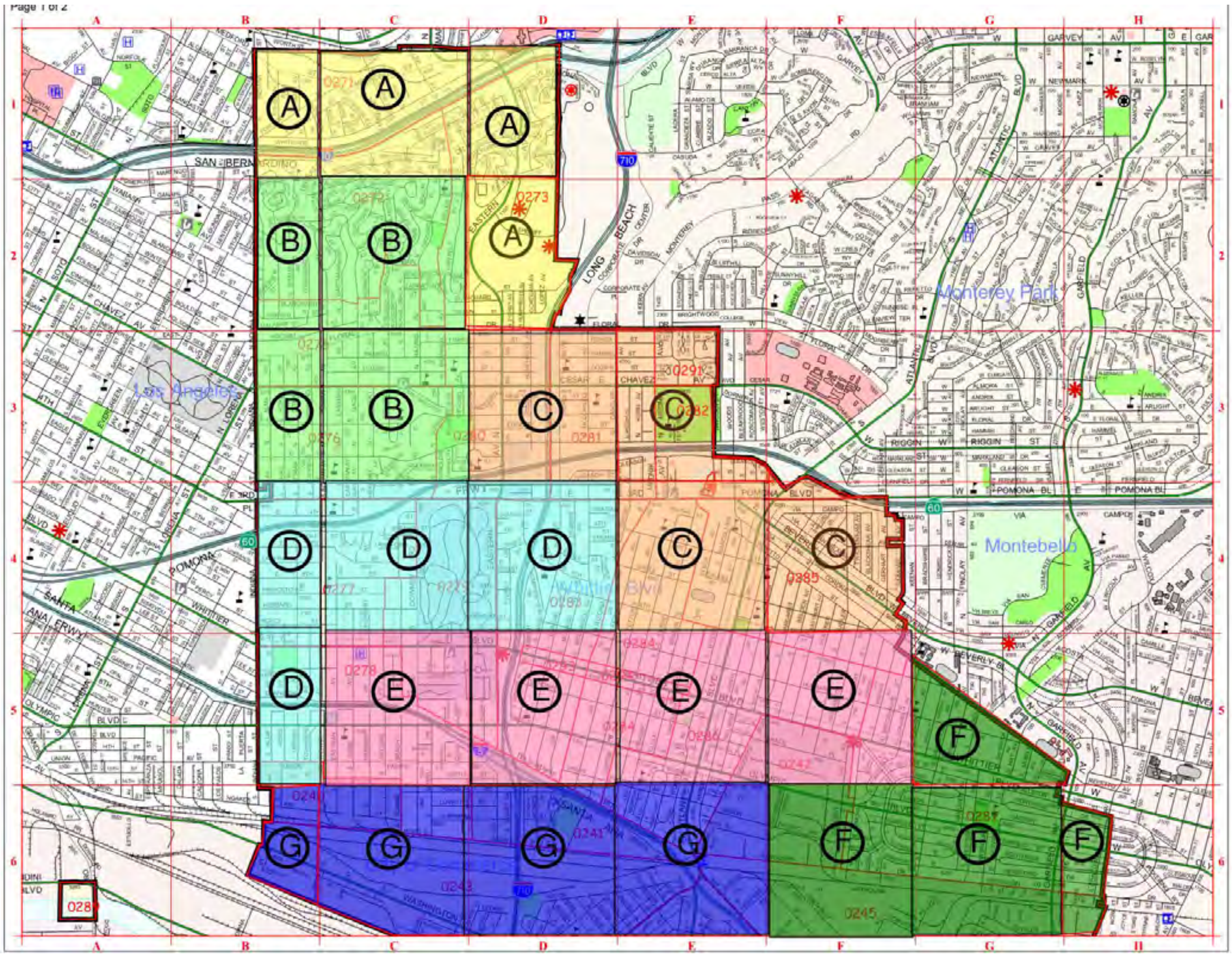
When a Parking Control Officer position becomes vacant, the manager and supervisor verify permission to request an advertisement of the Class Specification Bulletin. Once permission to advertise has been granted, the Bulletin is posted for internal and external view for a minimum advertisement period. Once the Bulletin advertisement is closed, the County's Human Resource Department will begin the process of certifying the applicants to see which applicants meet the minimum training and experience requirements. The certification list is then valid for a minimum three-year period, regardless of how many positions must be filled or how many applicants are interviewed to fill the vacant positions.

One example was provided where the manager requested a certification list of 39 applicants. 24 interviews were conducted for 15 vacancies. Of the 24 interviews, they may only have 2 pass the background check investigation. Some, which pass the background check investigation, may find they do not care for the work duties once they have been trained and spend time in the field with a Parking Control Officer. Essentially, the process must start all over.

Staffing

To better serve the enforcement needs of the community, it is recommended that parking control enforcement personnel be added to the East LA district for consistent coverage from 8:00 a.m. through 10:00 p.m., seven days per week. To further address coverage needs, we recommend establishing enforcement tours which allow regular enforcement rounds through each of the community streets. Use of enforcement tour methodology will help define a grouping of streets within a subsection of the East LA district. Tours should be developed to enable a Parking Control Officer to cover the tour every two hours at a minimum. Under this approach, every street will be enforced a minimum of four times during an eight hour scheduled shift. We have assembled the following exhibit to help demonstrate potential enforcement tours for the East LA district.

Exhibit 24: Sample Enforcement Tours for the East LA District



Source: Los Angeles County Sheriff's Department and Walker Consults; 2020

This exhibit attempts to break down the East LA district using the district boundaries and map grids to create enforcement subsections labeled as enforcement tours A through F. As a result of varying neighborhood densities, it may also be necessary to rearrange the tours to reduce tour footprints by two to three map grids versus the use of four grids per Parking Control Officer as shown in the figure.

Daytime coverage would continue to be provided by the use of the eight existing fulltime Parking Control Officers, however, we recommend adding additional fulltime and part-time Parking Control Officers to cover the evening and weekend coverage hours.

Walker Recommendation

Based on our general observation notes of the parking enforcement operations for unincorporated East Los Angeles, Walker recommends that the County should focus on the following areas:

- Increase the amount of parking enforcement resources to allow for consistent coverage in all unincorporated areas of East Los Angeles County from 8:00 a.m. to 10:00 p.m., seven days per week.
- Establish regular enforcement tours for the assignment of Parking Control Officers each day. Require the Parking Enforcement Officers to rotate through the enforcement tours every two weeks to reduce the perception of targeting and promote best practice enforcement behaviors.

03 Organizational Analysis

Organizational Analysis

Walker was asked to identify the county department that is best positioned to provide parking enforcement services in unincorporated East Los Angeles. Thirty-seven (37) departments/agencies are listed under the Los Angeles County Departments website. The departments are as follows:

- Agricultural Commissioner/Weights & Measures
- Alternate Public Defender
- Animal Care & Control
- Arts and Culture
- Assessor
- Auditor-Controller
- Beaches & Harbors
- Chief Executive Office
- Child Support Services
- Children & Family Services
- Consumer & Business Affairs
- County Counsel
- Development Authority
- District Attorney
- Executive Office, Board of Supervisors
- Fire Department
- Health Agency
- Health Services
- Human Resources
- Internal Services
- Library
- Medical Examiner-Coroner
- Mental Health
- Military & Veterans Affairs
- Museum of Art
- Natural History Museum
- Parks and Recreation
- Probation
- Public Defender
- Public Health
- Public Social Services
- Public Works
- Regional Planning
- Registrar-Recorder/County Clerk
- Sheriff
- Treasurer & Tax Collector
- Workforce Development, Aging & Community Services

Sheriff's Department

Upon review of the descriptions and roles of each department, the LA County Sheriff's Department remains the clear choice to provide parking enforcement services in unincorporated East Los Angeles. From time to time, the Sheriff's Department works with the Human Resources Department to update Class Specification Bulletins providing salary ranges, classification standards, examples of duties and minimum requirements for Parking Control Officer and Supervisor Parking Control Officer recruitment efforts. Once hired, Class Specification training is provided through a one week orientation class and multiple field assignments with experienced Parking Control Officers over several weeks.

Most notably, the Parking Enforcement Detail of the LA County Sheriff's Department has reasonable levels of human capital to provide periodic coverage amongst all 16 patrol stations despite temporary vacancies created by medical leave of absence and personal time off requests, if necessary.

Public Works Department

Often times, other county jurisdictions employ code enforcement personnel for parking enforcement needs. To some organizations, this makes sense as law enforcement agencies are typically concerned with establishing safe and peaceful communities, including neighborhoods, parks, schools, business districts and homes. Typically, code enforcement agencies are concerned with upholding local ordinances to include unsafe and unhealthy conditions, abandoned structures, abandoned vehicles, and inoperable or neglected trash, junk and debris.

The LA County Public Works Department oversees a code enforcement component that reports to its Building and Safety Division. While much of the Building and Safety Division's responsibility includes application of building laws and regulations, the Department oversees property rehabilitation violations and the more difficult nuisance abatement violations which may involve interfacing with the Departments of Regional Planning, and Public Health and the Sheriff's Department.

While the Public Works Department doesn't necessarily have the human capital resources of the Sheriff's Department for parking enforcement related activities, it may be a reasonable option to encumber a contract monitor position to oversee a parking enforcement outsource contract. By association, this contract management position should be an extension of the Department's code enforcement agency.

Walker Recommendation

Based on our general observation notes of the organizational analysis for unincorporated East Los Angeles, Walker recommends that the County focus on the following areas:

- Should the Parking Enforcement Detail remain an in-house service of the County, the LA County Sheriff's Department remains the clear choice to provide parking enforcement services in unincorporated East Los Angeles. The training and ability to shift personnel resources remain adequate to provide minimal coverage in the event of temporary employment vacancies.
-
- Develop a Code Enforcement Team led by the Department of Public Works to coordinate the various departments, such as the Sheriff's Department, Regional Planning, Public Health, Fire Department to collaborate and share in the role of code enforcement that is more community oriented and with a clearly defined mission of improving the quality of life for the East LA Community.

04 Best Practices

Best Practices

As East LA considers the viability of implementing different types of parking districts and refining its enforcement program to improve current parking conditions, Walker researched the parking programs and enforcement methods at four municipalities. Understanding that there are differences between unincorporated areas and municipalities in terms of the functionality of local governance, and in this case in terms of socioeconomics as well, this section is intended to present examples of parking management program features that have worked well for the subject communities. Additionally, this section highlights the trade-offs of each of the parking programs presented. It is important to note that no program is perfect, and what one community values may differ from that of another, but the common denominator in all of these programs is the management of on-street parking.

The four municipalities selected, for the analysis were:

- City of Sacramento, CA
- City of Pasadena, CA
- City of Los Angeles, CA
- City of Glendale, CA

The purpose of this analysis was to present best practice examples from other California municipalities, how they operate their parking programs, and how they enforce parking in relation to these programs. The subsequent findings presented, reflect information gathered from conversations with staff from those municipalities as well as from online sources researched by Walker.

Types of Parking Districts

Several types of Parking Districts could be established in East LA to help meet the goals of sharing the limited on-street parking inventory equitably amongst residential and commercial users. Observations conducted within the study area around on-street conditions show vehicles parking for extended periods, parking in restricted areas, and causing potential hazards (such as in red curbed areas, in front of fire hydrants, and on sidewalks), and double parking on area streets. Residential Parking Permit Programs provide an opportunity for the County to better manage their on-street parking resources by allowing them to define areas/zones that designate who may park, what credential is needed to park, when and how they may park, where they can park, and the policies and procedures that must be followed to park, including how enforcement may be handled.

The following sections describe the different types of parking programs that may be implemented. The comps demonstrate that many jurisdictions may have a hybrid program of several of these types of programs. The constants are that they have some type of residential and/or commercial permit program, revenue from the programs in place either stay with the jurisdiction to fund their programs or are given/shared with the neighborhood(s), and some type of enforcement program is in place.

Parking Enforcement District

A Parking Enforcement District is typically a geographically defined area wherein the municipalities' official parking rules and regulations are enforced by Parking Enforcement Officers (PEO's) to manage available spaces to help ensure availability for users. The PEO's are customarily responsible to patrol the district and monitor, enforce, and cite vehicles in violation, and may also be required to boot and/or tow vehicles as per the stated parking rules and regulations.

- Parking areas are actively managed and enforced.
- Citation revenues are used to offset the organizations operating and personnel costs.
- The community enjoys the benefit of enforced policies but does not receive financial benefit.

Parking Permit District

A Parking Permit District is typically a geographically defined area where parking is actively managed via permits to allow for on-street parking use by residents, businesses, and transient/short term parkers. Parking permits are required to park in designated areas on the streets within the district. It is customary to charge a fee and require that the vehicle be registered to an address within the district. These types of programs may be implemented in the following circumstances:

- For a predominately residential area that is impacted by parking use by non-residents. The residents are required to have a parking permit to park and many times resident parking takes priority during certain days/times.
- For a commercial district to assist with short term parking turnover and encourage off-street parking and shared/parking.
- For significantly mixed-used areas or residential and commercial developments to maximize on-street parking for both user groups.

A Parking Permit District typically requires buy-in from a set percentage of residents and/or business owners, though municipalities may create without this buy-in.

A Preferential Parking District (PPD) is a type of Parking Permit District that has posted regulations that limit parking without permits in an effort to reduce impacts of non-resident parking. Some municipalities call this type of district a Residential Parking Permit District (RPP).

An Overnight Parking District is an area that has posted regulations limiting parking by non-permitted vehicles between set (overnight) hours in an effort to reduce criminal and public nuisance activities by non-resident vehicles parked late at night.

Parking Benefit District

A Parking Benefits District is typically a geographically defined area whereby parking is monetized to manage supply and demand and the parking revenues collected within that district are used to fund parking and transportation infrastructure and improvements within that district. Revenues may fund items such as building or improvements to sidewalks, streets, landscaping, cleaning, or lighting and may even include things such as purchase, maintenance, and/or upgrades to parking meters or improvements to bus lines or biking infrastructure.

A Parking Benefits District typically requires City approval to create the district as well as the creation of an advisory committee that determines goals and strategies, creates policy/procedures, and decides how to allocate any funding received from the district. Revenue collected typically helps pay for district improvements.

City of Sacramento, CA

Type of Programs In Place: Parking Permit District and Parking Enforcement District

Overview

The City of Sacramento, CA (the City), like many other cities, is challenged with providing an adequate amount of street parking for both residents and visitors. Many residential areas experience a deficiency in on-street parking due to area workers (commuters) parking on residential streets. Parking issues in Sacramento span decades as the City established a Residential Parking Permit (RPP) program to help alleviate this issue in 1979.

The RPP program is in place in areas affected by commuter parking and where the supply of off-street parking is limited. Sacramento has multiple RPP program areas. They range from six square blocks to seventy-eight square blocks, with over 25,000 on-street spaces regulated by the RPP program. Permits allow residents to park on the street without the need to follow time restrictions that may be posted. In metered areas, the permit exempts the requirement to pay the parking meter. Non-residents may still be allowed to park in RPP areas as long as they follow posted time restrictions and pay the parking meter, if applicable.

The Parking Enforcement Unit conducts enforcement of parking regulations throughout the RPP.

Residential Parking Permit Program

Establishing or Changing an RPP Zone

To implement or to make changes to an RPP program area, residents must go through the process established by City Code Chapter 10.48 Residential Permit Parking Program. First, residents interested in a new RPP zone discuss the proposed zone with the City. The City conducts a study with the following occupancy thresholds:

- Occupancy rates of 95 percent or more support a parking limit of one hour or less
- Occupancy rates of more than 50 percent, but less than 85 percent support a limitation of more than one hour.
- Occupancy rates of 50 percent or less result in no change to the current parking restriction, and the City will decline the request.

If the parking study demonstrates a greater than 50 percent occupancy rate, the parking manager undertakes voting surveys of the owners of the properties located on the blockface(s) being considered for an RPP zone. A vote of greater than two-thirds is required for establishing an RPP zone. After the vote, the City mails notices to the residents of the proposed RPP zone, the proposed regulations, and fees (if any) to be charged.

Obtaining an RPP Parking Permit

First-time Residential Parking Permit (RPP) applicants must apply in person at the City Hall Revenue Division, while permit renewals may be requested in-person or by mail. To obtain the permit, the applicant must complete the City’s Residential Permit Application and submit proper documentation which includes a copy of the applicant's

Department of Motor Vehicles (DMV) registration showing their name and current address and current (last 45 days) proof of residency (includes items such as a current utility, phone, or cable bill or property owner's tax bill). An unlimited number of resident permits can be obtained.

Permits are valid for two years, after which they must be renewed. The same documentation is required to apply for a permit as it is to renew a permit. Business owners within the RPP zone may also apply for a permit by completing the application and providing the same proof of residency documents.

Visitor Permits:

- Visitor permits may also be obtained using the process outlined above, though a DMV registration is not required. Only one visitor permit can be issued per household.

Temporary Residential Permits may be issued in certain circumstances including:

- Resident does not have proper documentation to receive the RPP – i.e., outdated DMV registration, no proof of residency, etc.
- Active military personnel (vehicle registration cannot be changed to the current address but have proof of Residency).
- Students living in the RPP area (permits must be renewed each semester).
- Home improvement or service technicians (performing work on a home in RPP).
- Temporary permits valid for 24 hours are available via an online system to residents that possess an RPP or Visitor Permit. A maximum of 10 permits may be printed per month, per address.

Other Permits/Exemptions:

- Home health care workers providing in-home health care services residents within the RPP may apply for a Home Health Care Worker permit.
- As California law exempts ADA permit holders from time-restricted parking and meter payment requirements, ADA permit holders (residents or visitors) are not required to obtain any type of RPP.

RPP Permit Costs/Program Funding

All Residential Parking Permits, including visitor and temporary permits, are free of charge. All outstanding parking citations must be cleared before an RPP is issued, though a temporary permit will be issued until the citation(s) are cleared. Replacement due to lost, stolen, or damaged permits is $25.00 (online temporary 24-hour permits can be reprinted if the valid time is still in effect).

Approximately 15 years ago, the City considered charging for the RPP's but received negative feedback from the community and the plan did not progress.

Funding for the RPP program is obtained through parking citations issued by the City.

RPP Permit Regulations and Violations:

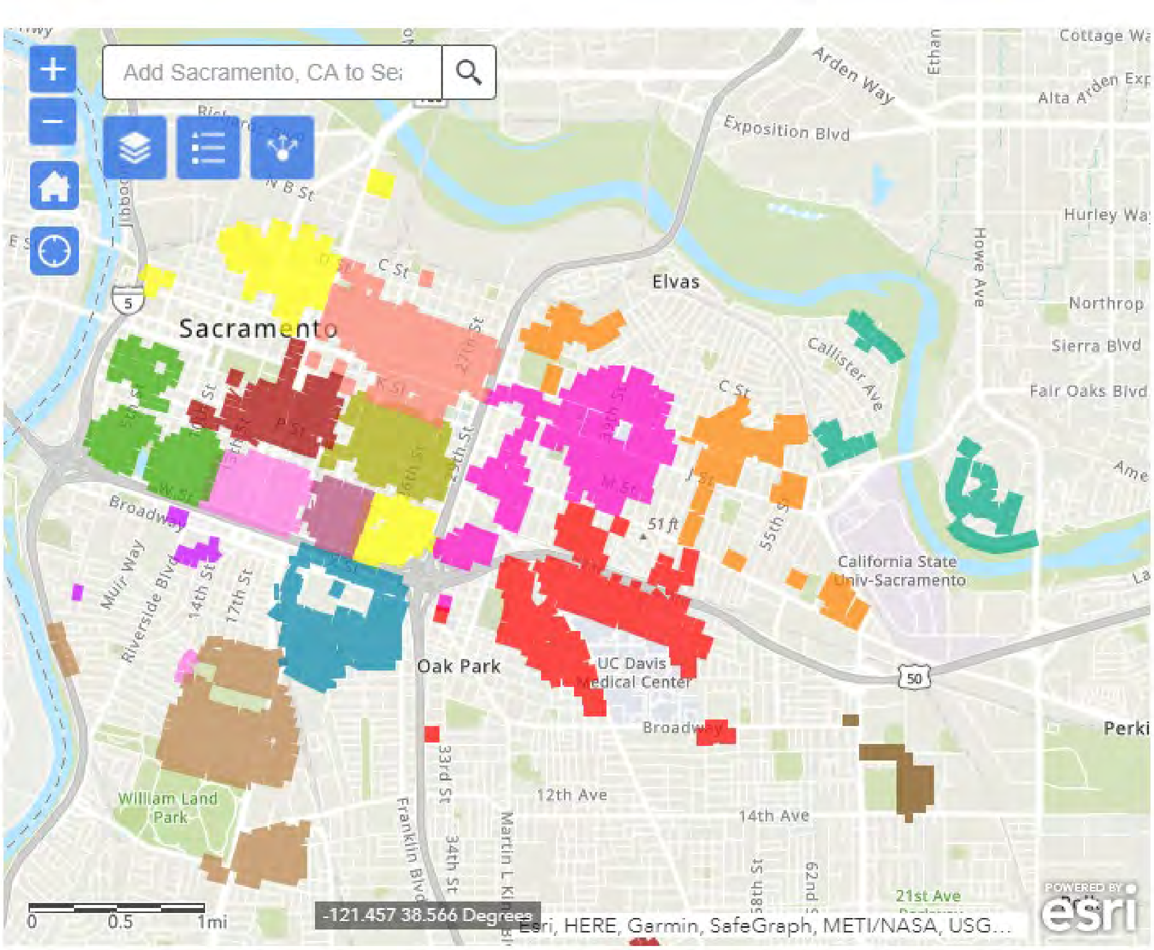
The following regulations apply to RPP zones:

- RPP permits exempt a motorist from the posted time limit (if any).
- RPP permit holders must park within three city blocks of the home address and must abide by posted regulations, such as street cleaning.
- Non-motorized vehicles are not eligible for parking permits unless attached or hitched to a motorized vehicle displaying a valid permit.
- Residents are responsible for renewing their parking permits and for notifying the City of any address change.
- Vehicles with valid ADA placards are exempt from RPP requirements and do not need to display a permit.

RPP Permit Zone Locations and Restrictions

The City provides Zone A through Zone U Residential Parking Permit Zones. Exhibit 25 shows the highest concentration area of permit zones, though some smaller RPP zones in effect are outside of the below map. Each color represents a different RPP Zone.

Exhibit 25: Sacramento Residential Parking Permit Program Areas



Source: City of Sacramento.org, 2020

The RPP zones have a variety of time restrictions, and some zones do not have any time restrictions. The zones with time limits typically have a 1 or 2-hour limit.

Benefits of RPP Program:

City

- The RPP program is a tool that helps to manage on-street parking in residential areas.

Neighborhoods

- RPPs limit parking on-street by non-residents to provide more parking for residents and their guests.
- RPPs are free of charge for residents.

Challenges of RPP Program:

City:

- The RPP requires consistent enforcement and staffing needs to follow posted time restrictions.
- Technology is required to promote an effective and efficient program. As with any technology, there can be challenges such as up-front costs, learning curves for staff using the technology, software/hard issues, on-going expenses, etc.
- Vehicles with ADA placards are not required to obtain a permit to park in RPP areas. This can result in high demand for parking from vehicles with ADA placards, particularly in areas adjacent to locations that charge for parking.
- The RPP limits or disallows parking for customers of businesses in RPP areas.
- The RPP may unwittingly incentivize car usage when residents can limit parking on their streets and park any number of vehicles registered to their address.
- A challenge with providing free parking permits, is there is potential for fraud, as residents may sell parking permits to employees or visitors that currently pay to park.
- The City is not generating permit fee revenue from the RPP program, limiting the funding available for administering the program.
- The RPP areas around hospitals and universities are challenging as there is high demand for parking on residential streets from those uses, requiring more enforcement needed for the City.

Neighborhoods:

- Establishing a new parking permit district is an administrative process that requires time to complete.
- Residents are required to apply for and renew permits which is an additional administrative burden.
- RPPs give residents of a specific area the ability to park within the limits of that area, but do not guarantee the availability of a space.

Parking Enforcement

As with most cities, the City of Sacramento would rather have compliance then issue citations. The City enforces parking via the Parking Enforcement Unit, which is responsible for ensuring compliance with local and state regulations. The City has stated that their goal for enforcement is not punitive, but rather to gain compliance to help ensure space availability for users. Approximately 80% of the Parking Enforcement District boundaries are found in the downtown area, as shown in Exhibit 25, with the remaining 20% found in several outlying areas.

Parking is enforced in both metered and unmetered areas. While enforcement times may vary by zone, most metered and/or time-limited parking areas are enforced Monday through Saturday except City holidays (though Old Sacramento, the City's riverfront historic district, is enforced all days of the week).

Per the City, consistent enforcement that follows posted time restrictions is necessary for the parking districts to be successful. Enforcement must correspond with the posted time limits, no matter the time of day.

In addition to the set cost of the infraction, a State surcharge of $12.50 is assessed on each citation as per the California State Budget Act of 2010. This surcharge is mandatory and goes to the State of California. Revenues from the meters are required, by code, to be used for parking program expenses. For citation revenue, approximately 50% of revenue collected goes back into the parking program and the remaining revenue is allocated to other areas as the City deems appropriate.

City of Pasadena, CA

Type of Programs In Place: Parking Benefit District, Preferential Parking Permit District, and Annual Overnight Permits

Overview

Prior to the early 1990s, Pasadena's downtown area (Old Pasadena) had been experiencing economic decline. Prior to 1993, the City of Pasadena did not have parking meters. All on-street parking was free and restricted to a two-hour time limit.[2] Customers had difficulty finding parking as employees often parked in the two-hour parking spaces and moved their vehicles throughout the day. The City proposed to install parking meters to alleviate this issue, but received pushback from the business owners, who feared that meters would drive away customers. Proponents of parking meters argued that meters would free up parking spaces for more customers to park downtown. The City made a compromise with the business community that meter revenue would be used to pay for public investments in Old Pasadena.

Organizational Structure

The City worked with the Old Pasadena Business Improvement District (BID) to establish the boundaries of the Old Pasadena Meter Zone (PMZ) where the parking meters would be installed. Only the blocks within the PMZ would directly benefit from the meter revenue.

Currently, the Old Pasadena Parking Meter Advisory Commission ("Commission") recommends to the City Council the priority expenditures of net revenues from the parking meters within the PMZ for street and parking related expenditures; and to study and examine other parking related issues such as proposed changes and amendments to the parking meter rates. The Commission is comprised of property owners and lessees (or employees of property owners and lessees) who are located in the PMZ. Commissioners serve a three-year term. City staff receive feedback from the Commission regarding funding priorities, which are then recommended to City Council.

Parking Meter Revenue Allocation

Upon installation of the parking meters in 1993, meter revenue initially was used to pay down debt for a $5 million bond that funded the Old Pasadena Streetscape and Alleyways project, which paid for initial repairs to dilapidated alleyways and sidewalks, and installation of trees and tree grates, street furniture, and historic light fixtures.

Parking meter revenue funds the operation and maintenance of the parking meter program. Revenue also funds improvements in the PMZ such as tree grate maintenance, lighting improvements, traffic signal improvements, streetlight improvements, sidewalk maintenance, benches, wayfinding signage, security efforts and pedestrian safety improvements.

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[2] Shoup.

To support local restaurants during the COVID-19 pandemic, the Old Pasadena Parking Meter Advisory Commission is considering appropriating $100,000 from the parking meter fund for on-street dining.[3] The funds would be used to continue the rental of barriers and associated traffic control currently provided by the City for on-street dining.

To highlight the benefits of the program to parking patrons, the meter head includes the following text "Your meter money will make the difference in Old Pasadena: Signage, Lighting, Benches, Paving."

Parking Meter Hours of Operation

On-street parking meters have the following hours of operation:

- Sunday through Thursday: 11:00 a.m. to 8:00 p.m.
- Friday-Saturday: 11:00 a.m. to 2:00 a.m.
- Overnight parking is not permitted from 2:00 a.m. to 6:00 a.m.

Parking Meter Rates

The parking meter rate is $1.25 per hour in Old Pasadena.

Benefits of the Parking Benefit District:

City:

- The implementation of parking meters helps to manage parking in the Old Pasadena area.
- The parking meter revenue provides a funding source for improvements within the Parking Meter Zone area.

Community

- Revenue received from the parking meters funds improvements that benefit the area that the meters are located.
- The revenue received from the parking meters comes at no cost to the businesses, property owners or taxpayers.
- The meters promote turnover of parking spaces, thereby increasing availability of parking spaces for customers.
- The parking enforcement officers who monitor the meters, particularly late in the evening, help provide "eyes on the street," promoting safety in Old Pasadena.
- The Old Pasadena Parking Meter Advisory Commission, which consists of representatives from the local business community, advises the City on the spending of the parking meter revenue. This gives the community direct input on what the parking meter revenue should be used for.
- Sales tax revenue increased in the Old Pasadena area when the parking meters were installed.

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[3] Source: https://www.pasadenanow.com/main/parking-meter-commission-to-consider-funds-for-on-street-dining/

Challenges of the Parking Benefit District:

City:

- There is a substantial amount of city staff time required to administer and serve as a liaison with the Commission.
- When parking meter rates remain constant over a long period of time, there is less revenue to support investments in the district.

Community:

- Motorists are required to pay a fee to park in Old Pasadena.

Preferential Parking Permit District

Pasadena has a Preferential Parking Permit Program in place to manage spillover of parking demand from adjacent commercial and institutional uses onto residential areas. The City of Pasadena passed a Preferential Parking Permit Ordinance in 1996.

Establishing or Changing a Preferential Parking Permit District (PPD)[4]

The process for establishing a PPD can be initiated by citizen request or by a motion of City Council. The citizen request must be received from a property owner of a parcel abutting the proposed residential street segment for which the restriction is requested.

Once the process is initiated, Department of Transportation staff meet with the property owner to discuss parking concerns and identify mitigation measures. The Department of Transportation conducts field surveys to document the severity of the parking intrusion by non-residents. Once the City has determined that none of the alternative measures to Preferential Permit Parking will mitigate the problem, the City or neighborhood initiates a petition process by mailing a ballot. A 67 percent concurrence from the property owners abutting the proposed district is required.

The Department of Transportation completes a parking study to establish the boundaries of the district. A minimum occupancy of 70 percent must be consistently observed during the days and times of the parking problem. A minimum of 40 percent of those observed parked must be non-local. The parking study also includes review of any adjacent street segments that may be negatively impacted by the implementation of the PPD. The proposed PPD and parking study are submitted to the City's Transportation Advisory Commission for approval. If approved by the Commission, a majority (more than 50 percent) of property owner concurrence within the proposed district is required. The district is ultimately approved by the City Council.

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[4] City of Pasadena Procedures for Establishing Preferential Permit Parking, October 2014.

To expand an existing PPD, a majority of written support (51 percent) by abutting property owners is required. The City Council can also expand an existing PPD under the following circumstances:

- To mitigate the direct impact of a chance in the configuration of a street or public right of way or similar action of government which changes traffic flow or patterns
- Where there is verifiable and measurable parking intrusion in the adjacent area from the source which impact the established PPD.

Obtaining a PPD Parking Permit

Permits may be obtained in person at the City's Parking Office or by calling the City. The applicant must provide a current valid vehicle registration that matches the address of the residents that qualified for a permit. Each household is eligible to receive up to three (3) parking permits. Permits are valid for one year following issuance.

Visitor Permits

- Each household can obtain up to three visitor permits
- Visitor permits are used for visitors of residents or those conducting business in the resident's home.

Daily Permits

- Each household can obtain up to ten daily guest permits.

PDD Permit Costs and Program Funding

The fee for the initial set of Preferential Parking Permits which includes up to 3 Residential Permits, 3 Guest Permits, and 10 Daily Permits is $11.

Each additional 10 pack of Daily Permits is $5.

PPD Permit Regulations and Violations

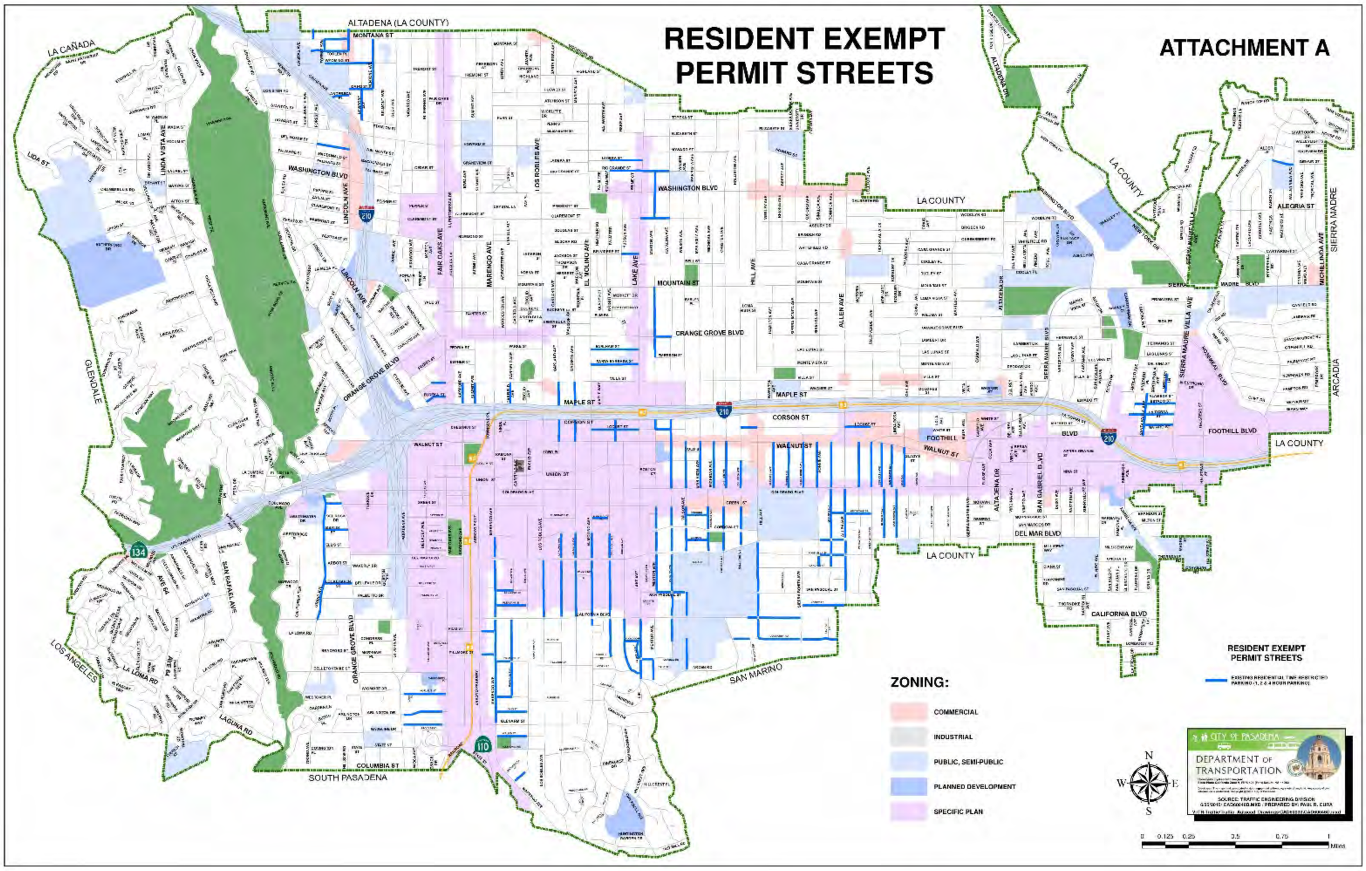
The following regulations apply to PPD permits:

- Resident permits are affixed to the lower corner of the driver's side windshield.
- One day guest passes should be visibly displayed hanging from the rear-view mirrors.
- Vehicles are required to follow all other posted parking regulations.

PPD Permit Zone Locations and Restrictions

The locations of current PPD permit zones is shown in Exhibit 26. These locations are residential time restricted parking (1, 2, and 4-hour parking). The permit exempts permit holders from the posted time restriction.

Exhibit 26: City of Pasadena PPD Permit Zone Locations



Source: cityofpasadena.net, 2020

The City also has PPD's in residential locations around the California Institute of Technology and Pasadena City College that are not shown in the figure above. These locations restrict all parking except by permit.

Benefits of PPD Program

City

- The RPP program is a tool that helps to manage on-street parking in residential areas, particularly in those areas adjacent to commercial development.

Neighborhood

- RPPs limit parking on-street by non-residents to provide more parking for residents and their guests.
- Residents have the opportunity to obtain both resident permits and guest permits.

Challenges of PPD Program

City

- The process requires staff time to establish and manage the permit districts.

Neighborhood

- Establishing a new PPD is an administrative process that requires time to complete.
- Residents are required to apply for and renew permits which is an additional administrative burden.
- PPDs give residents of a specific area the ability to park within the limits of that area, but do not guarantee the availability of a space.
- Residents are required to pay for permits.

Overnight Parking Permits

The City of Pasadena prohibits parking on most streets from 2:00 a.m. to 6:00 a.m. for public safety purposes and for street sweeping. Residents can obtain overnight parking permits to exempt them from this requirement.

Obtaining an Overnight Parking Permit

An application for an overnight permit must be completed and submitted to the Parking Division in person, online or by mailing an application. A separate application form is required for each vehicle requiring a permit.

To obtain a permit, residents must provide a current vehicle registration for all vehicles that matches the address of the residence. No more than two overnight permits can be issued per residence. Permits are valid for one year.

In order to obtain a permit, residents must have more vehicles than the available off-street parking at their residence. A field inspection is conducted by City staff to confirm this.

Temporary Permits

- A 30-day permit is available for purchase for a temporary need for on-street parking. Renewal of this permit requires investigation and approval by the Director of Transportation.

Other Permits/Exceptions

- Students whose vehicles are registered at another address must complete a form in order to be exempted from the change of address requirement. Students must provide a copy of a valid driver's license and valid current student identification card and/or current school registration.
- Residents with vehicles registered to their company must provide a letter from the supervisor confirming the car has been issued to the resident.

Overnight Permit Costs and Funding

There is a permit application fee of $47 for applications requiring a field inspection.

Overnight Parking Permit Violations and Regulations

The following regulations apply for Overnight Parking Permits:

- Vehicles must be parked within a 500-foot radius of a permit holder's place of residence.
- Permits are invalid in locations with red painted curb and in posted hours for street sweeping.
- Permits must be affixed to the inside left rear window of the vehicle.

Benefits of Overnight Parking Permit Program

City

- The overnight parking restriction helps the City more efficiently perform street sweeping during the hours of 2:00 a.m. and 6:00 a.m.
- Managing parking demand overnight helps to promote public safety.
- The program effectively manages parking demand overnight, as residents must utilize all available off-street parking before parking on-street.

Neighborhood

- Managing parking demand overnight helps limit the number of non-residential vehicles parked in residential areas.
- The more efficient street sweeping and increased safety benefits neighborhoods.

Challenges of Overnight Parking Permit Program

City

- Significant staff time is required to inspect each residence for on-site parking.

Neighborhood

- Residents are required to apply for and renew permits which is an additional administrative burden.
- Residents must use all available parking in their driveway and in their garage in order to obtain a permit.
- Older residences that have smaller garages and driveways are more likely to need parking permits.

City of Los Angeles, CA

Type of Programs In Place: Preferential Parking District and Overnight Parking District

Overview

Preferential Parking Districts began in the City of Los Angeles, CA (the City) in 1979 when the City Council passed its Preferential Parking Ordinance – two years after the US Supreme court upheld the constitutionality of Preferential Parking Districts (PPD). The PPD Program, administered by the Los Angeles Department of Transportation (LADOT) is designed to address the negative impacts of non-resident parking in neighborhoods – specifically, to limit "intrusion" of non-residential and/or commuter parking while allowing residents and their visitors to park.

A formal process is required for neighborhoods to implement a PPD and LADOT requires a formal request from a homeowner's association, council member, or neighborhood council to begin the process of potentially implementing a PPD. PPD's are required to be over three blocks in size to be considered. The PPD program allows residents to purchase permits that exempt their vehicles, and their visitor's/guest's vehicles, from posted Preferential Parking Program restrictions.

An Overnight Parking District (OPD) is an area that has posted regulations that limit parking between 2:00am and 6:00am to those vehicles with valid resident parking permits. OPD's are meant to reduce criminal and public nuisance activities that may occur with parking at that late hour. Residents may purchase permits that allow parking for their, and their visitor's/guest's vehicles, during that timeframe.

LADOT's traffic officers enforce the parking laws and are scheduled 24/7 to address violations and respond to parking complaints.

Preferential Parking Permit Program

Establishing or Changing a Preferential Parking District

To implement or to make changes to a Preferential Parking District (PPD) LADOT must receive a formal request from a neighborhood council, homeowners association, or a council member. Once the formal request is received, an informal meeting is held to identify the parking issues and discuss solutions. To establish a PPD, signatures must be collected for a petition and the signatures must be verified by LADOT. LADOT then performs a study to identify the parking problem – a "problem" is defined as at least 75 percent of the on-street parking spaces are being occupied, with at least 25 percent of those spaces being occupied by non-residents. When at least four to six blocks within the study area have met these criteria (six blocks for a new PPD area, four blocks for a new PPD area that is near an existing PPD area), LADOT produces a report and conducts a public hearing. The report is sent to the City Council's Transportation Committee, and then to the full Council for approval. If Council approves, the PPD is put in place.

Obtaining a Permit

First-time PPD permit applicants, or those with PPD permit renewals, may apply/renew either in person at one of several public service centers or online. The PPD permit allows the permitted vehicle to park anywhere within the assigned parking district, though permit holders still must follow any additional posted restrictions (such as red zones or street cleaning).

To obtain the PPD permit, the applicant must first establish an account with the City and submit proper documentation which includes a copy of the applicant's Department of Motor Vehicles (DMV) registration showing their name and current address and two additional proofs of residency (includes items such as a driver's license, current utility, phone, or cable bill, a property owner's tax bill, or a rental/lease agreement). Each household is limited to three total PPD permits (except where special conditions have been assigned by City Council).

Permits are valid for one year, after which they must be renewed. The same documentation is required to apply for a permit as it is to renew a permit.

PPD Visitor Permits:

- PPD visitor permits may be obtained using a similar process as outlined above, though a valid photo ID is needed in place of a DMV registration.
- Only two visitor permits are issued per household (except where special conditions have been assigned by the City Council).
- Parkers must park within the limits of the assigned district and must still observe additional posted restrictions (such as a red zone or street cleaning).

PPD Guest Permits:

- Each household within the district is entitled to one-day guest permits.
- PPD guest permits may be obtained using a similar process as outlined above, though a valid photo ID is needed in place of a DMV registration.
- There is no limit to the number of guest permits that may be purchased.
- Guest permits are only intended for the use of residents of the district and their guests. Re-sale or transfer of these guest permits will result in revocation of resident's permit privileges.
- Parkers may park within the limits of the assigned district and must still observe additional posted restrictions (such as a red zone or street cleaning).

Other Permits/Exemptions:

- As California law exempts ADA permit holders from time-restricted parking and meter payment requirements, ADA permit holders are not required to obtain any type of PPD permit. However, they are required to purchase permits for their guests and caretakers.
- When engaged in qualified work, the following are exempt from established parking restrictions:
    - Vehicles owned/operated by a utility that is engaged in authorized work.
    - Vehicles owned or operated under contract to a government agency when used in official government business.

PPD Permit Costs and PPD Program Funding

Parking Permit District Permit:

- $34.00 per year

Parking Permit District Visitor Permit:

- $22.50 per four months (max 2 permits)

Parking Permit District Guest Permit:

- $2.50 (unlimited number of permits may be purchased)

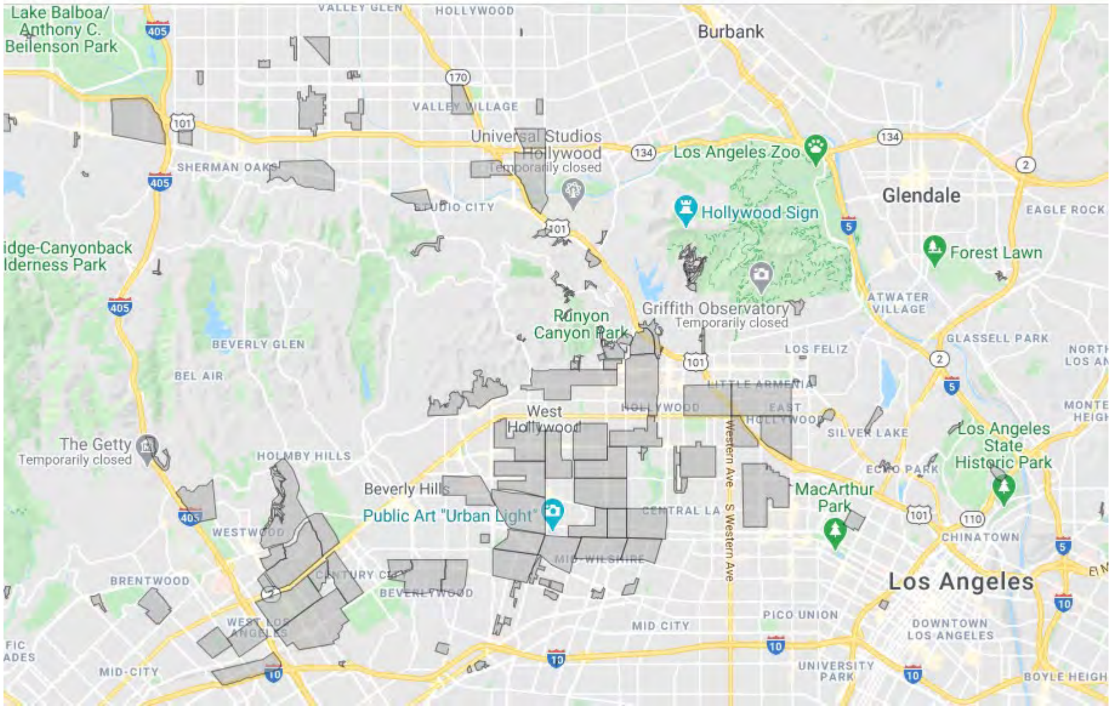
Those requesting PPD permits may only purchase permits if all outstanding parking fines have been paid.

The PPD program is required to be self-sustaining and funding for the program is via revenue from permit sales permits only.

Preferential Parking District Locations

The City Council designates certain parts of the city as Preferential Parking Districts. These districts are designated with signs and restrictions may vary by district. Exhibit 27 shows the highest concentration area of PPD's, though some smaller PPD districts in effect may be outside of the areas shown on the below map. The gray shaded areas denote each PPD.

Exhibit 27: Los Angeles Preferential Parking Districts



Source: data.lacity.org, 2020

Benefits of PPD Program:

City :

- The PPD program is a tool that helps to manage on-street parking in residential areas.
- Since commercial parking is finite, by limiting commercial parking in residential areas, the City could encourage the use of non-driving modes of transportation.
- The PPD program promotes an enhanced quality of life in neighborhoods by reducing noise, traffic hazards, and reducing litter.

Neighborhood:

- The PPD program helps to limit use of on-street spaces by non-residents. Therefore, the likelihood of finding a parking space improves.
- Residents can obtain a permit either on-line or in person.
- The PPD program promotes an enhanced quality of life in neighborhoods by reducing noise, traffic hazards, and reducing litter.
- The PPD program results in fewer instances of residents having their driveway blocked, trash cans moved, or late-night noise problems.

Challenges of PPD Program:

City:

- There needs to be consistent enforcement during the time restrictions of each PPD program area, requiring sufficient enforcement staffing (which can be costly).
- A challenge with providing guest PPD permits is there is a potential for fraud or misuse. LADOT provided an example where "influencers" were throwing parties and requesting hundreds of PPD guest permits. As there is currently no limit on the number of guest permits, LADOT was required to provide them though this is not the intent of the program. LADOT is currently working on changes to limit guest permits.

Neighborhood:

- The PPD does not necessarily solve the issues of resident's having numerous vehicles and parking them on the street. For example, some residents that have garages or driveways, but do not use them to park vehicles or multi-generational households have a large number of vehicles that park on street.
- Establishing a new Preferential Parking District is an administrative process that requires time to complete.
- Residents are required to apply for and renew permits which is an additional administrative burden.
- Residents are required to pay for permits for themselves and their guests and visitors.
- PPD's give residents of a specific area the ability to park within the limits of that area, but do not guarantee the availability of a space.

Overnight Parking Permit District Program

Establishing or Changing an Overnight Parking District

An OPD will only be established if a letter is received from Los Angeles Police Department (LAPD) that there are criminal issues in the area. The LAPD review their crime statistics program for the area, and if they determine there is an issue, they will write a letter supporting an OPD Program.

Obtaining an OPD Permit

The procedures for obtaining a new Overnight Parking District (OPD) permit, or renewing an OPD permit, are the same as those described above under the "Obtaining a Preferential Parking Permit" section.

- OPD's do not have the same ADA California law exemptions as PPD's – meaning ADA permit holders will need to purchase a permit to park in the OPD.

OPD Visitor Permits:

- OPD Visitor Permits may be obtained using a similar process as outlined under Obtaining a Preferential Parking Permit, though a valid photo ID is needed in place of a DMV registration.
- Only two OPD Visitor Permits will be issued per household (except where special conditions have been assigned by the City Council).
- Parkers must park within the limits of the assigned district and must still observe additional posted restrictions (such as a red zone or street cleaning).

OPD Guest Permits:

- Each household within the district is entitled to one-day overnight guest permits.
- An existing Residential Parking Permit account number and an active annual or visitor permit is required to purchase an overnight guest permit.
- OPD guest permits may be obtained using a similar process as outlined above, though a valid photo ID is needed in place of a DMV registration.
- Overnight guest permits are limited to 25 per day.
- Guest permits are only intended for the use of residents of the district and their guests. Re-sale or transfer of these guest permits will result in revocation of resident's permit privileges.
- Parkers must park within the limits of the assigned district and must still observe additional posted restrictions (such as a red zone or street cleaning).

OPD Permit Costs and OPD Program Funding

Overnight Parking District Permits:

- $15.00 per year

Overnight Parking District Visitor Permit:

- $10.00 per four months (max 2 permits)

Overnight Parking District Guest Permit:

- $1.00 per day (max 25 permits per day)

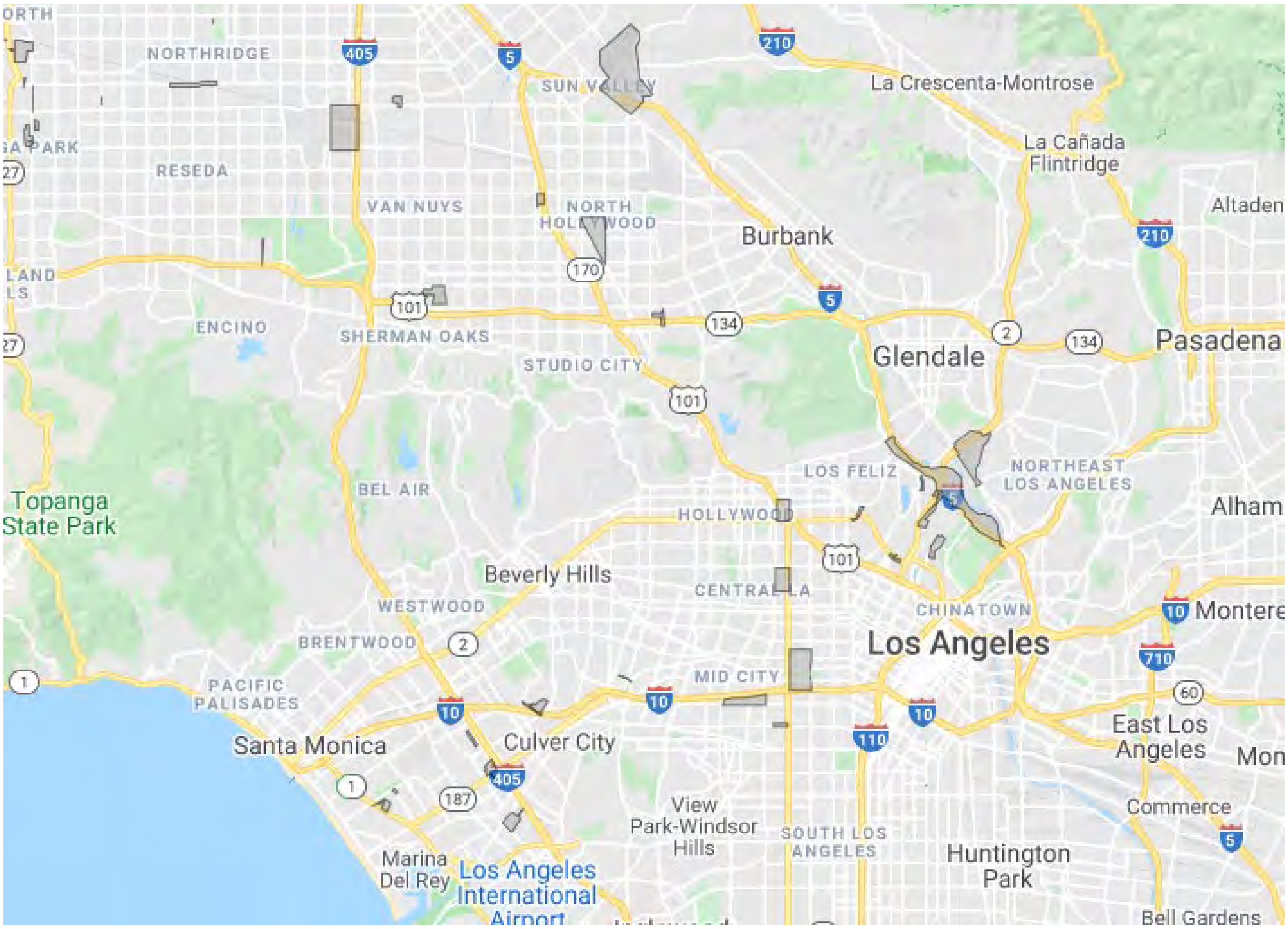
Those requesting OPD permits may only purchase permits if all outstanding parking fines have been paid.

The OPD program is required to be self-sustaining and funding for the program is via revenue from permit sales permits only.

Overnight Parking District Locations

The City Council designates certain parts of the city as Overnight Parking Districts. These districts are designated with signs and restrictions may vary by district. The exhibit below shows the highest concentration area of OPD's, though some smaller OPD districts in effect may be outside of the areas shown on the below map. The gray shaded areas denote each OPD.

Exhibit 28: Los Angeles Overnight Parking Districts



Source: data.lacity.org, 2020

Benefits of OPD Program:

City:

- The OPD program can assist and help deter existing criminal activity by not allowing non-resident parking from 2:00 am to 6:00 am daily.

Neighborhood:

- The OPD helps to deter criminal activity as stated above.

Challenges of OPD Program:

City:

- The OPD requires consistent enforcement which requires staffing.

Neighborhood:

- Establishing an OPD is an administrative process that requires time to complete.
- Residents are required to obtain permits which is an additional administrative burden.
- Residents are required to pay for permits for themselves and their guests and visitors.

Parking Enforcement

LADOT traffic officers are responsible for enforcing all parking laws in the California Vehicle Code and Los Angeles Municipal Code. Traffic officers are on duty 24/7 and patrol to address parking violators and respond to constituent complaints around parking.

Enforcement times of PPD and OPD areas vary by the stated time restrictions of each PPD and OPD zone.

Parking citations revenue is not used for the PPD or OPD programs, which are funded via permit sales, only. Parking citation revenue and meter revenue goes into the general fund.

City of Glendale, CA

Type of Program In Place: Preferential Parking District

Overview

The City of Glendale established the Preferential Parking Permit (PPD) Program in 1980 to discourage non-residents from parking in residential neighborhoods. Parking permits exclude residents from the posted time limits.

The City has two types of PPD's, a Preferential Parking District and a Special Preferential Parking District.

1. *Preferential Parking District* - a district of certain streets or portions thereof, which are designated by the transportation and parking commission as a preferential parking district in which certain vehicles displaying valid preferential parking permits are exempt from posted parking restrictions, or in which vehicles may not park unless an authorized permit is displayed.
2. *Special Preferential Parking District* - a residential area designated by the city council where vehicles displaying valid Special Preferential Parking District permits are exempt from parking restrictions; and due to unique circumstances, that do not apply generally to other areas of the City, is designated as a Special Preferential Parking District for which special rules may apply.

Establishing or Changing an PPD Zone

To implement a PPD program area, residents must go through the process established by City Code Chapter 10.36.030 Preferential Parking District Program Established. To implement an RPP program area, 75 percent of residents must support the request and studies must be conducted by the City to determine whether reasonably convenient parking is unavailable, whether more than 25 percent of the vehicles parked in the area under consideration are not registered to people residing in adjacent residences, and whether current posted time limits are causing a hardship for residents. The Transportation and Parking Commission makes the final decision to grant or deny a PPD zone. To reduce the secondary impacts of the establishment of PPDs, the City can expand the area of an established PPD to encompass other adjacent streets surrounding a district.

Special PPDs are designated by City Council. Special PPDs can be divided into zones in order to administer restrictions to address unique parking conditions or restrictions within a particular zone. There are two Special PPDs established in Glendale, the Glendale Community College Special PPD and the South Brand Special PPD. To establish designated PPD areas within the Glendale Community College Special PPD, residents must submit a petition signed by residents living in at least 75 percent of adjacent dwelling units. To establish designated PPD areas within the South Brand PPD, residents must submit a petition signed by residents living in at least 66 percent of adjacent dwelling units.

To terminate a PPD, residents must submit a petition representing at least 75 percent of adjacent dwelling units.

Obtaining an PPD Parking Permit

Residents can obtain a preferential parking permit online or via mail. Residents are required to provide a valid photo ID or driver's license to obtain a permit. If the photo ID does not contain the address in question, applicants must

provide a utility bill, property tax statement, mortgage payment/bill, or rental agreement. A California vehicle registration is also required for each vehicle. Permits are valid through December 31 from the date of issuance, and residents must renew their permits each year. Permits are in the form of hang tags to be displayed on the rear-view mirror of the vehicle. Any resident of a PPD who owns a vehicle can apply for a permit.

Guest Permits

- Each household can purchase up to two guest permits

Temporary Parking Permits are also available under certain circumstances:

- *Special Event Guest.* Temporary parking permits for special occasions can be requested via phone or in-person, when more than two guest permits are required for special events. Residents seeking temporary special event guest permits must contact the City at least two days prior to the event. No more than two special events requiring temporary special event guest permits can be issued to any one permittee during a calendar year. The special event guest permits are not available in the South Brand PPD.
- *Health Care Guest.* Temporary parking permits can be issued to residents with in-home health care provides. Residents must submit a statement to the City indicating the medical necessity of the permit and the approximate amount of time the permit would be needed.

Other Permits/Exemptions:

- As California law exempts ADA permit holders from time-restricted parking and meter payment requirements, ADA permit holders are not required to obtain any type of PPD permit.
- Due to the unique circumstances of the Glendale Community College Special Preferential Parking District, the City can issue permits to the Woodlands Elementary School for exclusive use of the school's faculty, employees, and volunteers.
- In the South Brand Special Preferential Parking District, residents can obtain up to three resident parking permits. Guest permits are granted on a case by case basis.

PPD Permit Costs/PPD Program Funding

Residential permits, guest permits, and temporary permits cost $25/vehicle/year. Permit fees contribute toward the administration of the PPD program.

Permit Regulations and Violations:

The following regulations apply to PPD zones:

- PPD permits exempt a motorist from the posted time limit (if any) posted on the signage.
- PPD permits do not allow oversized vehicles to park in residential neighborhoods.

- PPD permits do not allow any other vehicle from parking at “no parking anytime” zones, parking meters, pay stations, loading zones, 30-minute parking zone, and street sweeping days.

PPD Permit Zone Locations and Restrictions

As mentioned in the “Establishing or Changing a PPD Zone” section, the City has two established Special Preferential Parking Districts: the Glendale Community College Special PPD and the South Brand Special PPD. The Glendale Community College Special PPD is divided into four zones and the South Brand Special PPD is divided into eight zones. In addition to these two zones, there are approximately 148 individual districts, ranging in size from one half block to three more blocks.

Benefits of PPD Program:

City:

- The PPD program helps the City to manage on-street parking in residential neighborhoods.
- Since commercial parking is finite, by limiting commercial parking in residential areas, the City could encourage the use of non-driving modes of transportation.
- The process to establish a new PPD is collaborative between the neighborhood and the City.

Neighborhood:

- PPDs limit parking on-street by non-residents to provide more parking for residents and their guests.
- Residents have the option to request permits online, which enhances the convenience of the process.
- If a PPD that has been implemented is not meeting the needs of the residents, residents also have the opportunity to petition to remove parking permit districts
- The process to establish a new PPD is collaborative between the neighborhood and the City.

Challenges of PPD Program

City:

- In certain districts, an unlimited number of residential permits can be issued, which can result high demand for parking in PPD areas.
- There are approximately 150 districts in the City, with varying enforcement hours and time restrictions, making the program difficult to administer and enforce.
- The PPD procedures for the South Brand district are different than the other districts, making the program more challenging to administer.

Neighborhood:

- Establishing a new parking permit district is an administrative process that requires time to complete.
- Residents are required to apply for and renew permits which is an additional administrative burden.
- PPDs give residents of a specific area the ability to park within the limits of that area, but do not guarantee the availability of a space.
- Residents are required to pay for permits for themselves/families/tenants as well as guests and visitors.

05 Appendix

Appendix A: Parking Violation Description by Violation Code and Fine Amount

VIOLATION DESCRIPTION	VIOLATION CODE	EFFECTIVEDATE	FINE AMT	PENALTY1
ABANDONMENT PROHIBIT	22523A	12/7/10	$113.00	$100.00
ABANDONMENT PROHIBIT	22523B	12/7/10	$113.00	$100.00
AIRPORT-UNAUTH CLNG	1904990	12/7/10	$48.00	$35.00
AIRPORT-UNAUTH PRKNG	1904980	12/7/10	$48.00	$35.00
ANGLE PARKING	1564240	12/7/10	$48.00	$35.00
ANNUAL TRAIL PASS	17041175	12/7/10	$28.00	$18.00
ANTI-GRIDLOCK ACT	22526	12/7/10	$68.00	$55.00
ARBORETA/BOT GRDN PK	1708110	12/7/10	$48.00	$35.00
BIKE PATH	1704370E	12/7/10	$53.00	$40.00
BLOCKING DRIVEWAY	1704370L	12/7/10	$53.00	$40.00
BLOCKING FIRE LANE	225001	12/7/10	$78.00	$65.00
BLOCKING HANDICAPPED	22500L	12/7/10	$258.00	$50.00
BLOCKING HIGHWAY OR	1564300	12/7/10	$53.00	$40.00
BUS LOADING ZONE	1564110	12/7/10	$263.00	$50.00
BUS ZONE	1704370I	12/7/10	$53.00	$40.00
CROSSWALK	1704370F	12/7/10	$53.00	$40.00
CURB PARKING ONE-WAY	22502E	12/7/10	$53.00	$40.00
DOOR OPEN TO TRAFFIC	22517	12/7/10	$68.00	$55.00
DOUBLE PARKING	1564250	12/7/10	$53.00	$40.00
DOUBLE PARKING	1704370J	12/7/10	$53.00	$40.00
DOUBLE PARKING	22500H	12/7/10	$53.00	$40.00
EMERGENCY ACCESS	19121410	12/7/10	$68.00	$55.00
EVID. OF REGIST. WRO	4462B	12/7/10	$38.00	$25.00
EXCEED 14000 LB	1548060	12/7/10	$53.00	$40.00
EXPIRED METER	1564470	12/7/10	$33.00	$20.00
EXPIRED METER COUNTY	1564480	12/7/10	$33.00	$20.00
FAIL TO APPLY FOR RE	41525	12/7/10	$38.00	$25.00
FAILURE TO OBEY MARK	15200703	12/7/10	$63.00	$50.00
FAILURE TO OBEY SIGN	1520070	12/7/10	$63.00	$50.00
FAILURE TO OBEY SIGN	15200701	12/7/10	$63.00	$50.00
FAILURE TO PAY VEH F	1704370N	12/7/10	$53.00	$40.00
FIRE HYDRANT	1704370M	12/7/10	$53.00	$40.00
FRONT YARD PARKING	1564271	12/7/10	$63.00	$50.00

VIOLATION DESCRIPTION	VIOLATION CODE	EFFECTIVEDATE	FINE AMT	PENALTY1
FUEL CAP REQUIRED	27155	12/7/10	$38.00	$25.00
GRASS	1704370B	12/7/10	$53.00	$40.00
GRIDLOCK 2ND	22526A	12/7/10	$113.00	$100.00
GRIDLOCK 3RD	22526B	12/7/10	$303.00	$290.00
HANDICAPPED PARKING	225078A	12/7/10	$338.00	$50.00
HANDICAPPED PARKING	225078C	12/7/10	$338.00	$50.00
HANDICAPPED PKG. OFF	225078B	12/7/10	$338.00	$50.00
HOUSE TRAILER	1704380	12/7/10	$63.00	$50.00
HOUSNG AUTH-NO PARK	1544120B	12/7/10	$48.00	$35.00
KEY IN IGNITION	1564210	12/7/10	$48.00	$35.00
LIC.PLATES ATTACH OR	5201	12/7/10	$38.00	$25.00
LOADING ZONE	1704370H	12/7/10	$53.00	$40.00
LOCKED VEHICLE	22516	12/7/10	$48.00	$35.00
MDR/BIKE IMMOBLE	19121340	12/7/10	$48.00	$35.00
MDR-FAIL TO OBSERV P	19121320	12/7/10	$48.00	$35.00
METERS NO DEPOSIT	1564490	12/7/10	$53.00	$40.00
MORE THAN ONE SPACE	1704370K	12/7/10	$53.00	$40.00
MOTOR VIHICLE, PARKI	1712230	12/7/10	$48.00	$35.00
MOTOR VIHICLE, PARKI	17212230	12/7/10	$28.00	$18.00
MULT. REAR PLATE	4457	12/7/10	$38.00	$25.00
MV-PARKING RESTRCTNS	19121330	12/7/10	$48.00	$35.00
NO COMM PKG ANY RES	1564052	12/7/10	$78.00	$65.00
NO COMM. VEH PKG	1564055	12/7/10	$78.00	$65.00
NO FRONT PLATES	5200	12/7/10	$38.00	$25.00
NO FRONT PLATES	5200A	12/7/10	$38.00	$25.00
NO LICENSE PLATES DI	5202	12/7/10	$38.00	$25.00
NO PARKING SIGNS	1564260	12/7/10	$53.00	$40.00
NO VALID PASS	1704370R	12/7/10	$53.00	$40.00
NO VEH. MAINT. IN PU	1544160	12/7/10	$48.00	$35.00
OBSTRUCTING EXCAVATI	22500G	12/7/10	$53.00	$40.00
PARK HOURS	1704370Q	12/7/10	$53.00	$40.00
PARK W/IN 3' SIDEWAL	22522	12/7/10	$288.00	$50.00
PARK W/IN 7 1/2' RAI	22521	12/7/10	$43.00	$30.00

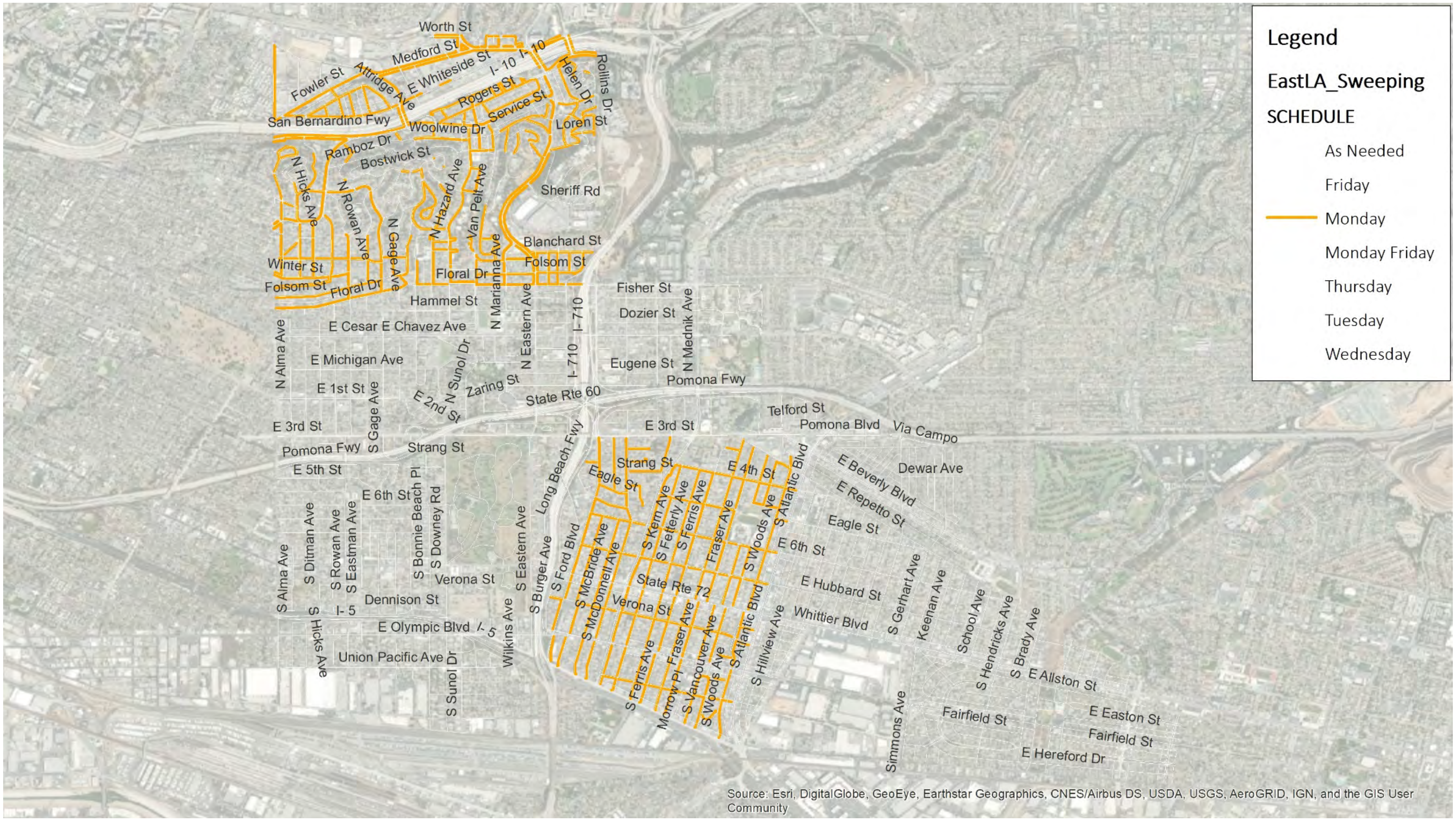
VIOLATION DESCRIPTION	VIOLATION CODE	EFFECTIVEDATE	FINE AMT	PENALTY1
PARKED IN INTERSECTI	1564330	12/7/10	$53.00	$40.00
PARKING ADJACENT TO	1564360	12/7/10	$53.00	$40.00
PARKING AND DRIVING	19121360	12/7/10	$48.00	$35.00
PARKING AT MAIL BOX	1564040	12/7/10	$48.00	$35.00
PARKING BETWEEN SAFE	22500C	12/7/10	$53.00	$40.00
PARKING DISCONNECTED	1564100	12/7/10	$53.00	$40.00
PARKING FIRE HYDRANT	1564370	12/7/10	$68.00	$55.00
PARKING HOURS 8:00 A	1704330	12/7/10	$40.00	$18.00
PARKING IN ALLEY	1564130	12/7/10	$53.00	$40.00
PARKING IN BUS LOADI	22500I	12/7/10	$263.00	$50.00
PARKING IN DESIGNATE	1544140	12/7/10	$48.00	$35.00
PARKING IN OR BLOCKI	22500E	12/7/10	$53.00	$40.00
PARKING IN PARKWAY	1564290	12/7/10	$53.00	$40.00
PARKING IN PASSENGER	1564120	12/7/10	$53.00	$40.00
PARKING IN RED ZONE	1704370	12/7/10	$53.00	$40.00
PARKING LIMIT-SPECIA	1564070	12/7/10	$48.00	$35.00
PARKING LOADING ZONE	1564020	12/7/10	$78.00	$65.00
PARKING ON A BRIDGE	22500K	12/7/10	$53.00	$40.00
PARKING ON GRADES	1564220	12/7/10	$48.00	$35.00
PARKING ON PUBLIC GR	21113A	12/7/10	$53.00	$40.00
PARKING OVERNIGHT	1564060	12/7/10	$53.00	$40.00
PARKING PARALLEL WIT	1564230	12/7/10	$48.00	$35.00
PARKING PUBLIC & PRI	1564270	12/7/10	$53.00	$40.00
PARKING SPACE MARKIN	1520130	12/7/10	$48.00	$35.00
PARKING SPACES FOR H	1564400	12/7/10	$338.00	$50.00
PARKING SPECIAL HAZA	1564350	12/7/10	$53.00	$40.00
PARKING TIME LIMIT-P	1564030	12/7/10	$48.00	$35.00
PARKING WITHIN INTER	22500A	12/7/10	$53.00	$40.00
PARKING WRONG SIDE O	1564280	12/7/10	$53.00	$40.00
PEDESTRAIN WALKWAY	1704370O	12/7/10	$53.00	$40.00
PICNIC AREA	1704370A	12/7/10	$53.00	$40.00
PKG HAZARD.WASTE	31303D	12/7/10	$363.00	$350.00
PKG IN SHOW AREAS	22510	12/7/10	$53.00	$40.00
PKG. ASSIGNED PKG. S	1564390	12/7/10	$53.00	$40.00

VIOLATION DESCRIPTION	VIOLATION CODE	EFFECTIVEDATE	FINE AMT	PENALTY1
PKG. DRIVEWAYS/PVT.	1564320	12/7/10	$53.00	$40.00
PKG. SPACES FOR HAND	1564410	12/7/10	$338.00	$50.00
PLATES CLEARLY VISBL	5201F	12/7/10	$38.00	$25.00
PLATES CLEARLY VISBL	5201G	12/7/10	$38.00	$25.00
PREFERENTIAL PKG NO	1564700	12/7/10	$53.00	$40.00
PRKING 15' FIRE HYDR	22514	12/7/10	$68.00	$55.00
PRKING 18" FROM CURB	22502A	12/7/10	$53.00	$40.00
PRKING FIRE STA.ENTR	22500D	12/7/10	$68.00	$55.00
PRKING IN TUNNEL	22500J	12/7/10	$53.00	$40.00
PRKING ON CROSSWALK	22500B	12/7/10	$53.00	$40.00
PRKING ON SIDEWALK	22500F	12/7/10	$53.00	$40.00
PRKNG LOT-STREET/ALL	22951	12/7/10	$48.00	$35.00
RECREATION BLDNG	1712220	12/7/10	$23.00	$20.00
RED ZONE	1704370G	12/7/10	$53.00	$40.00
REGISTRATION CARD	4454A	12/7/10	$38.00	$25.00
REPAIRING VEHICLE IN	1576120	12/7/10	$53.00	$40.00
RESTRICTED PARKING	1544150	12/7/10	$48.00	$35.00
ROADWAY	1704370C	12/7/10	$53.00	$40.00
SERVICE ROAD	1704370P	12/7/10	$53.00	$40.00
SIDEWALK	1704370D	12/7/10	$53.00	$40.00
STATE HIGHWAY PARKIN	22505B	12/7/10	$53.00	$40.00
STOPPED/PKG. VEHICUL	23333	12/7/10	$45.00	$32.00
STOPPING ON FREEWAY	22520	12/7/10	$43.00	$30.00
STREET SWEEPING	15200702	12/7/10	$63.00	$50.00
TABS	5204	12/7/10	$73.00	$60.00
TABS	5204A	12/7/10	$73.00	$60.00
TAXICAB STANDS	1564440	12/7/10	$33.00	$20.00
TEMPORARY SIGNS	1564140	12/7/10	$53.00	$40.00
TIME LIMITS	1564010	12/7/10	$48.00	$35.00
UNATTENDED VEHICLES	22515	12/7/10	$53.00	$40.00
UNINCORPORATED AREA	22504A	12/7/10	$58.00	$45.00
UNREGISTERED VEHICLE	4000A	12/7/10	$73.00	$60.00
UNREGISTERED VEHICLE	4000A1	12/7/10	$73.00	$60.00
VEH. PKD WITH HARZ.	1564310	12/7/10	$363.00	$350.00

VIOLATION DESCRIPTION	VIOLATION CODE	EFFECTIVEDATE	FINE AMT	PENALTY1
VEHICLE IN BIKE LANE	1552040	12/7/10	$48.00	$35.00
VEHICLE ON SIDEWALK	1576080	12/7/10	$53.00	$40.00
WASHING VEHICLE ON H	1576130	12/7/10	$53.00	$40.00
WEIGHT EXCEEDING 600	1548050	12/7/10	$53.00	$40.00
WRNG DEVICE ON DSBLE	25300E	12/7/10	$45.00	$32.00
WRNG DEVISE ON DSABL	25300C	12/7/10	$45.00	$32.00

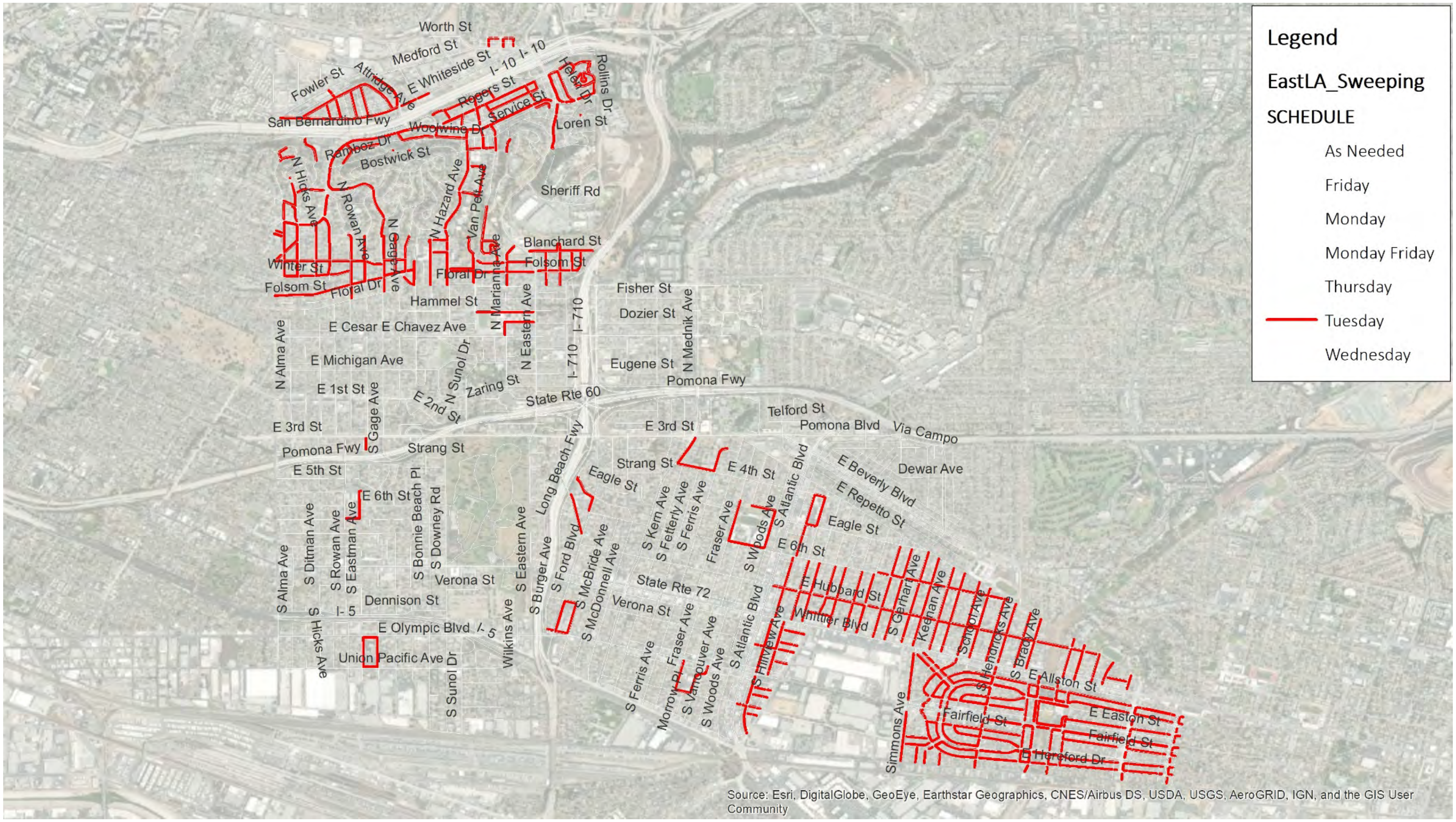
Source: LA County Sheriff, Conduent; 2020

Appendix B: East LA County Street Sweeping Schedule – Monday



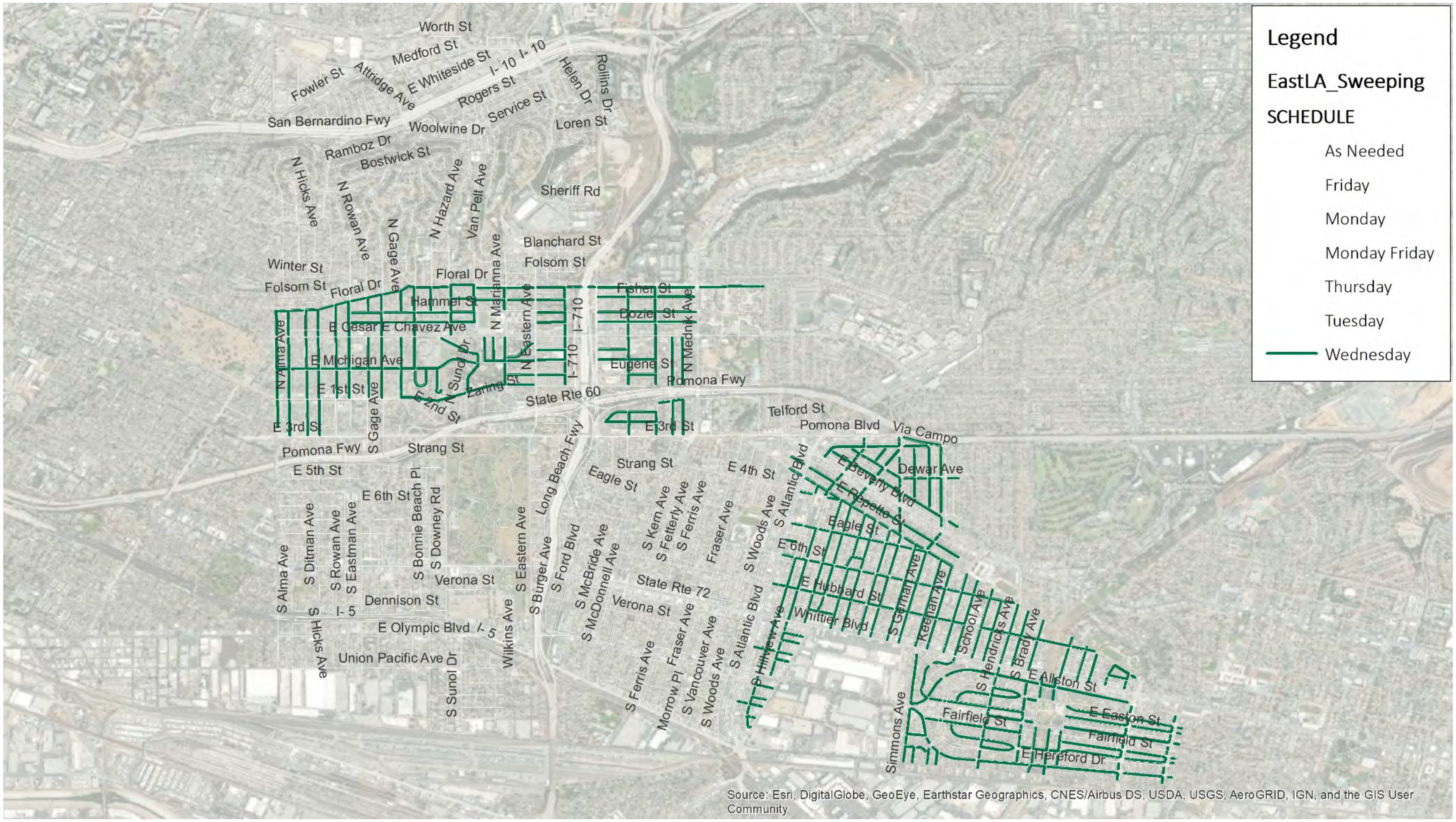
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Appendix C: East LA County Street Sweeping Schedule – Tuesday



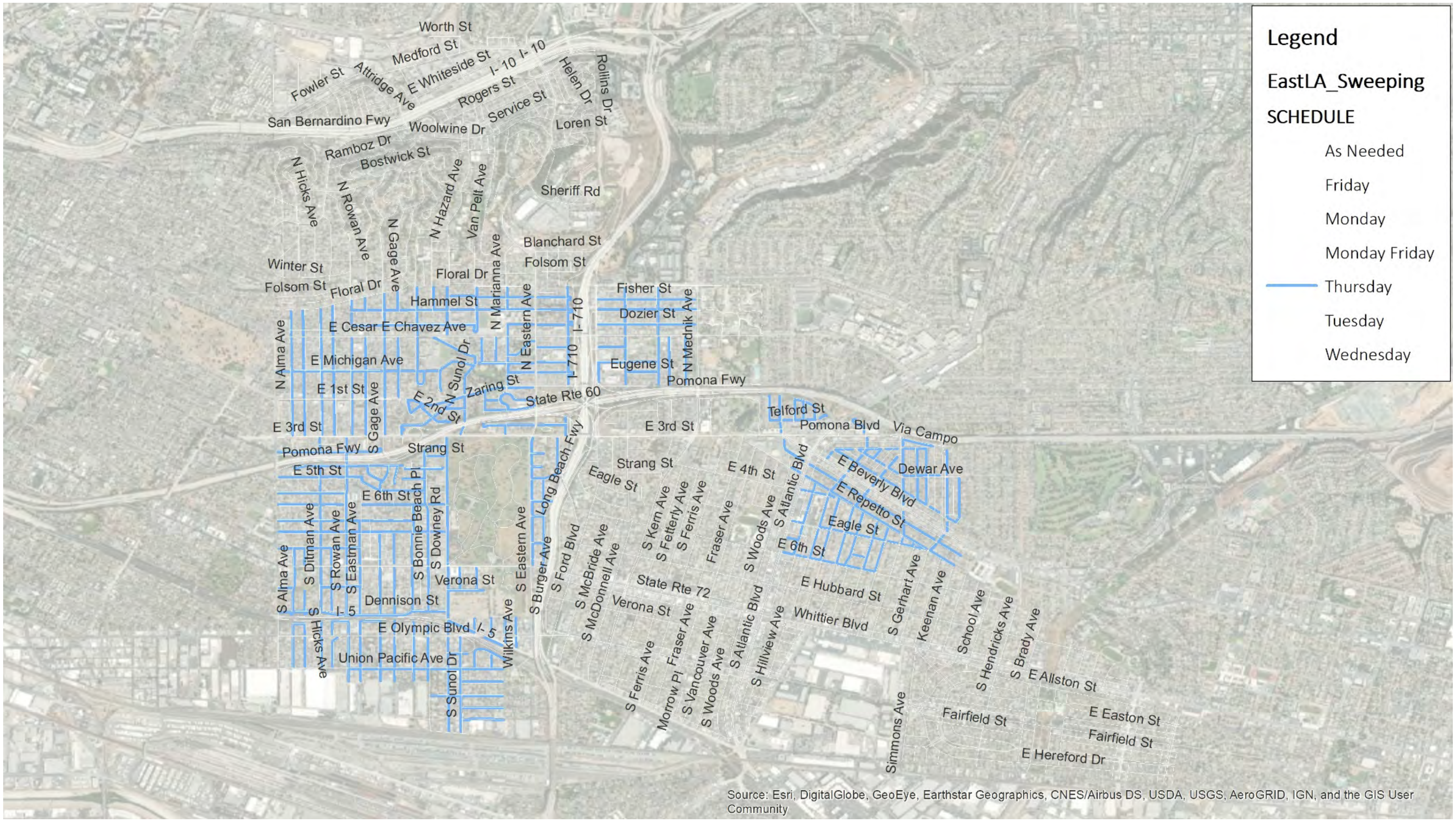
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Appendix D: East LA County Street Sweeping Schedule – Wednesday



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Appendix E: East LA County Street Sweeping Schedule – Thursday

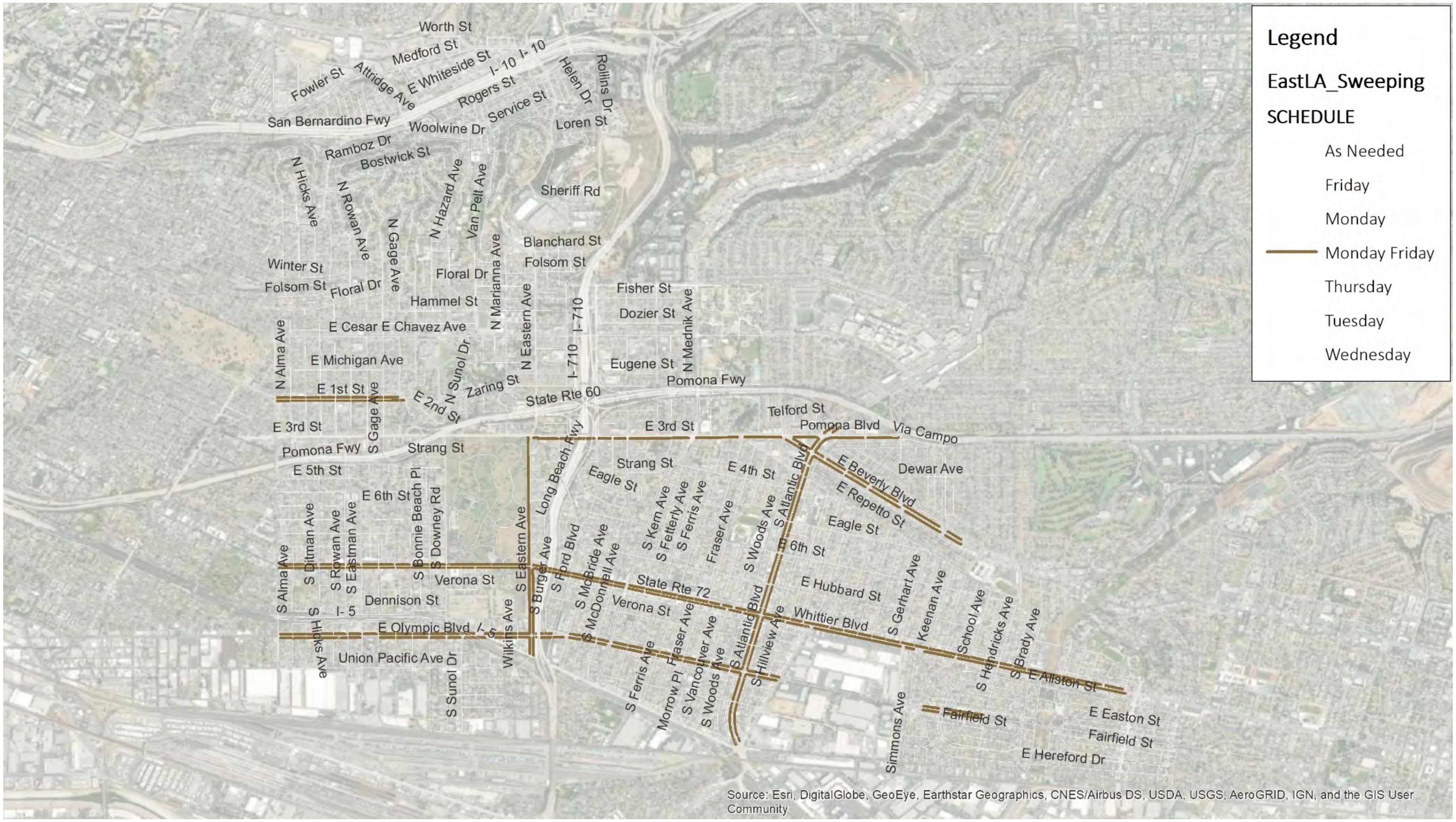


Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Appendix F: East LA County Street Sweeping Schedule – Friday

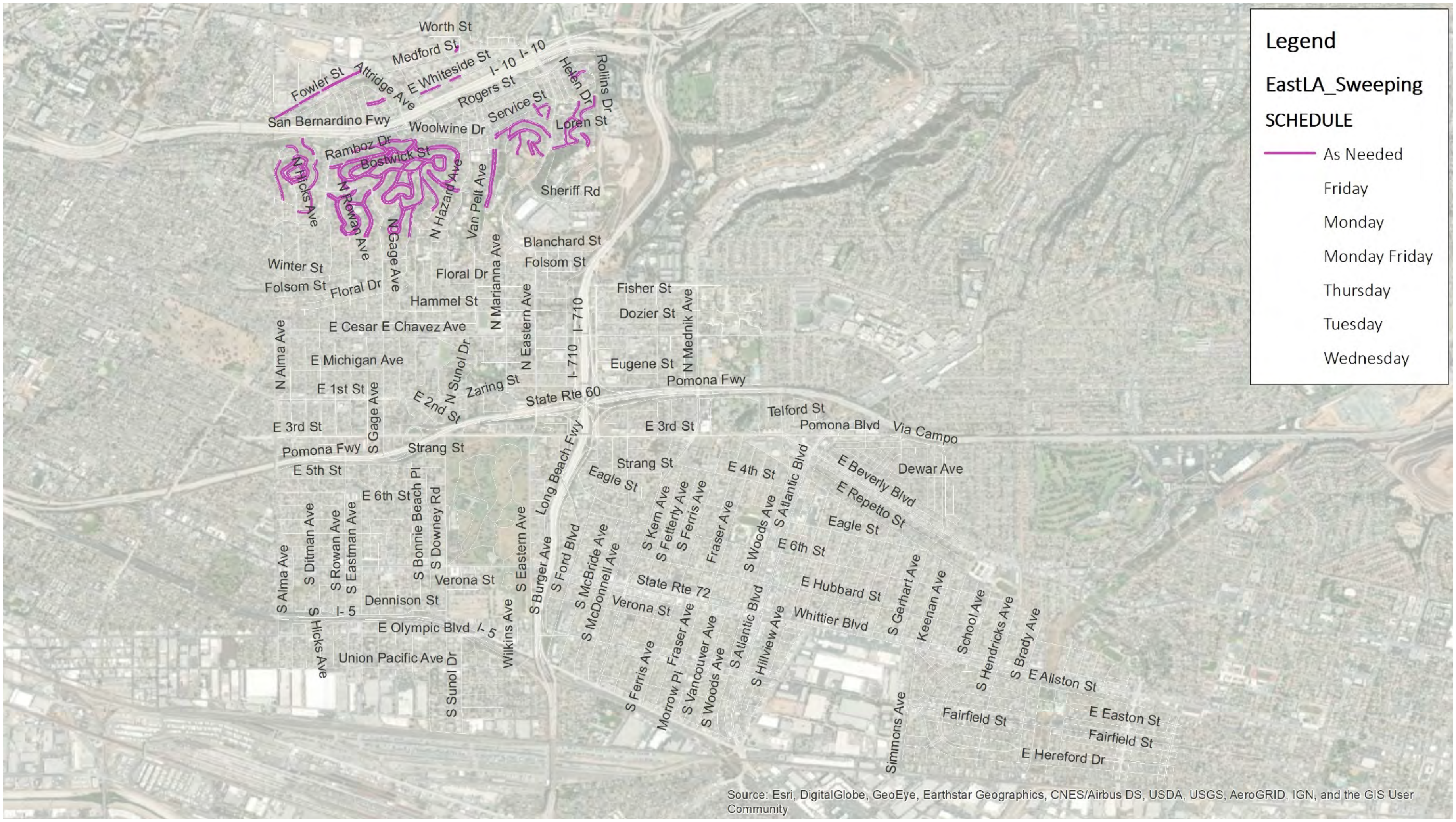
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Appendix G: East LA County Street Sweeping Schedule – Monday and Friday

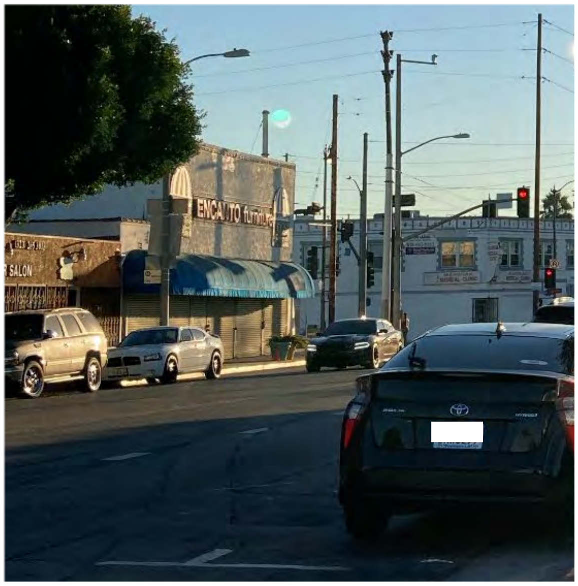


Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Appendix H: East LA County Street Sweeping Schedule – As Needed



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



East Los Angeles Parking Availability Improvement Study

Recommendations for Improved Parking Conditions, Restrictions, and Enforcement Practices

County of Los Angeles, CA

September 24, 2021

Prepared for:
Chief Executive Office Budget and Operations
Community Services

WALKER CONSULTANTS

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Executive Summary

Consistent with a previous comprehensive review of parking conditions in the unincorporated community of City Terrace, similar conditions have been found to exist within other areas of unincorporated community of East Los Angeles (East LA). Key findings for the residential neighborhoods include limited on-street and off-street parking, lack of or difficult-to-access driveways, and households with multiple vehicles. On the commercial side of the equation, limited parking availability was reported and observed, which we concluded was due to a lack of enforcement of posted short-term parking limits, as well as food truck vendors occupying prime curbside inventory in direct competition with the parking needs of established "brick and mortar," fast casual and neighborhood dining establishments.

Solutions Exist

A consistent finding in both residential and commercial areas identifies general overflow (i.e., spillover) parking concerns, which may be addressed with regulatory measures and associated enforcement that is designed to limit the amount and types of vehicles parked on the street in residential neighborhoods and enforce short-term time limits along commercial corridors. Parking spillover generally refers to when parking demand for one land use spills over into the parking supply of an entirely different use, and those users subsequently may then suffer from insufficient parking.

Walker Recommends

1. Establish a parking enforcement district throughout unincorporated East Los Angeles, enforced by a professional parking enforcement services provider dedicated to this task, funded by parking citations, which reports to a separate contract management team within the Sheriff's Department.

2. Establish a preferential parking district in the residential neighborhoods immediately surrounding the proposed Whittier Boulevard Parking Benefit District. The purpose of the program is to limit the number of household vehicles parked along the street during program operating hours as well as to control the amount of time a visitor may park on neighborhood streets.

3. Establish a parking benefit district (PBD) along Whittier Boulevard East of the I-710, and consider other PBD locations throughout the commercial corridors of unincorporated East LA where low on-street parking availability has been identified as a problem. A portion of the revenue from the parking benefit districts should be used in part to secure off-street parking inventory, such as sites considered not suitable for housing, or public private partnerships with local churches, commercial areas after hours, or schools, in each district to address overflow parking demands by accommodating parking needs, including the ability of food truck vendors to operate within defined areas of the community.

Overview of Findings

The following categories and concepts have been provided to provide an overview of our findings as described in the deliverables for Walker's Task 2 *Existing Parking Conditions* and Task 3 *Current Parking Restrictions and Enforcement Practices.*

Limited availability of on-street parking

The limited availability of parking in on-street spaces is likely the single-most problematic finding in many residential neighborhoods and commercial corridors in unincorporated East LA. The lack of available on-street parking stems not only from sheer volume of vehicles and parking congestion that results from multi-generational housing scenarios, but also from inappropriate and in some cases unlawful use of on-street parking that includes long-term and inoperable vehicle storage, curbside vending, spillover from unauthorized commercial business activity, and in some cases, developments that provide fewer spaces than the number of cars they generate.

Limited enforcement

Parking enforcement in unincorporated East Los Angeles is managed by eight (8) parking control officers and one supervisor parking control officer, who operate as part of the East Los Angeles Station of the Los Angeles Sheriff's Department. While coverage is provided seven days per week, staffing resources and coverage hours are mostly limited outside of the weekday hours of 5:00 am to 3:00 pm. Many areas within the 7.45 square miles do not see regular enforcement on a consistent basis. These areas rely upon call center requests, which may or may not immediately resolve the enforcement need. Additional parking enforcement support is provided by California Highway Patrol (CHP), although it is understood this effort has resulted in less than 300 citations being issued in the most recent 2019 calendar year, a small fraction of the total number of citations issued by the LASD.

Abandoned/Inoperable vehicles

Abandoned and inoperable vehicles left on street should be held to the 72-hour ordinance that permits the Sheriff to remove such vehicles to a safe place owned by, maintained by or under the jurisdiction of the County of Los Angeles (See Los Angeles County Code, Chapter 15.64.200, Vehicles parked over 72 hours – Removal by Sheriff). Inoperable vehicles discovered on public and private property shall also be handled in the manner described in the Los Angeles County Code, Chapter 15.80, Abandoned or Inoperable Vehicles. This code language permits a California Highway Patrol officer to have the authority to cause the abatement and removal of such vehicles after a 10-day notice of intention to abate has been served and the appropriate window for a public hearing has been observed. Any vehicle parked long term on the street, but especially an inoperable vehicle, has an impact on parking availability beyond the number of long-term vehicles parked on the street.

Reserving on-street spaces

Rotational use of multiple vehicles within the same household to reserve on-street parking spaces, as well as placing solid waste bins in the rights of way to reserve on-street parking is a common practice in neighborhoods where on-street parking is limited. Placement of solid waste bins and other materials in the rights of way should be handled with code enforcement policies, up to and including confiscation of materials upon appropriate notification. On-street spaces are for public use and not for individual benefit and personal gain.

Illegal parking

Illegal parking, including double-parking, using parking spaces for people with disabilities but without a placard or hangtag, fire hydrant, and blocking intersections are considered infringements upon public safety. These enforcement matters must be dealt with urgently within all commercial and residential areas of the community. Consistent and comprehensive enforcement coverage is vital to the success of the parking program with no exceptions. Allowing these behaviors to occur due to lack of consistent enforcement exacerbates matters over time and ultimately favors the appellant within the adjudication process.

Street vending and food trucks

Viewed as a significant problem throughout many of the commercial corridors, the growing numbers of street vending and food trucks have created an unwanted burden for maintaining sidewalk accessibility, as well as making it difficult for patrons to park curbside when accessing traditional “brick and mortar” businesses and restaurants. Often times, food truck patrons are observed taking advantage of off-street customer parking set aside for curbside businesses and restaurants.

Parking spillover into residential neighborhoods

Often as a result of commercial car sales, repair shops, non-residents (such as employees or customers), and spillover from transit riders who park near transit stations, vehicular spillover from non-residential uses on to residential streets creates a condition whereby parking spaces do not experience turnover during the business day and potentially into the evening and overnight hours, which is needed to provide opportunities for all drivers to park. Limiting the duration of neighborhood on-street parking during the business day and developing a preferential permit parking program would help to resolve these potential conflicts between multiple parking users.

Additional measures to mitigate the impacts of introducing a preferential parking program include offering the shared use of additional off-street inventory for multiple vehicle households during the evening hours and potentially for food truck vending services during the daytime hours. The ability to offer these alternate off-street locations not only provides a reasonable solution to the previously mentioned regulatory measures, but nudges residents and business owners to prioritize and modify their behavior and rethink their residential lifestyles and business plans. Parking conditions have reached the point where the impacts of unregulated, underregulated, and under enforced regulations of spillover parking are unsustainable for the community.

Multi-vehicle ownership

Households with more vehicles than licensed drivers may contribute to low availability of on-street parking. Ownership of multiple vehicles without sufficient off-street parking availability lends to the need to park daily-use vehicles on street while storing recreational, secondary-use, or leisure vehicles in available off-street inventory for longer periods of time. There is no incentive for a resident to behave otherwise in this instance when valuable yet under managed parking on the public street becomes impacted as a result.

Code enforcement

Code enforcement has an opportunity to play a pivotal role in the East Los Angeles Parking Availability Improvement Study. Under multiple scenarios, parking availability is adversely impacted by the growth of illegal accessory dwelling units, unauthorized home business activity, unhoused living, such as campers and recreational vehicles on street, and oversized vehicles, as well as commercial service vehicles and vehicles not authorized by code standards. While many of these code enforcement opportunities may be directly related to the cost of high neighborhood rents, underutilized driveways, and landlords restricting or limiting the use of off-street parking, a concerted awareness campaign should be reviewed and revisited within the community.

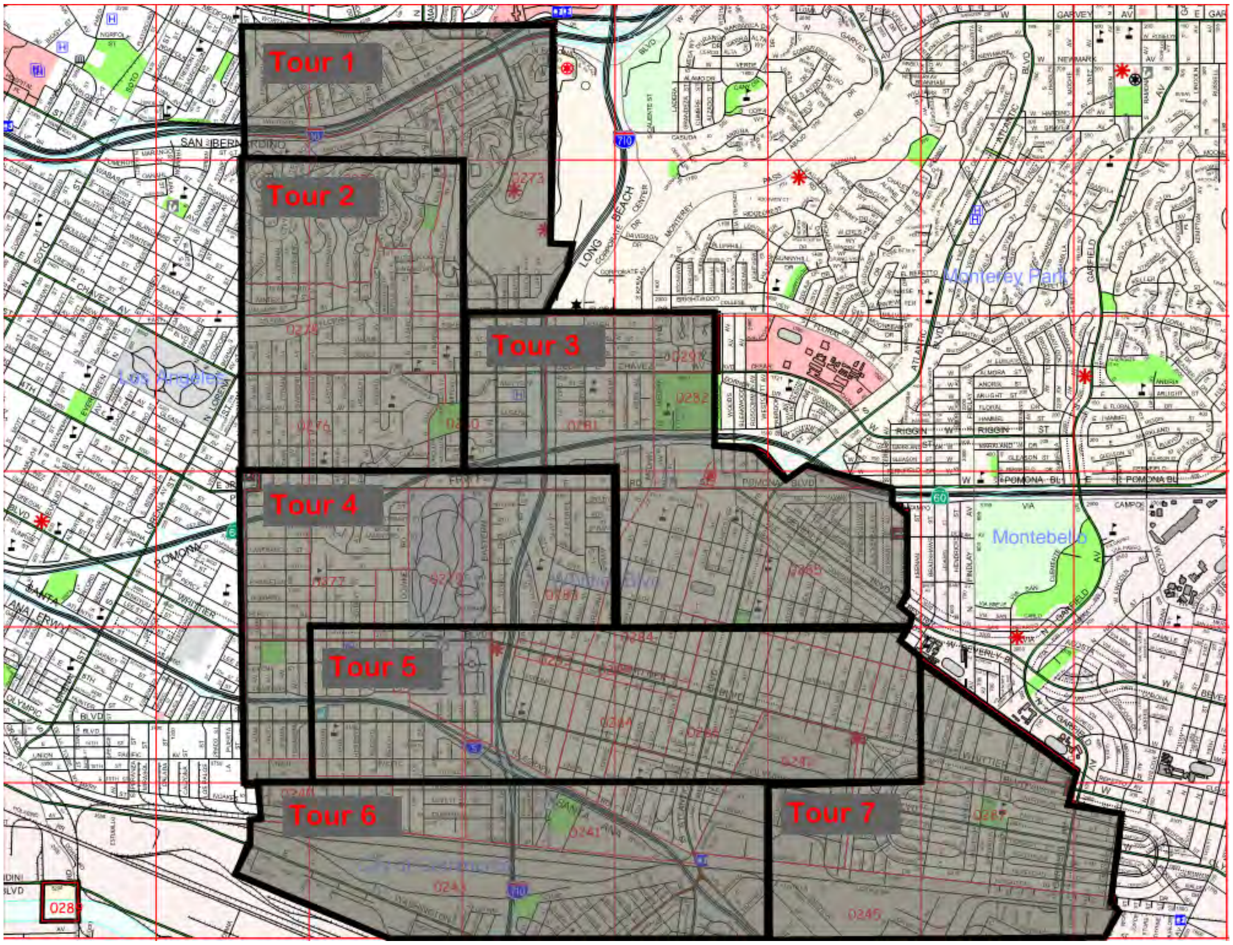
Recommendations

Based on past findings, current observations, and our review and analysis of the parking availability concerns in unincorporated East LA at this time, we recommend the County consider the following best practice measures to manage parking availability within the community.

Parking Enforcement District

A parking enforcement district is a more intentional effort to manage and enforce parking in a geographically defined area. Walker recommends that citation revenue generated in unincorporated East LA, remain in East LA, doing so essentially creates a district. To effectively meet the needs of the community, parking enforcement resources within unincorporated East LA must be expanded to provide consistent coverage across all areas. The following exhibit has been provided to demonstrate coverage areas by designated enforcement tour.

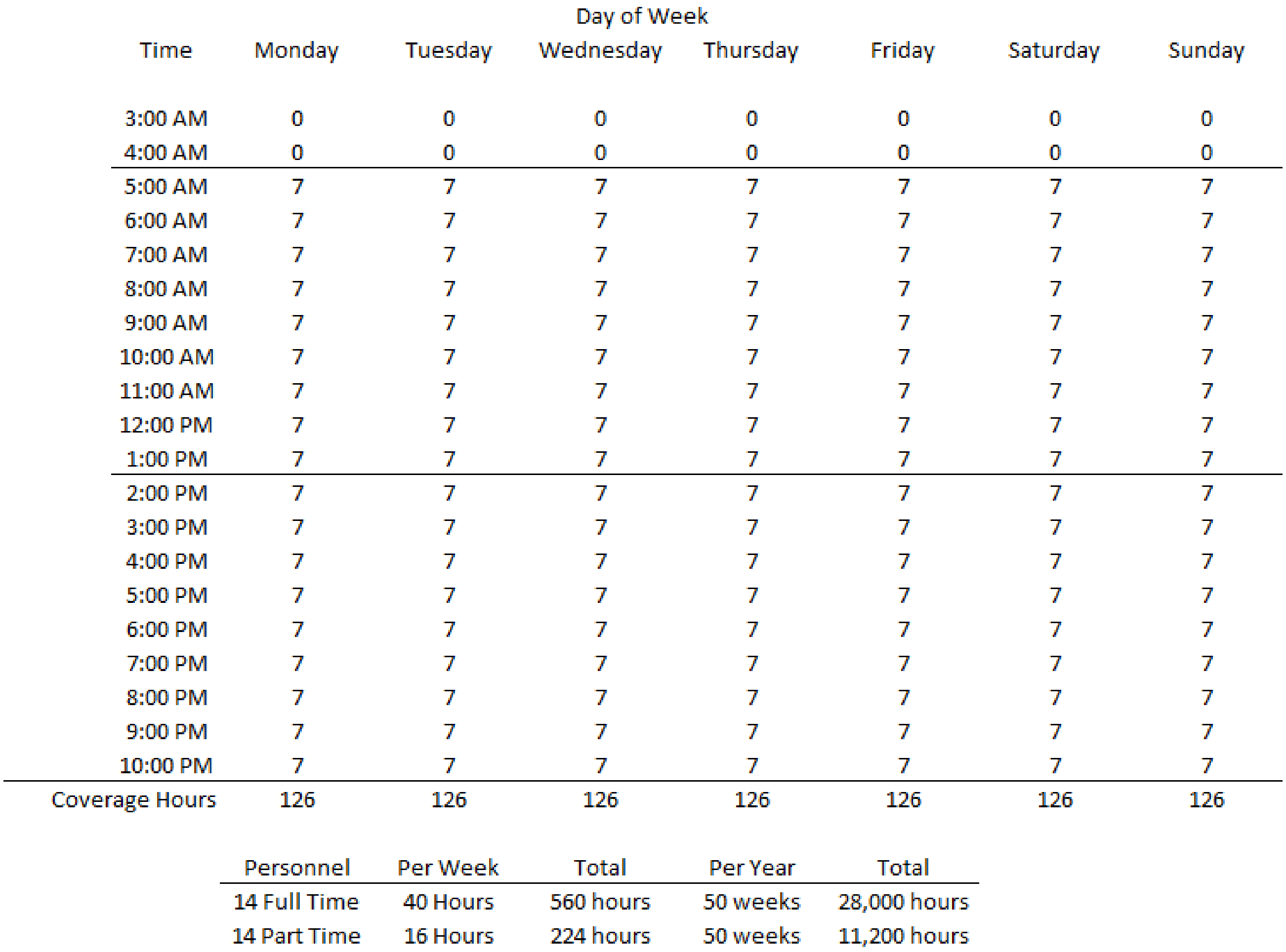
Exhibit 1: Recommended Enforcement Coverage and Enforcement Tours



Source: Los Angeles County Sheriff's Department and Walker Consultants; 2020

Each of the seven enforcement tours suggests the necessity of a minimum of seven parking control officers on duty during the recommended hours of enforcement from 5:00 am to 11:00 pm, seven days per week. To accommodate this recommendation, 14 full-time parking control officers and 14 part-time parking control officers should be recruited and trained to issue parking citations. The following exhibit has been provided to demonstrate the staffing needs by day of week and time of day. The minimum coverage number of seven officers is shown by hour of day with a total coverage hours per day summarized at the bottom of the exhibit. A one-hour meal period break has been factored into each nine-hour shift.

Exhibit 2: Recommended Parking Control Officer Schedule



	Day of Week						
Time	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
3:00 AM	0	0	0	0	0	0	0
4:00 AM	0	0	0	0	0	0	0
5:00 AM	7	7	7	7	7	7	7
6:00 AM	7	7	7	7	7	7	7
7:00 AM	7	7	7	7	7	7	7
8:00 AM	7	7	7	7	7	7	7
9:00 AM	7	7	7	7	7	7	7
10:00 AM	7	7	7	7	7	7	7
11:00 AM	7	7	7	7	7	7	7
12:00 PM	7	7	7	7	7	7	7
1:00 PM	7	7	7	7	7	7	7
2:00 PM	7	7	7	7	7	7	7
3:00 PM	7	7	7	7	7	7	7
4:00 PM	7	7	7	7	7	7	7
5:00 PM	7	7	7	7	7	7	7
6:00 PM	7	7	7	7	7	7	7
7:00 PM	7	7	7	7	7	7	7
8:00 PM	7	7	7	7	7	7	7
9:00 PM	7	7	7	7	7	7	7
10:00 PM	7	7	7	7	7	7	7
Coverage Hours	126	126	126	126	126	126	126

Personnel	Per Week	Total	Per Year	Total
14 Full Time	40 Hours	560 hours	50 weeks	28,000 hours
14 Part Time	16 Hours	224 hours	50 weeks	11,200 hours

Source: Walker Consultants; 2020

In this exhibit, 1st shift officers are assigned to work from 5:00 am to 2:00 pm and 2nd shift officers are assigned to work from 2:00 pm to 11:00 pm. Both full-time and part-time officers have the same shift start and end times, regardless if assigned to working a weekday or a weekend day.

Organizational Structure

The Sheriff's Department remains the logical organization within the County to oversee the proposed parking enforcement district in unincorporated East Los Angeles. While it is understood the Department is unable to add full-time equivalent positions to meet the recommended number of positions required to serve the unincorporated East Los Angeles community, it is anticipated the staffing requirements may be met with the use of a contract with a professional parking enforcement firm.

Program Management

Use of a professional parking enforcement firm will greatly facilitate the County's ability to increase enforcement resources without bearing the financial impacts and recruitment challenges associated with hiring a full-time employee. Often times, position postings require a lengthy process to qualify, interview, and test applicants for an entry level position with the Sheriff's Department. Many of the candidates fail to pass the testing procedures and require the process to start over. Professional parking enforcement firms typically have a pool of employees which they may rotate between local and regional government contracts with minimal training and acclimation effects. If the management contract has been set up accordingly, the professional firms are incentivized to keep positions filled and shifts covered at all times.

Preferential Parking Program

A key component of a preferential parking program for the East LA neighborhood's will require the need to define and address the program parameters and limitations. The potential for establishing rules consistent with the unique characteristics of individual neighborhoods may be a necessity. As an example, neighborhoods with narrow roadways and reduced rights of ways may be required to limit on-street parking permits to one permit per household; the number of cars that can safely and realistically park on block faces in this scenario may be far less than typical. Other locations may be served by two permits per household, regardless of roadway definition and off-street parking availability.

A recommended best practice identifies the need to verify on-street parking inventory within each neighborhood and compare this to the number of residential households to establish a baseline metric. A subsequent step suggests the need to identify off-street inventory associated with each residential household. Given these two data points, a determination may then be made to establish program permissions and limitations. In most circumstances, each household should be permitted the use of one on-street permit per household address. Using a license plate permit credential (by which a vehicle's license plate number communicates whether, where and how long it may be permitted to park), the on-street permit can be virtually assigned to the first household vehicle parked on-street, rendering all other household vehicle license plates inactive during this use period.

Parking Benefit Program

Communicating the advantages of a parking benefit program is almost always the most difficult task for a government agency as residents and business owners must be able to envision the immediate benefits of having to pay for something many have previously received for free. In addition, equity is a major factor here where low income households may not be able to afford this additional cost, but still rely on vehicles to access jobs.

It is important to develop a transparent process to identify the goals of the parking benefit program for the community. Which user groups may be the focus, beneficiaries, but also the potential funders of the parking benefit program? Multiple vehicle households? Out of town visitors? Premium repeat parkers (customers) who simply want access and convenience and are willing to pay for the convenience? All these options should be considered and discussed with a focus and policy goals in mind. What then becomes of the revenue benefit? Parking and mobility infrastructure needs? Recurring community maintenance and subscription costs? Under the parameters of a parking benefit district, the district and its stakeholders should have a say in the way the revenue proceeds are reinvested in the community.

Neighborhood Incentive Programs

As discussed during the community stakeholder meetings, several neighborhood incentive programs may be supported through the County's resources to help residences and businesses make land resources available for parking. Such programs as "cash for clunkers," garage sales and single-day disposal services, and local business coupons or incentives, can provide sufficient financial incentive for residents and business owners to take action during times when simple coordination efforts seem too difficult to overcome. In addition, public car sharing programs like the BlueLA program; or offer micromobility options to provide better access to transit stations as a way to reduce the need for private car ownership.

Infrastructure and Capacity Needs

To address parking facility and capacity needs, the County should explore the possibility of using County real estate within unincorporated East LA to address some parking needs. Can existing facilities and surface parking areas be utilized for off-hour parking needs and overnight parking? Can underutilized land parcels be converted into parking lots or multi-purpose properties that offer increased off-street parking with reasonable minimal investment? Are walking distances, safety, or bike/pedestrian friendly locations such that some parkers would choose to park in these locations? These efforts typically precede opportunities for the County to explore land acquisition, or better yet, public/private land development opportunities where private developers may take advantage of development incentives after a public parking component is included with their development approval process. More simply and less costly, some jurisdictions have created formal, or facilitated informal, programs to use existing, underutilized public or private off-street spaces to enhance the supply of parking available to some or all members of the parking public.

East Los Angeles Parking Availability Improvement Study

Parking Enforcement District Feasibility Analysis

County of Los Angeles, CA

September 24, 2021

Prepared for:
Chief Executive Office Budget and Operations
Community Services

WALKER
CONSULTANTS

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Executive Summary

The purpose of this report is to discuss the feasibility of establishing a parking enforcement district in the unincorporated community of East Los Angeles (East LA).

Recommendations

The key recommendations as part of Task 5 include the following.

Walker recommends that the parking enforcement operation for unincorporated East LA be partially outsourced to a professional parking enforcement firm or an interagency agreement because that entity will have significant resources specifically dedicated to parking enforcement. The professional enforcement firm would augment existing County personnel. The issue is one of the scale of resources available. Current LA parking enforcement staff perform their duties diligently but do not have the resources at their disposal to cover the enormous area and long hours required for effective parking enforcement in East Los Angeles. Having an additional dedicated, professional parking enforcement entity perform parking enforcement duties should allow for more consistent enforcement for longer periods of time over a longer area. Enforcement conducted by a private firm, or possibly a dedicated parking enforcement entity with significant resources should be more efficient and effective at deploying resources to operate at lower costs than insourced enforcement.

The Sheriff's Department should be responsible for providing contract management and oversight of the professional parking enforcement firm. It is anticipated that a full-time equivalent staff member of the Sheriff's Department would handle the daily oversight of the professional parking enforcement firm and would be required to provide education and training with regard to the LA County Code requirements. The professional parking enforcement firm would be required to submit a variety of monthly reports that include the types and number of citations, monthly management reports, and status reports.

Walker recommends that the parking enforcement responsibilities be conducted using license plate recognition (LPR) which to help maintain the timeliness of district-wide enforcement practices and discourage scofflaw behavior. LPR enforcement can provide many benefits to the enforcement operation and conveniences to the public.

With a parking enforcement district in unincorporated East LA, the revenue obtained from parking citations in unincorporated East LA would be used to fund the parking enforcement operation for unincorporated East LA. Walker projects the revenue obtained from parking citations will cover the costs of the parking enforcement operation, with a surplus that would go toward the County General Fund or invested in the community.

01 Introduction

Introduction

The primary mission of Los Angeles County's ("LA County" or "County") parking enforcement program is to ensure that residents, visitors, and other community stakeholders adhere to the County's parking regulations. Parking regulations exist to provide safety and to facilitate the availability of parking on the street.

The Parking Enforcement Detail (PED) of the Los Angeles County Sheriff's Department provides centralized administration of parking violation enforcement and parking citation processing in the unincorporated areas of LA County. PED also provides the administrative review of contested citations and schedules administrative hearings conducted by civilian hearing officers. The PED unit provides services for other County departments, police agencies, and some Contract Cities. PED is comprised of 1 manager, 8 headquarters staff members, 55 parking control officers, and 11 supervisor parking control officers deployed throughout 16 patrol stations. Through regular patrol, parking control officers issue citations to vehicles that are parked in violation of the law, identify abandoned vehicles, and recover stolen vehicles. They also respond to community complaints regarding parking violations.

In unincorporated East Los Angeles ("East LA"), the PED is comprised of eight parking control officers, and one supervisor parking control officer reporting to the East Los Angeles Station. Table 1 demonstrates current staff coverage and assigned shifts.

Table 1: Unincorporated East Los Angeles Parking Enforcement Detail Staff and Assigned Shifts

#	Rank	Day of Week	Time of Day	Number of Staff (Shift Length)
1	SPCO	Monday through Friday	6: 00 AM to 2:00 PM	Five (8-hour tour)
1	PCO	Tuesday through Friday	5: 00 AM to 3:00 PM	Four (10-hour tour)
2	PCO	Tuesday through Friday	7:00 AM to 5:00 PM	Four (10-hour tour)
3	PCO	Monday through Friday	6:30 AM to 2:30 PM	Five (8-hour tour)
4	PCO	Sunday	3:00 AM to 1:00 PM	One (10-hour tour)
		Monday through Wednesday	5:00 AM to 3:00 PM	Three (10-hour tour)
5	PCO	Monday through Friday	4:00 AM to 12:00 PM	Five (8-hour tour)
6	PCO	Monday through Thursday	5:00 AM to 3:00 PM	Four (10-hour tour)
7	PCO	Monday through Friday	5:00 AM to 1:00 PM	Five (8-hour tour)
8	PCO	Thursday and Friday	9:00 AM to 7:00 PM	Two (10-hour tour)
		Saturday and Sunday	5:00 AM to 3:00 PM	Two (10-hour tour)

Source: LA County Sheriff Department; May 2020

Current Parking and Enforcement Challenges

East LA has the highest population density in the County for communities with a population over 100,000. There are 16,000+ persons per square mile residing in unincorporated East Los Angeles. At the same time 84 percent of commuters drive or carpool to work, and 88 percent of unincorporated East Los Angeles households have access to one or more vehicles. The combination of a high population density and high vehicle reliance for mobility results in high parking demand.

The most evident and vocalized issue in unincorporated East Los Angeles is the lack of available on-street parking. On residential streets, parking occupancy levels are so high, that instances of illegal parking (e.g., parking in intersection, red curb, blocking driveways, double parking, etc.) are commonplace, thus pushing on-street occupancies above 100 percent. This issue is so broad that it can be found in most residential neighborhoods. The factors leading to the scarcity of available on-street parking include inconsistent or ineffective enforcement of current regulations, a free to park system, high automobile reliance, high population density, and limited residential parking options, among others.

East LA parking enforcement personnel resources are limited to a number of budgeted positions making it difficult to increase enforcement efforts and consistently enforce all parking related aspects of unincorporated East Los Angeles. To effectively meet the needs of the community, we believe more enforcement officer positions should be staffed throughout the day and, in the case of the residential neighborhoods, into the early evening hours and weekends.

As identified in the public survey responses and further supported through comments made during the community stakeholder sessions, both residents and business merchants believe enforcement coverage is not substantial or consistent enough to meet the needs of the community. A number of stakeholders shared that enforcement officers are seldom seen enforcing matters on their community streets, especially during the afternoon and early evening hours. On days when street sweeping is scheduled in specific neighborhoods, as few as 2-3 parking control officers are available to cover the remainder of the unincorporated East LA district. Considering conditions that affect scheduled and unscheduled paid time off (PTO) or medical leave of absence (MLA), the challenge becomes increasingly difficult to meet the coverage needs, not only each day, but in the early evening hours as well.

Parking Enforcement District

In light of these current enforcement challenges, the County is considering the implementation of a parking enforcement district for East Los Angeles. East LA already has a form of parking enforcement district in place, as it has a Sheriff's Department station that serves the East LA area. Under a parking enforcement district model, the citation revenue generated within East LA would fund the parking enforcement operation in the East LA area. Parking enforcement operations and responsibilities would be separate for the East LA area than for the rest of the County.

02

Insourcing vs Outsourcing Enforcement

Insourcing vs. Outsourcing Parking Enforcement Services

When determining the recommended organizational structure for the unincorporated East LA parking enforcement district, the first consideration is whether parking enforcement responsibilities in unincorporated East LA should continue to be provided by PED staff or if they should be outsourced to a professional parking enforcement firm.

Many public agencies conduct their own parking enforcement while others prefer to hire a professional management company to enforce. While the duties of parking enforcement can be delegated to a professional parking enforcement firm, the ultimate responsibility resides with the County to ensure the professional parking enforcement firm is acting in the best interest of the community. The following is a list of advantages for outsourcing parking enforcement services:

- Parking enforcement firms are usually experienced in handling enforcement responsibilities by offering experienced management, customer service, and quality control.
- Contract management typically requires lower startup costs. Parking enforcement firms can provide an established enforcement system. The County can require that the enforcement firm prepare specific reports, meet with ownership periodically to discuss those reports and other issues, and can usually offer specific recommendations to make the parking enforcement operation more efficient.
- In an area where it may be difficult to recruit or maintain a staff with the needed experience and expertise, a regional or national firm has the labor flexibility to provide continuous service. However, the County can also request that existing enforcement staff be retained by the professional parking enforcement firm.
- The parking enforcement firm is responsible for hiring and training qualified enforcement personnel. They can develop a location-specific procedure manual, approved by the County, which documents the day-to-day duties of all persons working at that location.
- Contracting through a parking enforcement firm allows greater employee flexibility should problems arise. For example, ownership may request the parking enforcement firm to remove any of the its employees from the premises. As the parking enforcement firm has managerial responsibility, they then can simply transfer the employee to another location under their contractual oversight.
- Employee labor cost and benefits may be less expensive. Labor rates may not be governed by established public agency employee labor agreements. The parking enforcement firm is usually free to establish an approved labor and benefit schedule that may be lower than established rates for County employees.
- The County benefits from the expertise of the parking enforcement firm without giving up control of the policy decisions.
- The management fee paid to the parking enforcement firm is usually off-set by cost savings realized by reducing the workload on certain departments.
- The professional parking enforcement firm’s local manager may be required to attend meetings on a regular basis so that coordination between the County and parking enforcement is ensured.
- The purchasing power of the parking enforcement firm may save the County money in the procurement of parking enforcement equipment, insurance, and supplies.

Self-operation has the following advantages over contracting the parking enforcement:

- Public employees may be perceived to have more at stake with the operation in terms of customer service and enforcement responsibilities.
- There is no direct parking management fee; although there may be additional payroll expenses and most likely higher benefit costs.

Private parking enforcement typically is more nimble, and therefore more efficient at deploying resources and tends to operate at lower costs than public agency enforcement programs. These lower costs usually compensate for the enforcement firm's management fee. With contract management, the public agency has control over major policies; however, the public agency does not have to employ several parking personnel for the day-to-day operations. Contract management removes the burden of employee supervision from the public agency staff. If the employees are employed by the public agency there is much less flexibility when increasing or decreasing staffing levels and providing benefits.

Another advantage of using the services of a parking enforcement firm is that a parking enforcement firm has specific expertise in the business. Even though the public agency has the final say on policy decisions, the parking enforcement firm is a great source of information and may be called upon to offer their recommendations in parking related matters.

Most disadvantages of contract management can be met through changes to the operating agreements. The professional parking enforcement firm could provide financial incentives for reaching financial goals, meeting standards of service, or reducing on-going issues. In this manner, the firm is more likely to attend to the daily parking operation and to provide the best possible care to the enforcement system.

Walker Recommendation

Due to the current enforcement challenges in unincorporated East LA described in the previous section, Walker recommends that the County engage a professional parking enforcement firm or dedicated entity for parking enforcement responsibilities in unincorporated East LA if a Parking Enforcement District is created:

- Having a professional parking enforcement firm conduct parking enforcement duties will allow for enforcement of longer hours with more consistent enforcement.
- In the event the outsourcing of enforcement services creates a reduction in force for the current County parking enforcement detail (PED), the County should require the third-party operator to extend employment offers to County employees affected by reduction in force policies. Current PED staff have the background and experience with parking enforcement in unincorporated East LA.
- The Sheriff's Department should be responsible for providing contract management and oversight of the professional parking enforcement firm. It is anticipated that a full-time equivalent staff member of the Sheriff's Department would handle the daily oversight of the operator and would be required to provide education and training of the LA County Code requirements.
- The professional parking enforcement firm would be required to submit a variety of monthly reports that include the types and number of citations, monthly management reports, and status reports.

03

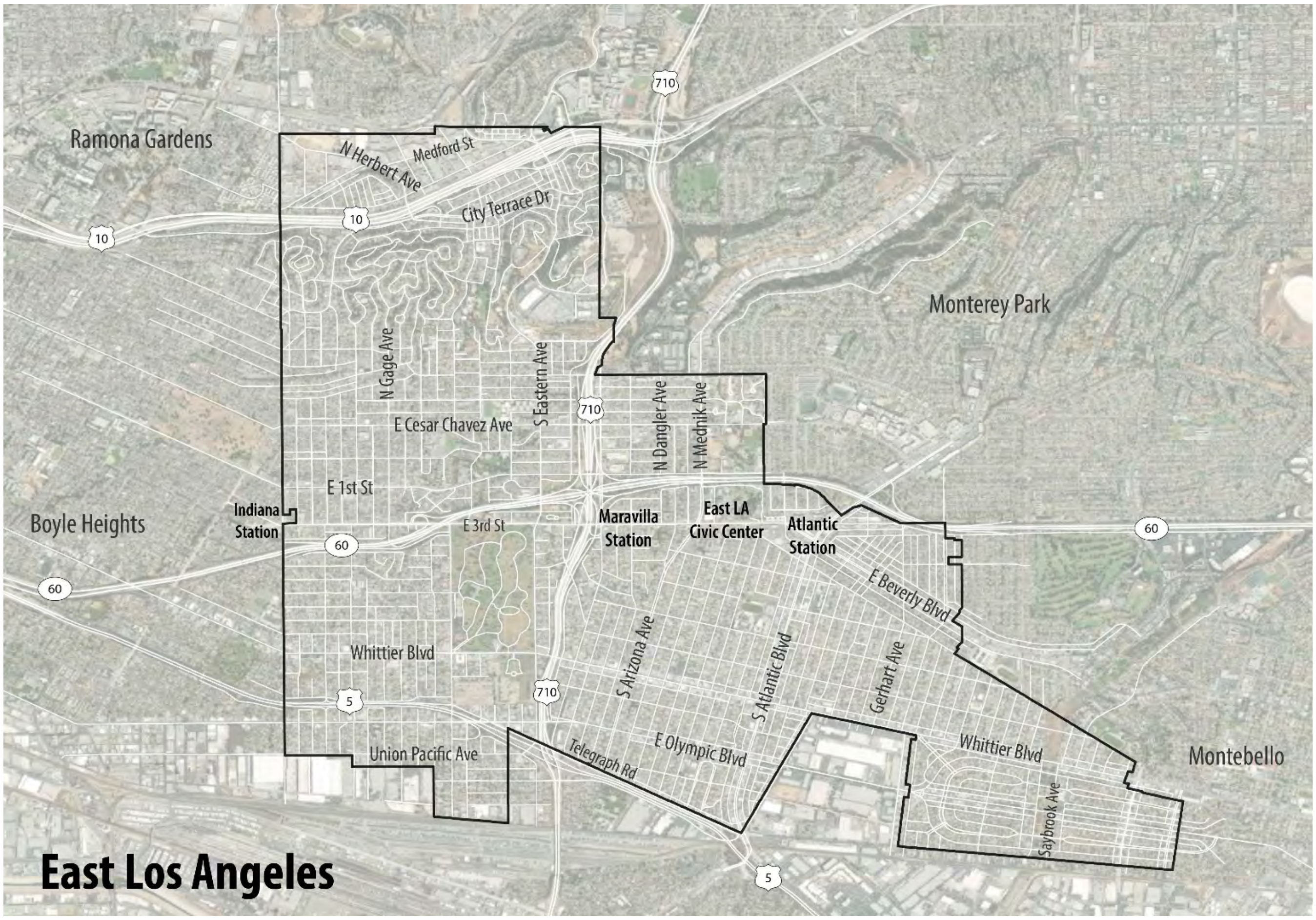
Parking Enforcement District Feasibility Analysis

Parking Enforcement District Feasibility Analysis

This section discusses the financial feasibility of a proposed parking enforcement district in unincorporated East LA. The following parameters would be associated with the district:

- The enforcement responsibilities within the unincorporated East LA area should be performed by a professional parking enforcement firm or dedicated entity with a Sheriff's Department representative managing the contract between the County and the entity providing enforcement services.
- The parking enforcement operation should demonstrate consistent enforcement practices in all areas of unincorporated East Los Angeles County to increase parking compliance and encourage vehicle owners to take greater responsibility for their parking behavior.
- The enforcement firm should continue to promote payment options and encourage the practice of citation payment within the first 21 days of issuance to avoid subsequent penalties.
- Enforcement hours should be modified to cover the operating hours of 5:00 a.m. to 11:00 p.m. seven days per week.
- The parking enforcement district should cover the entire unincorporated East LA area (7.45 square miles), as shown in the following Figure 1.
- The enforcement firm should use license plate recognition (LPR) to maintain the timeliness of district-wide enforcement practices and discourage scofflaw behavior.
- The enforcement firm should be incentivized to provide a high level of accuracy in issuing parking citations. A key performance indicator (KPI) for the enforcement firm should be the issuance of "valid issued citation percentage" rather than "citation revenue generated." This KPI should be established as part of the contract between the County and enforcement firm.

Figure 1: Unincorporated East Los Angeles Boundary



Source: Walker Consultants, 2020.

Revenue for a Parking Enforcement District

The primary source of revenue to fund a parking enforcement district is anticipated to be from parking citations. Table 2 summarizes the parking citation data for unincorporated East LA for the period of 2017 through 2019. The total citation amount ranges from $2,918,807 to $3,390,374. The average citation amount paid over the three-year period was $3,203,285.

Table 2: Unincorporated East Los Angeles Parking Citation Data – Recent Three-Year Historical

	CY2017	CY2018	CY2019
Citations Issued	50,757	47,690	47,860
Citations Paid*	34,868	35,515	35,015
Total PAID AMT	$3,390,374	$3,300,673	$2,918,807
Citations Unpaid	15,889	12,175	12,845
Total AMT Due (Unpaid)	$2,363,122	$2,196,682	$2,566,571
Percentage Paid	68.70%	74.50%	73.20%

*By Process Date

Source: Conduent; August 2020

During the initial three to six months of program implementation, it is anticipated that citation numbers are likely to increase due to more officers patrolling the unincorporated East LA area. In particular, areas that do not have much enforcement now are likely to see an increase in citation rates, at least initially. However, the number of citations should begin to normalize after the first six months as compliance with regulations improves and repeat violators are likely to change their behaviors. Since citation rates will likely level off, it can be assumed that future citation revenue amount will be similar to what has been reported in recent years; therefore, citation revenue is assumed to be in the range of $3.2mm to $3.3mm on average, per year.

Expenses for a Parking Enforcement District

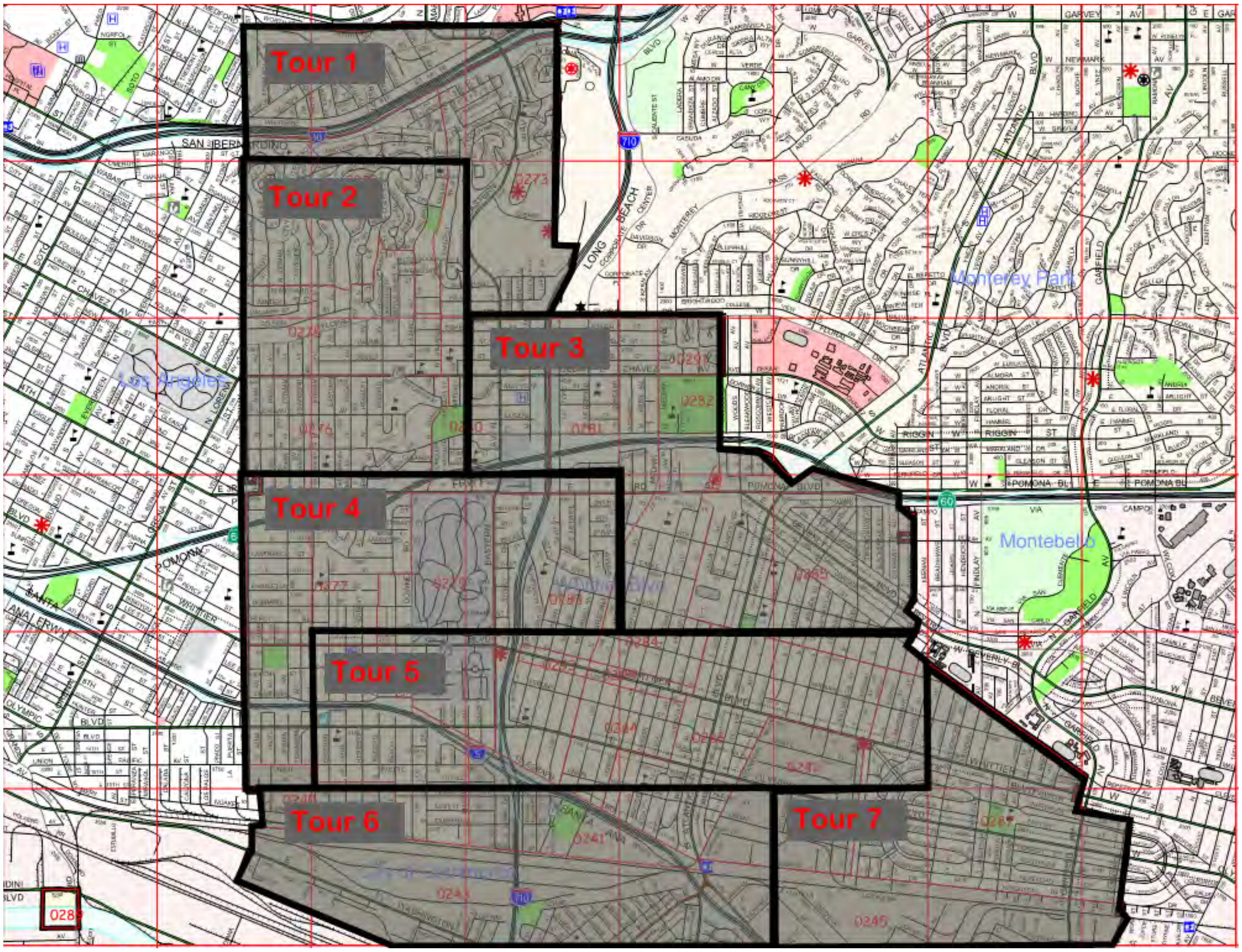
Typical operating expenses which may be associated with a parking enforcement district include the following:

- Parking enforcement staffing hourly wages and benefits
- Parking enforcement vehicles
- License Plate Recognition (LPR) equipment and software

Enforcement Staffing Schedule

To effectively meet the needs of the community, parking enforcement resources within unincorporated East Los Angeles County should be expanded to provide consistent coverage across all areas. The following exhibit has been provided to demonstrate coverage areas by designated enforcement tour.

Figure 2: Recommended Enforcement Coverage and Enforcement Tours



Source: Los Angeles County Sheriff's Department and Walker Consultants; 2020

Each of the seven enforcement tours suggest a need to have a minimum of seven parking control officers on duty during the recommended hours of enforcement of 5:00 a.m. to 11:00 p.m., seven days per week. Two shifts of seven parking enforcement officers would work nine-hour shifts (with one-hour break). 1st shift officers are assigned to work from 5:00 a.m. to 2:00 p.m. and 2nd shift officers are assigned to work from 2:00 p.m. to 11:00 p.m.

Table 3 demonstrates the staffing schedule proposed.

Table 3: Recommended Weekly Parking Control Officer Staffing Schedule

	Number of Staff per Day and Hour						
Start Time	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
5:00 a.m.	7	7	7	7	7	7	7
6:00 a.m.	7	7	7	7	7	7	7
7:00 a.m.	7	7	7	7	7	7	7
8:00 a.m.	7	7	7	7	7	7	7
9:00 a.m.	7	7	7	7	7	7	7
10.00 a.m.	7	7	7	7	7	7	7
11:00 a.m.	7	7	7	7	7	7	7
12:00 p.m.	7	7	7	7	7	7	7
1:00 p.m.	7	7	7	7	7	7	7
2:00 p.m.	7	7	7	7	7	7	7
3:00 p.m.	7	7	7	7	7	7	7
4:00 p.m.	7	7	7	7	7	7	7
5:00 p.m.	7	7	7	7	7	7	7
6:00 p.m.	7	7	7	7	7	7	7
7:00 p.m.	7	7	7	7	7	7	7
8:00 p.m.	7	7	7	7	7	7	7
9:00 p.m.	7	7	7	7	7	7	7
10:00 p.m.	7	7	7	7	7	7	7
Total Coverage Hours	**126**	**126**	**126**	**126**	**126**	**126**	**126**

*Staffing schedule assumes a one-hour break during shift.

Source: Walker Consultants, 2020.

In addition to parking control officers, there are other staff that would be required to manage the operation, including:

- Dispatcher(s) to answer calls and dispatch parking enforcement officers.
- A supervisor to oversee the parking enforcement officers.
- A contract analyst to provide administrative functions and contract management for the third-party operator contract.
- A project manager to oversee the parking enforcement operation and to be the first point of contact between the County and the parking enforcement operator.
- A Sheriff's Department representative to oversee and manage the contract with the third-party operator. Walker recommends that this position reside with the Sheriff Department's internal team.

Table 4 summarizes the staffing schedule for the dispatcher, supervisor, contract analyst, and project manager. The project manager is a salaried position that is likely to work varying hours during the week.

Table 4: Recommended Enforcement Position Schedule

	Weekday			Weekend		
	Hours of Coverage*	Number of Staff	Weekday Staff Hours	Hours of Coverage*	Number of Staff	Weekend Staff Hours
Dispatcher	5:00 a.m. – 11:00 p.m.	2	32	5:00 a.m. – 11:00 p.m.	1	16
Supervisor	8:00 a.m. – 5:00 p.m.	1	8	N/A	0	0
Contract Analyst	8:00 a.m. – 5:00 p.m.	1	8	N/A	0	0
Project Manager	Salary	1	Salary	Salary	1	Salary

*Assumes 1-hour break

Source: Walker Consultants, 2020.

Table 5 summarizes the recommended number of staffing hours per year. A total of 34 staff members are recommended for the unincorporated East LA parking enforcement operation.

Table 5: Recommended Hourly Annual Professional Parking Enforcement Firm Staffing Schedule

Position Type	Number of Staff	Hours per Staff per Week	Weekly Labor Hours by Position Type	Weeks Per Year*	Total Labor Hours per Year	Hourly Rate	Total Cost
Full-time Parking Control Officer	14	40	560	52	29,120	$31	$902,720
Part-time Parking Control Officer	14	16	224	52	11,648	$31	$361,088
Full-time Dispatcher	2	40	80	52	4,160	$42	$174,720
Part-time Dispatcher	2	16	32	52	1,664	$42	$69,888
Full-time Supervisor	1	40	40	52	2,080	$42	$87,360
Full-time Contract Analyst	1	40	40	52	2,080	$50	$104,000
Project Manager	1	Salary	Salary	Salary	Salary	Salary	$140,000
Total Annual Staffing/Cost	34						**$1,839,776**

*52 weeks per year includes vacation and holidays.

**Hourly rates are derived from the U.S Bureau of Labor Statistics data for Parking Enforcement Workers and Walker experience with other Parking Enforcement procurement efforts in Southern California.

Source: Walker Consultants, 2020.

Additional Enforcement Expenses

In addition to the staffing requirements, there will be parking enforcement expenses related to the equipment needed to complete the enforcement responsibilities. These additional expenses may include the following items:

- 14 parking enforcement vehicles, one vehicle for each parking control officer assigned per day
- 14 vehicle-mounted LPR units, one for each vehicle

- 17 LPR handheld devices, one for each enforcement officer assigned per day with three spare units in case of unit malfunction
- Recurring costs, including software, subscription fees, and administrative costs

License Plate Recognition

Mobile license plate recognition (LPR) technology has made the enforcement of pay-by-plate, pay-by-cell, and license plate permit parking remarkably efficient and cost-effective.

Mobile LPR utilizes vehicle mounted cameras that read and record license plate numbers as an enforcement vehicle is driven through the designated enforcement areas of unincorporated East LA. The cameras use a series of algorithms to convert the photographic image of license plates into text data that can be compared with lists or databases of paid or permitted license plates, to determine if the vehicle has the right to park in that particular location at that particular time.

If the LPR camera reads a plate that is not recorded as registered or paid, or has been otherwise identified as searchable, an audible alarm sounds to alert the driver, who can then take the appropriate action. The LPR software can integrate with multi-space meter software, pay-by-cell software, permit software, and other databases such as law enforcement agencies to not only identify paid and unpaid motorists, but also stolen or otherwise significant license plates, such as Amber Alerts, felons, or scofflaws.

Figure 3: Mobile LPR Examples

Source: Genetec

Mobile LPR can be used to enforce time restricted parking, as the software time-stamps every image. The software can also be programmed to identify license plates that have moved, but are still parked on a particular street or zone (to circumvent time limit or chalk enforcement). This is far more efficient than manual chalking, and the photographic images reduce the appeals process due to the hard evidence (the photo). Eliminating manual chalking can also reduce staff injuries and worker's compensation claims.

Another benefit of LPR enforcement is the ability to use license plates as employee permits, residential, business or monthly permits. This not only eliminates the need for paper, hang tag or decal permits, since the motorist already has the license plate; it also makes enforcement extremely efficient. Registration is typically done online and can be fulfilled on a 24/7 basis. Permit holders can enter their own data, saving office staff time. Furthermore, the license plate is a regulated credential, providing a higher level of integrity and less opportunity for misuse or fraud.

License plate permitting significantly reduces the possibility of counterfeit permits or real permits being distributed, loaned or sold to unauthorized users. The permit software allows individuals to register more than one vehicle (for owners with multiple cars), while enforcement can restrict usage to one or more vehicles at a time. Permit parking can also be restricted to particular days, timeframes and even locations. The LPR system includes global positioning system (GPS) monitoring to enable the software program to identify and segregate parking zones.

At a driving speed of 15 miles per hour, mobile LPR is far more efficient than patrolling of foot, as the average foot patrol speed is two miles per hour; however, occasionally vehicles get stuck in traffic, need to stop at traffic lights, and need to park to verify license plate images and issue citations.

Another benefit of mobile LPR enforcement is the potential for 'post-processing' parking citations. Rather than placing citations on vehicle windshields, system software integrates with state motor vehicle registries to ascertain mailing addresses associated with vehicle license plates, and citations are sent via U.S. mail. The ability to mail citations rather than place them on vehicles is remarkably efficient, as the officer doesn't need to stop or get out of the enforcement vehicle. This is also safer for staff and for the public, as it reduces the possibility of a negative exchange or altercation resulting from the issuance of the citation.

A mobile LPR system will cost approximately $50,000 per vehicle (excluding the vehicle) and will have recurring subscription software costs that will contribute to the enforcement district operating expenses.

Summary of Additional Parking Enforcement Expenses

The projected cost of the additional parking enforcement expenses is summarized in Table 6. The cost of vehicles, vehicle-mounted LPR units, and enforcement handhelds are assumed to be provided under a condition of the professional parking enforcement operator agreement and therefore are only expected during the first year of the operation.

Table 6: Projected Parking Enforcement Expenses

	Unit Price	Units	Total Cost
Enforcement Vehicles (14)	$30,000	14	$420,000
Mobile LPR Units (14)	$50,000	14	$700,000
Enforcement Handhelds	$5,000	17	$85,000
Recurring Costs*	$50,000	Annual Cost	$50,000 per year

*Recurring costs include software, subscription, and administrative costs. It is assumed that these costs are subject to inflation.

Source: Walker Consultants, 2020.

Feasibility Analysis Results

A summary of the projected costs compared to the anticipated citation revenue for a five-year contract with a third-party operator (with three extension years) is included in Table 7.

Walker recommends that the County enter into a minimum five-year contract with a professional parking enforcement firm with three, one-year extension options. The parking enforcement staffing and recurring expenses are expected to increase year over year for the life of the contract. Walker assumes a 1.7 percent annual inflation rate for the life of the contract, consistent with average Consumer Price Index (CPI).

Table 7. Walker projects first-year expenses will be the highest with the purchase of the vehicles and LPR equipment. However, a net operating surplus is projected for the life of the contract.

Table 7: Projected Parking Enforcement Expenses

Position Type	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
Staffing*	$1,839,776	$1,871,052	$1,902,860	$1,935,209	$1,968,107	$2,001,565	$2,035,592	$2,070,197
Vehicles	$420,000	$0	$0	$0	$0	$0	$0	$0
LPR Equipment	$785,000	$0	$0	$0	$0	$0	$0	$0
Recurring Costs**	$50,000	$50,850	$51,714	$52,594	$53,488	$54,397	$55,322	$56,262
Total Expenses	$3,094,776	$1,921,902	$1,954,575	$1,987,802	$2,021,595	$2,055,962	$2,090,913	$2,126,459
Projected Citation Revenue	$3,203,285	$3,203,285	$3,203,285	$3,203,285	$3,203,285	$3,203,285	$3,203,285	$3,203,285
Net Revenue for Improvements	**$108,509**	**$1,281,383**	**$1,248,710**	**$1,215,483**	**$1,181,690**	**$1,147,323**	**$1,112,372**	**$1,076,826**

* It is assumed that labor costs will be subject to a 1.7 percent inflation rate.

**Recurring costs include yearly software and subscription costs. It is also assumed these costs are subject to a 1.7 percent inflation rate.

Source: Walker Consultants, 2020.

Feasibility Analysis Disclaimer

The costs included in this section are rough order of magnitude costs based on high-level projection of typical parking enforcement operation recommendations. These costs were developed based on Walker's experience with parking enforcement operations in other communities in Southern California. Because Walker Consultants does not control the cost of labor, materials, equipment or services furnished by others, methods of determining prices, or competitive bidding or market conditions, any opinions rendered as to costs are made on the basis of our experience and represent our judgement as experienced and qualified professionals, familiar with the industry. Walker cannot and does not guarantee that proposals, bids, or actual costs will not vary from its opinions of cost.

The citation revenue projected is based on past citation revenue collected and reported for unincorporated East LA and assumes that citation revenue will remain constant over the eight-year maximum term of the contract, unless fine amounts are adjusted.

Integration with Conduent Software

It is recommended that the professional parking operator would utilize the citation software that the County is already using, Conduent. A separate account with a separate access portal would be provided for unincorporated East LA. The parking enforcement operator would have primary access to the East LA system in order to manage the enforcement operation.

Adjudication Process

The adjudication process is also assumed to be conducted by the operator through the citation software. However, due to State of California legislation, it is likely the adjudication process could not be outsourced completely, as the County would still need to have a role. With the use of LPR camera enforcement as visual evidence, much of the adjudication process will potentially be minimized or supported with use of photographic evidence. Walker recommends that a first-level review of each contested citation be conducted by the operator with a level-two adjudication step forwarded to the County if the appellant is not satisfied with the first-level decision.[1]

County Code Changes to a Establish a Parking Enforcement District

Walker reviewed the County of Los Angeles Code of Ordinances and did not see any language related to the establishment of parking enforcement districts. Since the language is not currently in place to establish a parking enforcement district, it is anticipated that changes to the LA County Code of Ordinances would be required to establish a new parking enforcement district for unincorporated East LA. LA County should work with their legal counsel to identify specific changes necessary to the LA County Code of Ordinances to allow for a parking enforcement district.

Potential Impacts of a Parking Enforcement District

With the implementation of a parking enforcement district in East LA, with increasing enforcement, there would be impacts on area residents and businesses.

Establishing a parking enforcement district, separate from the parking enforcement detail of the Sheriff's Department, suggests an opportunity for greater enforcement coverage in unincorporated East LA. Parking enforcement staff will help to mitigate inappropriate use of on-street parking including long-term and inoperable vehicle storage, curbside vending, and spillover from unauthorized commercial business activity.. Residents, business employees, and business customers are more likely to find available parking near their destination.

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[1] The assumed adjudication process is based on Walker experience with other public agencies around the country. LA County should consult their legal counsel to confirm any established process meets state and local laws.

Increased parking enforcement that focuses on a primarily punitive system may discourage residents and visitors from parking in East LA. For this reason, the parking enforcement program should have customer service focused KPIs, such as the number of citations issued versus the number of citations appealed, rather than revenue performance thresholds.

This addendum addresses questions that the County of Los Angeles had regarding the draft deliverable Task 5: Parking Enforcement District Feasibility Analysis. Specifically, the County had the following questions/requests:

- Examples of other cities in Southern California that have outsourced parking enforcement operations and the department/division responsible for overseeing the professional parking enforcement firm.
  - An overview of the minimum Parking Control Officer (or similar) position requirements of the professional parking enforcement firm as compared to the minimum requirements of LA County Sheriff's Parking Enforcement Detail.
  - An overview of the employee training required for a newly hired Parking Control Officer (or similar).
- In Task 5, Walker recommended that if the County chooses to outsource parking operations in unincorporated East LA, the Sheriff's Department should oversee the contract. The County has requested that Walker evaluate an alternative department that could oversee the contract.

Comparable Research

Walker researched municipalities in Southern California that outsource all or a portion of parking operations to a professional parking enforcement firm, as summarized in Table 1.

Table 1: Example of Southern California Municipalities that Outsource Parking Enforcement Operations

City	City Department/Division Responsible for Parking Enforcement	Professional Parking Enforcement Firm
City of Glendale	Police Department/Parking Enforcement Team (Public Works Department/Parking Services oversees the third-party contract)	SP+ Municipal Services
City of Santa Clarita	Community Development Department/Community Preservation Division	Ace Parking Management
City of Inglewood	Police Department/Patrol Bureau	Serco
City of Pasadena	Department of Transportation/Parking Services	Inter-Con Security Systems
City of West Hollywood	Public Works/Parking Services	Serco

Source: Walker Consultants, 2021.

City of Glendale

The Glendale Police Department Traffic Bureau oversees the parking enforcement unit which is responsible for issuing parking citations. The goal of the parking enforcement unit is "to efficiently respond to calls for service, and effectively enforce parking laws and regulations that provide for the safe and efficient flow of traffic and parking for our residents and visitors." The Parking Services Division, located within the Public Works Department, manages the City's parking assets, which encompasses the oversight and management of metered and time-restricted parking spaces, residential parking permit program, the City's public parking structures, on and off-street parking spaces, and valet operations city-wide. Parking Services operates in conjunction with the Glendale Police Department Parking Enforcement Unit for many parking enforcement functions including parking citation processing, budget operations, customer service request, and operational support.

Walker Consultants conducted an organizational review for the City in 2016 and found three primary obstacles for the parking operation:

- Parking Enforcement actual time spent enforcing impacted by other police duties.
- Legacy dedicated enforcement technology with limited usability.
- Bifurcated organization structure prioritized police services over parking enforcement.

In response to these issues, the City conducted a restructuring effort for the enforcement program. The City Council approved new positions within the Glendale Police Department and Public Works Department, including the Parking Services Supervisor, Police Services Officers, and Police Services Supervisor/Parking. The existing Parking Enforcement personnel were retained by the Police Department to perform 100% of their time in areas that include minor collision reporting, data collection, school area enforcement, routine investigation and reports.

In 2018, the City released an RFP for citywide parking enforcement services and entered into a five-year contract with professional parking enforcement firm SP+, with a five-year optional contract extension. As part of the contract, SP+ provided up to 16 full-time Parking Enforcement Officers and management staff, as well as new hybrid or electric vehicles, and license plate recognition (LPR) equipment. The City's Parking Services Supervisor, who is in the Department of Public Works Parking Services Division, is tasked with the management and oversight of the parking enforcement services contract. In addition to the Parking Enforcement Officers provided through SP+, the Police Department retained approximately 10 Parking Enforcement Officers who work alongside SP+ staff.

Minimum Position Requirements

The following position requirements are listed for an Enforcement Officer with SP+ for the City of Glendale:[1]

- Knowledge of geography of the area they are enforcing.
- Knowledge of hazards and safety precautions.
- Ability to use a handheld computer.
- Ability to operate a motorized vehicle or bicycle.
- Ability to understand and apply parking regulations.
- Ability to interact with others in a courteous and tactful manner.
- Ability to walk for extended periods of time.
- Ability to work in all weather conditions.
- Must be 18 years of age or older at time of hire.
- The individual will be required to have and maintain a valid state-issued driver's license with a current address and acceptable driving record.

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[1] SP+ website. https://tinyurl.com/y64d4qwf

Training Requirements

SP+ has pre-screening and training requirements for their employees. The pre-screening requirements include a background and drug checks. Once employees are hired, there is also both online and in-person customer service training and employee development. A detailed description of the SP+ training program, as written in their RFP response proposal, is provided as an Attachment 1 to this Addendum.

City of Santa Clarita

In the City of Santa Clarita, parking enforcement responsibilities are provided in the Community Development Department's Community Preservation Division, which encompasses five functions, including Code Enforcement, Housing, Graffiti Removal, Animal Care and Control, and Parking Enforcement. The Community Preservation Division has the following mission:[2]

- Maintain and preserve the integrity of Santa Clarita neighborhoods.
- Encourage residents to preserve the appearance and value of neighborhoods in the City while promoting public safety.
- Develop successful relationships with residents and businesses to instill pride and continue to improve the quality of life in the community.
- Ensure compliance with State and City of Santa Clarita municipal codes and regulations while providing excellent service to residents and businesses.

Prior to 2010, parking enforcement was provided by the Los Angeles County Sheriff's Department. In 2010, the City contracted with a third-party, Data Ticket, Inc to provide parking enforcement and citation processing services. In 2018, the City issued an RFP for parking enforcement and traffic control service. The contract includes two Parking Enforcement Officers on duty 24 hours per day, 7 days per week and one g40-hour per week Field Supervisor Monday through Friday. The RFP requested that the proposer provide parking enforcement vehicles equipped with License Plate Recognition (LPR) equipment. Ace Parking Management was selected to provide parking enforcement and traffic control services. The City recommended that Data Ticket retain citation processing services.

Minimum Parking Enforcement Officer Position Requirements

The following position requirements are listed for Parking Enforcement Officers with Ace Parking Management for the City of Santa Clarita:[3]

- An outgoing and enthusiastic personality.
- The ability to navigate the city efficiently.
- A willingness to do whatever it takes to earn a "Thank You."
- Great customer service and communication skills.
- An ability to work flexible shifts/hours, including days, evenings, weekends, and holidays.
- Must be able to stand and walk for extended periods of time.

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[2] https://www.santa-clarita.com/city-hall/departments/community-development/community-preservation

[3] Indeed.com https://tinyurl.com/y43hlmmb

- Must possess a valid driver's license.

Training Requirements

Ace Parking Management provides each of their Parking Enforcement Officers with training before starting their position. For a minimum of five days, a certified trainer walks the new employee through their daily roles and responsibilities. The enforcement officer is made familiar with their work environment and taught the various policies and procedures of their job. In addition, a special safety training, driver training, and radio training are conducted for enforcement officers. Ace Parking also has a series of training programs that continue throughout the employee's time on the job. A detailed description of the Ace Management training program, as written in their RFP response proposal, is provided as an Attachment 2 to this Addendum.

City of Pasadena

The City's Parking Services Division, housed in the Department of Transportation, has primary responsibility for the administration of the City's parking enforcement program. The Department of Transportation's Mission Statement is "The Department of Transportation is committed to achieving the safe and sustainable movement of people and goods within Pasadena, while concurrently ensuring a balance between land use and transportation to maintain a livable community in which cars are not necessary to travel within the City."

The City has 320 miles of streets with an estimated 1,250 metered (multi-space and electronic single-head meters) and 13,000 non-metered spaces on-street. The City also owns four surface parking lots and nine parking garages with over 7,000 parking spaces. Additionally, there are ten Preferential Parking Districts, which restrict residential and/or commercial parking, and overnight parking is prohibited in most of the City without a valid permit.

The City's Parking Enforcement Program consists of three full-time and four-part-time Parking Enforcement Representatives, one Senior Parking Enforcement Representative and a Parking Services Supervisor employed by the City's Department of Transportation. Given the large area of coverage, the program is supplemented with contract personnel who provide parking patrol and related services during peak hours of operation when City staff is unavailable due to scheduling constraints.

Since 2015, the City has contracted with Inter-Con Security to provide the supplemental parking enforcement coverage. The contractor provides citywide enforcement services, and well as equipment to support parking enforcement, including six electric patrol vehicles, six license plate recognition units, one pickup truck for equipment transport, eight patrol bikes, and the uniforms and day to day equipment for the officers. The City provides radios and handheld citation issuance equipment. The Department of Transportation oversees the contract with Serco.

Minimum Position Requirements

The following position requirements are listed for Parking Enforcement Officers with Inter-Con Security for the City of Pasadena:[4]

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[4] Glassdoor https://tinyurl.com/y46uoxme

Qualifications:

- Be physically and mentally capable of performing all job-related duties.
- Have the ability to understand, speak, read and write in English.
- Have the ability to follow and give oral and written instructions in English.
- Be able to legally, safely and properly operate necessary equipment and tools.
- Be able to drive vehicles with manual and automatic transmissions.
- Have the ability to establish and maintain cordial and effective working relationships with the public and city staff.
- Have the ability to remain calm and use good judgement and initiate in a confrontational or emergency situation.

Requirements:

- Be at least 18 years of age or older.
- Have the legal right to work in the United States of America.
- Passing a developed reference check, drug screening test and medical examination to determine fitness to perform assigned duties.
- Must be able to legally, safely, and properly operate necessary computer databases, equipment, and tools.
- Ability to speak, read and write in the English language and be able to write intelligible reports.
- High school diploma or GED.
- Experience in daytime parking enforcement.
- Valid California Driver's License.
- Possession of valid permits, licenses, and certifications required for the performance of job-related duties.
- Have the ability to walk for several hours or distances.
- Be able to operate motor vehicles.

City of Inglewood

The City of Inglewood Police Department's Patrol Bureau, Parking and Traffic Department provides parking enforcement services for the City of Inglewood. The Parking Enforcement Unit is supervised by two Supervisors, who are City staff, and enforcement is outsourced to professional parking enforcement firm Serco who deploys the Parking Enforcement Officers.

In 2014, the City entered into a ten-year contract with Serco to provide parking enforcement, management of parking meter operations and traffic control operations. Serco provides daily parking enforcement, traffic control, dispatch, customer service, and enforcement using license plate recognition technology, and operations and maintenance of the City's ±1,900 parking meters. The Police Department oversees the contract with Serco.

After the City entered into an agreement with Serco Inc, the City held a job fair at City hall to fill the parking enforcement positions to be provided by Serco. Internal staff impacted by the change were given first priority to apply for the positions. The City also recruited at community locations to encourage Inglewood residents to apply. Approximately 30 full time and 30 part time staff positions were filled.[5]

City of West Hollywood

City of West Hollywood parking enforcement is a function within the Public Works Department's Parking Services Division. The Parking Services Division is responsible for City's public parking facilities, parking enforcement, parking permits, parking meters, bike racks, bike share, and special event parking.

For the past several years, the City of West Hollywood has engaged professional parking enforcement firm, Serco to perform parking enforcement and traffic control services. The parking enforcement operation includes a mobile license plate recognition (LPR) system and electric vehicles for enforcement. There is a total of 36 Serco staff that provide parking enforcement and traffic control services for the City of West Hollywood.

Minimum Position Requirements

The following position requirements are listed for Parking Enforcement Officers with Serco for the City of West Hollywood:[6]

- High School Graduate or equivalent.
- Must have at least two years of work experience in a related field and/or customer service.
- Ability to learn, comprehend, and retain knowledge of policies and guidelines related to the California Vehicle Code and West Hollywood Municipal Code.
- Must be computer literate to enter data accurately into handheld device.
- Excellent written and verbal communication skills.
- Must be able to report to work on-time for assigned shifts.
- Good sense of direction. Experience operating a company vehicle a plus.
- Candidate must be able to walk for long periods of time in a variety of weather conditions and be able to enter and exit out of a vehicle frequently.
- Flexibility in schedule to work holidays if scheduled and for mandatory special events including but not limited to LA Marathon (March), LA Pride (June) and Halloween (October).
- This position is contingent upon ability to pass a preemployment criminal history check and drug screen.

Additional desired experience and skills:

- Traffic control experience.
- Knowledge of radio calls (10-codes and NATO alphabet).
- Familiarity with City of West Hollywood streets and boundaries.
- Experience in conflict de-escalation and resolution.

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[5] http://v1.cityofinglewood.org/news/displaynews.asp?NewsID=2126&TargetID=1
[6] Indeed.com https://tinyurl.com/y6gfj7lg

Training Requirements

Training for Parking Enforcement Officers is conducted at the professional parking operator's expense. Training is required in basic industry requirements, such as conflict resolution, customer service and safety, annually. New hires and rehires must be training on contract specific items, such as enforcement equipment, West Hollywood Municipal Code, California Vehicle Code, City boundaries, driving etiquette, and other tools for success. Staff members are expected to be re-certified once a year via an online training module, demonstrating core competencies. A detailed description of the West Hollywood enforcement training requirements, as provided in the agreement between Serco and the City, is provided as Attachment 3 to this Addendum.

Minimum Position Requirement Review

By comparison, Parking Control Officers for the County of Los Angeles have the following requirements:

- Six months of experience in the public or private sector involving contact with the public, customer relations, or service to the community.
- A valid Class C Driver's License

The West Hollywood Parking Enforcement Officers provided through Serco must have a minimum of two years of experience in a related field or in customer service, which is 18 months more than the County of Los Angeles experience requirement. Pasadena Parking Enforcement Officers hired by Inter-Con Security Systems require daytime parking enforcement experience but does not specify a minimum length of time. Santa Clarita Parking Enforcement Officers hired by Ace Parking Management and Glendale Parking Enforcement Officers do not have a minimum experience requirement.

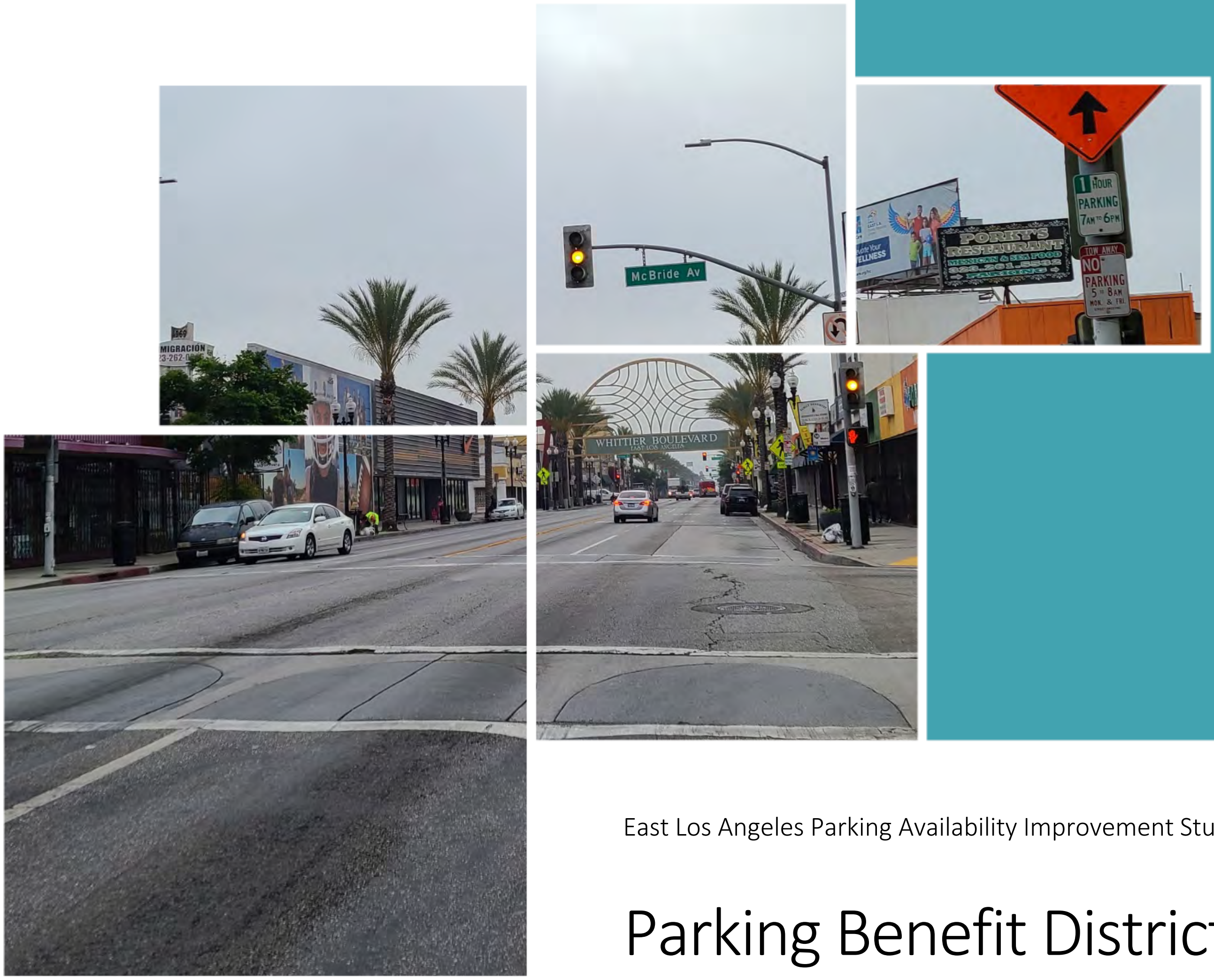
Glendale, Santa Clarita, Pasadena, West Hollywood, and LA County Parking Enforcement Officers must have a valid driver's license. The County of Los Angeles specifies the requirement of a Class C Driver's License.

Pasadena and West Hollywood Parking Enforcement Officers are required to have a High School Diploma or GED. A High School Diploma or GED are not listed as a requirement for Glendale, Santa Clarita, or County of Los Angeles Parking Enforcement Officers.

Recommendation

The County of Los Angeles is evaluating the considerations for outsourcing parking enforcement services in unincorporated East LA to a professional parking enforcement firm. If the County chooses to outsource parking enforcement services in unincorporated East LA, County staff would be required to oversee the third-party contract. In the Task 5 deliverable, Walker recommended that the Sheriff's Department oversee the contract with the professional parking enforcement firm.

Alternatively, we would recommend that Public Works would be a suitable option to oversee the contract. Public Works has functions that complement parking enforcement such as parking signage, maintenance of parking facilities, oversight of meter coin collection, and roadway maintenance. It is anticipated that a full-time equivalent staff member would handle the daily oversight of the contract operator and would be required to provide education and training of the LA County Code requirements. LA County has an existing Contract Monitor class title, Class Code 4227. Walker recommends that this position be modified to include oversight of the professional parking enforcement firm contract. Public Works would need to assess funding, personnel, and the department’s operational needs and determine where in the organization the contractor monitor would belong.



East Los Angeles Parking Availability Improvement Study

Parking Benefit District Feasibility

County of Los Angeles, CA

September 24, 2021

Prepared for:
Chief Executive Office Budget and Operations
Community Services

WALKER
CONSULTANTS

Contents

Exhibits

Introduction

Parking benefit districts (PBDs) are geographically defined areas, typically commercial areas in which the parking supply and revenue it may generate are focused on managing parking supply and demand to ensure that the parking serves the district. Parking revenue generated locally stays local. It is returned to the district to pay for neighborhood improvements that are prioritized by local stakeholders. Revenues may fund improvements such as operational or capital improvements to the parking supply, sidewalk cleaning, installing of planters or street trees, bike and pedestrian improvements, and store front beautification projects, among others.

A focus of PBDs is therefore to return revenues to the local community such that it can maintain an attractive and thriving commercial district, the broader goal of an effective parking system. As a result, business owners and residents of the nearby district may be more supportive of paid parking as well, when they see the possibilities of local benefits. The appeal of PBDs over simply installing parking meters is that PBDs ensure that some parking revenue generated locally remains within the district.

Given that one of the main concerns in the unincorporated community of East Los Angeles (East LA) is low turnover of parked vehicles, resulting in a lack of availability of on-street spaces along commercial corridors as shown in the current conditions section, the implementation of a PBD along an East LA corridor is an effort to improve on-street parking availability by encouraging turnover of short-term spaces. This section explores the feasibility of establishing a PBD along a commercial corridor in East LA including potential benefits and adverse consequences to local businesses and residents.

The PBD presented henceforth is assumed to operate under the following assumptions:

- Enforcement issues, as identified in Task 3, have been addressed and the enforcement program is operating as efficiently as it can to maintain acceptable parking conditions on the street.
- A preferential parking district policy has been developed and is working adequately. Restrictions are in place and enforced to a reasonable degree to limit parking spillover into adjacent residential areas.
- An entity is in place, whether a third party or within the County, that can administer and manage or oversee the PBD.

PBDs are not a panacea for all of the parking issues experienced in the community, but rather they can be an effective tool to help manage parking in a way that supports local commerce by retaining revenue within the community.

Executive Summary

Overview of Findings

The analysis of the feasibility of implementing a parking benefit district (PBD) in East LA demonstrated a potential for realizing a solvent PBD. Many of the key elements are in place already, but success will largely depend on whether enforcement services can support the district, whether there is buy-in from businesses and residents, and whether the County can identify how it can support its creation and maintain some oversight.

The following details a listing of our findings of the feasibility analysis of implementing a PBD in unincorporated East Los Angeles.

Whittier Boulevard PBD Based upon the results of the current conditions analysis, Whittier Boulevard east of the I-710 stands out as a leading candidate for a parking benefit district (PBD). Perhaps the most important criterion for determining the implementation of paid parking is high parking demand. Whittier Boulevard, from Burger Avenue to Woods Avenue was observed to have a 99 percent peak occupancy, the highest of the commercial corridors observed. Moreover, Whittier Boulevard has had parking meters in the past, and it has organized groups of business owners, merchants, and property owners that can steer the mission and operation of the prospective PBD. Still, it must be noted that many other commercial corridors in unincorporated East Los Angeles can arguably establish PBDs, such as 1st Street which is the only area in unincorporated East Los Angeles that already has parking meters in operation (150 total). However, all things considered, Whittier Boulevard serves as an appropriate location for a PBD.

Multi-Space Meters (MSM) In evaluating the parking meter options that are available, Walker recommends that for the Whittier Boulevard PBD the County opt for multi-space meters (MSMs). While the single-space meters (SSMs) will be familiar to unincorporated East Los Angeles residents and visitors already, given their presence along 1st Street, when all factors are considered MSMs offer specific benefits that SSMs do not. Among them are:

- More programmable options such as: pay-by-license plate, pay-by-space, pay-and-display, and pay-by-cell.
- Ability to include various payment options like cash (coins), credit cards, tokens, and mobile applications.
- With the option of pay-by-license plate, enforcement could be more efficient, which has been a particular concern of the community.
- Less pay stations than SSMs. This means less clutter on the street and more space for pedestrians or other public improvements like trees, benches, bike racks, etc. It also means less meters to remove should they need to be removed in the future.
- The future of on-street parking is moving toward mobile payments. MSMs facilitate that integration of mobile as they can already be programmed to accept mobile payment applications, and users become more accustomed to the idea of not having to pay at a meter directly in front of their vehicle.
- Ultimately, MSMs are more cost-effective than SMSs.

Financial Feasibility of a Whittier Boulevard PBD Assuming that enforcement is operating as efficiently as it can, that the level of business activities and commercial leasing along the corridor remains healthy, that there is 'buy-in' from the community and political support for paid parking, a potential Whittier Boulevard PBD can be financially feasible. Under a multi-space meter solution, with a parking rate of $1.00 per hour, operating Monday-Sunday from 8:00am to 9:00pm, we project a potential $1,600± of gross revenue annually per metered on-street space. If 333 spaces are metered, we project the potential for annual gross revenue of $535,000±, and annual net revenue for the PBD at $485,000±.[1]

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[1] All revenue projections contained in this and other Walker deliverables related to this engagement are for planning purposes only and not to be used in financing documents or otherwise by third parties.

Benefits and Potential Challenges of Implementing a PBD The potential impacts of the parking benefit district (PBD) proposed along Whittier Boulevard include the following.

For Businesses:

Benefits

- A new source of revenue by way of paid parking to pay for improvements along the Whittier Boulevard commercial corridor.
- The revenue generated within the district would be returned to the district.
- Local control over revenue, spending priorities, and parking policies.
- Increased on-street parking availability along the corridor, effectively allowing for more customer parking.
- Public improvement projects as a result of new revenue source.
- More efficient enforcement if using a mounted license plate recognition system.

Potential Challenges

- Parking for employees and business owners who drive would need to find parking that is not on-street along Whittier Boulevard, or on nearby residential streets. Parking for customers must always be the most convenient and the priority.
- There may be a customer learning period as they get accustomed to paid parking at a multi-space meter. However, paid parking should be implemented when the frustration of not finding convenient parking is exceeds a driver's willingness to pay a small amount for the availability of a conveniently located parking space.
- Best practice dictates that short-term spaces be available to customers, and so catering trucks and vendors should not occupy these spaces. However, the County, Whittier Boulevard businesses, and catering truck and street vending businesses can meet and confer regarding options that are agreeable to all parties.

For Visitors:

Benefits

- Increased availability of on-street parking.
- Convenience of payment for parking (e.g., credit card, mobile, coin)
- A more attractive commercial corridor if revenues are spent on amenities that benefit the public.

Potential Challenges

- No longer free on-street parking.
- May be a learning curve for customers to use some payment technologies.
  The speed at which vehicles travel along Whittier Boulevard may be less than conducive to frequent turnover of customer spaces. Slower speeds could facilitate the attractiveness of coming to Whittier Boulevard.

For Residents:

Benefits

- Economically healthier and improved commercial corridors for shopping.

- Increased enforcement tours through commercial corridor and neighborhoods.
- Increased availability of on-street parking along Whittier.
- Protection from long-term parkers that are not residents of the neighborhood, with accompanying implementation of a residential parking permit district.

Potential Challenges

- No longer free parking environment.
    - Paid parking implemented along Whittier Boulevard.
    - Permit parking implemented in the residential areas surrounding Whittier Boulevard.
- Because paid parking will be in place on Whittier, there is the potential from spillover onto residential streets from customers who do not want to pay for parking. However, there are two ways in which to mitigate this impact. The first is by implementing a two-hour time limit on all residential streets immediately surrounding Whittier Boulevard. This ensures that customers do not stay parked long-term. The second is the availability of off-street district parking to serve as an additional choice for customers. We note however that, at a 99% parking occupancy rate, some spillover must already be occurring in residential areas. The goal of paid parking is to provide the most convenient parking to the customer, not the employees or business owners.

Preferential Parking District (PPD) To better manage on-street parking demand, Walker recommends the implementation of a PPD program in the Whittier Blvd East zone. The PPD should be in place in the residential areas only not the commercial areas along Whittier Blvd, generally from Burger Avenue to Atlantic Boulevard, and Hubbard Street to Verona Street. Walker recommends that there be no more than three parking permits allowed for each household. The permit rates should be graduated so that the price of the second and third permit is higher than the price of the first permit. Walker recommends that the County provide an income assistance program for those in need of a permit, but cannot afford one, such as households with incomes below the poverty line. The assistance could come in the form of a credit as well; households could accept a subsidized permit or the cash equivalent.

Setup/Implementation of PBD In order to implement a high performing parking district, we offer the following considerations for implementation.

- Gather stakeholder buy-in.
    - The most important buy-in needs to come from the merchants and business groups that are located within the proposed district. Once businesses are onboard political support will follow more easily.
- Develop a mission statement and plan.
    - Effective parking districts today use comprehensive management and financial policies to address clearly stated objectives in the service of a broader mission.
- Identify or create a committee or board to oversee the PBD.
    - An important feature of the district will be the identification of the group to oversee the PBD revenue, spending priorities, and parking policies. In unincorporated East Los Angeles, there are numerous business stakeholders and merchants, such as the Whittier Boulevard Merchants Association and the East Los Angeles Chamber of Commerce. One approach the County can take is to create a commission composed of local business stakeholders and County liaisons.
- Draft enabling code language.

  - The County of Los Angeles Municipal Code currently allows for preferential parking districts (PPD), but there is no mention of parking benefit districts or zones. As such, the County would need to draft code language enabling the creation of such districts.
- Develop a list of objectives for the PBD.
  - The parking district needs to have a defined set of objectives that have been vetted by and are available to the public.
- Key Performance Indicators
  - To measure the performance of the PBD, a set of key performance indicators (KPIs) should be developed. The KPIs should be designed to measure performance in meeting the objectives of the PBD. These may include setting and measuring occupancy targets, methods of payment, and total and net revenues to determine the solvency of the district.
- First class parking operation
  - To serve the parking district's constituents and to meet overall Parking Management Mission, the operation of the parking in the district needs to be handled in a first-class manner. This includes addressing maintenance, upkeep, safety, security, signage, technology, and enforcement. Parking enforcement acting as ambassadors can facilitate this.
- Marketing Plan
  - Strong public relations are imperative to the successful implementation of paid parking; therefore, Walker recommends considering a robust stakeholder outreach effort to introduce the new meter program.

01 Parking Benefit District Location

Parking Benefit District

The purpose of a parking benefit district (PBD) is to enhance the district by effectively managing and thereby ensuring parking availability to enhance customer access and convenience to the businesses. But managing parking in a busy location has a beneficial byproduct. It generates revenue which typically goes to a general fund rather than being applied where it is generated. A Parking Benefit District however returns the revenue generated from paid parking to the neighborhood where it was generated, to further enhance the district beyond the parking availability. The improvements can be parking, pedestrian, aesthetics, cleaning, or other improvements that stakeholders or the PBD governing body prioritizes. Given this criterion, a PBD can generally be created anywhere that generates parking revenue. However, merely placing parking meters in a district does not guarantee that sufficient revenue will be generated to pay for improvements, let alone pay for the parking meters, their operation, and their maintenance. As such this report will explore a potential program that evaluates the financial feasibility of establishing a PBD within unincorporated East Los Angeles.

Successful Parking Benefit District Example

PBDs have been implemented successfully, one of the most notable examples being here in the Los Angeles area. The following section discusses how Pasadena implemented its PBD, why it was successful, and how the County may emulate this success in unincorporated East Los Angeles.

Old Pasadena

Perhaps the most recognized example of a successful parking benefit district (PBD) is that of Old Pasadena. Much like Whittier Boulevard in unincorporated East Los Angeles, Pasadena’s original downtown is characterized by historic buildings with little to no off-street parking. Old Pasadena was struggling as a commercial district through the 1980s, with high commercial vacancies, unkempt and deteriorating buildings, and crime. Furthermore, the low supply of off-street parking, combined with the free parking on-street, resulted in high on-street parking demand and little turnover. Thus, limiting the parking opportunities for customers to patronize businesses.

To reinvigorate the area, the City of Pasadena made two significant changes to its parking policy. First, implementation of paid parking with the promise that all parking meter revenue generated within Old Pasadena would be returned to the neighborhood. Second, creation of a policy that would allow businesses in Old Pasadena to satisfy their parking requirements by paying a fee for those spaces which they did not provide. These policies brought about the changes needed to bolster the area.

The promise of returning meter revenue to the neighborhood was the feature that encouraged merchants to buy into the idea of installing parking meters in Old Pasadena. Even more, knowing that the merchants would be the ones controlling the revenue generated from the meters facilitated political support for implementing paid parking.

Once buy-in for the meters was achieved, the City advanced implementation of the meters. The boundary of the PBD was determined following discussions with the merchants and the local business improvement district (BID). The meters were finally installed in 1993 and Old Pasadena soon recovered. As paid parking increased turnover of curbed spaces, more customers were able to patronize local businesses, resulting in increased sales tax revenue for the City.

Moreover, the popularity of Old Pasadena began to increase as improvements to public spaces attracted more customers to the area. In turn, this prompted the PBD to continue investing in public improvements to maintain the areas as an attractive destination for customers.

Today, Old Pasadena remains a popular commercial district. The lessons that the County can take from Old Pasadena are:

- The lack of available curb parking may be limiting local businesses' the opportunity to capture increased patronage, because parking spaces are not turning over sufficiently.
- To obtain buy-in from local business owners to install meters, return the meter revenue to the district.
- Have a local business group manage the revenue.

East Los Angeles Parking Benefit District Location Selection Methodology

In reviewing potential areas for a parking benefit district in unincorporated East LA, Walker developed a list of criteria that informed the selection of the district location. The criteria are based on Walker's experience and research into identifying the fundamental elements of PBDs. The criteria used to select the location are:

- High demand for on-street parking (peak occupancy rate at or above 85%)
- A mix of land uses such as restaurants, retail, and office among others that peak at different times and that see high customer traffic akin to a central business district
- Proximity to a supply of public off-street parking
- A supply of privately-owned publicly available off-street parking
- The existence and ongoing presence of business stakeholder groups
- Popular destinations for visitors and customers

Based upon the analysis of the current conditions, and factoring in the aforementioned criteria, Whittier Boulevard east of the I-710 stands out as a leading candidate for a parking benefit district (PBD) and can be the location of a pilot. However, it is important to note that this does not mean that PBDs cannot be implemented elsewhere, only that Whittier is the best positioned to mitigate the potential impacts that might arise from implementing paid parking.

Still, in addition to Whittier Boulevard, another commercial area that is suitable for a PBD is 1st Street, from Indiana Avenue to Eastman Avenue. This area of 1st Street is the only area in unincorporated East Los Angeles that already has parking meters in operation (150 total); thus, creating a PBD in this area may be more acceptable than any other. However, because most of unincorporated East Los Angeles's commercial corridors currently operate under a free parking system, the subsequent analysis focuses on the feasibility of establishing a PBD in a commercial area that currently has free parking.

Parking Benefit District - Whittier Boulevard East of I-710

The takeaway from the current conditions section of this study is that available parking in unincorporated East Los Angeles is difficult to find virtually everywhere. However, when thinking about a parking benefit district (PBD), which means implementing paid parking, Whittier Boulevard appears to be the most appropriate location.

In fact, parking meters along Whittier Boulevard is not a new concept. Whittier Boulevard had parking meters in the past. Figure 1 shows a photograph of Whittier Boulevard circa 1979, which displays parking meters lining the commercial corridor.

Figure 1: Parking Meters on Whittier Boulevard, circa 1979

Source: Photographer – Anne Knudsen; Collection – Herald Examiner Collection – Los Angeles Public Library, 2020.

Of course, there were also meters on Atlantic Boulevard as well, and parking meters are still in place today along 1st Street. In analyzing the potential for a new district, Whittier Boulevard is best suited to meet the challenges that come with establishing a PBD.

High On-Street Parking Demand

The most important factor in determining the location for a PBD is whether the prospective district has a high demand for on-street parking. While any number of commercial areas in unincorporated East Los Angeles could be considered for a PBD based on this criterion, Whittier Boulevard, from Burger Avenue to Woods Avenue was observed to have a 99 percent peak occupancy, the highest of the commercial corridors observed, even during the COVID-19 pandemic.

Under current conditions, there are few, if any, open on-street parking spaces along Whittier Boulevard, and moreover they do not turn over with regularity despite time limit restrictions, thus contributing to the low availability of parking. Without high parking demand, paid parking may not generate enough revenue to be solvent. A PBD along Whittier Boulevard could help with the turnover of on-street parking spaces along the corridor, which effectively creates more availability for customers to park and patronize local businesses situated along the boulevard.

Along a commercial street like Whittier, one or two regularly open parking spaces per block face would ideally provide sufficient availability for customers and patrons to park near their destinations. The goal of introducing parking meters is to increase turnover such that the district can achieve some availability short-term of spaces.

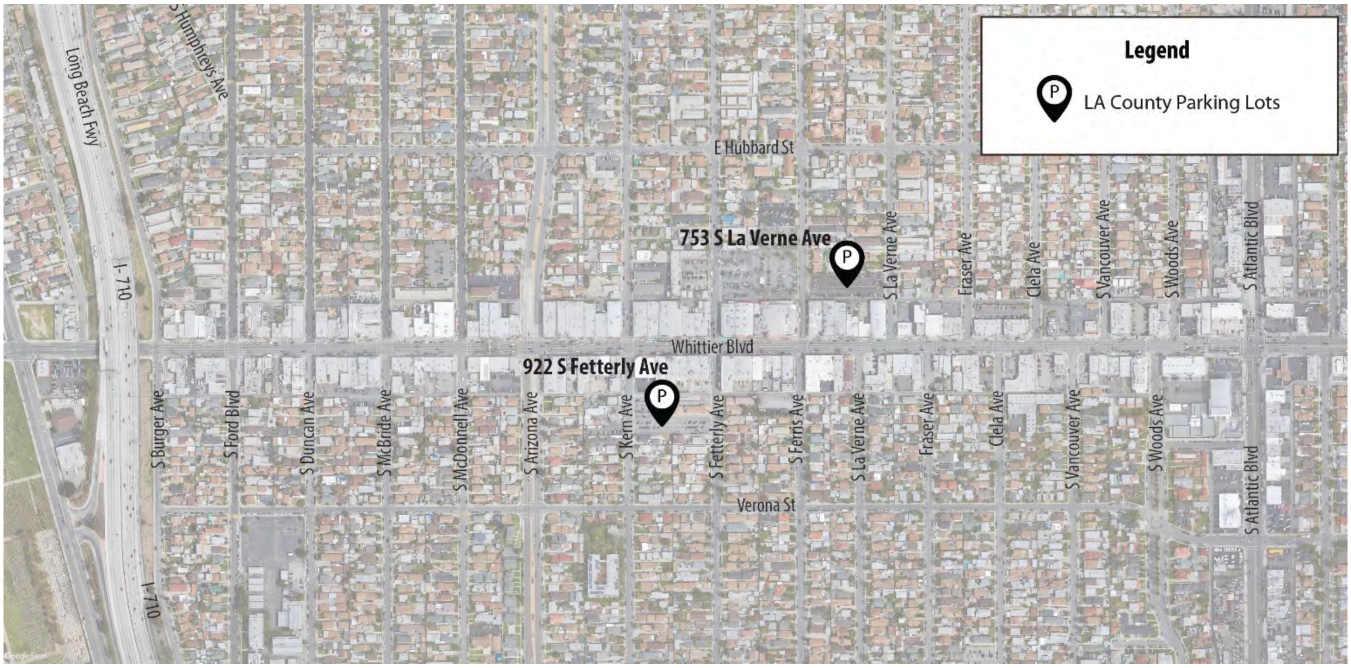
Of course, with the introduction of paid parking there is the potential that the vehicles that regularly occupy spaces on the boulevard for long periods of time, may spill over into areas that have less restrictions. As such, an important consideration for the PBD is to have a supply of off-street parking that can accommodate long-term parkers.

Off-Street Public Parking Supply

One feature that sets Whittier Boulevard apart from other commercial corridors in unincorporated East Los Angeles is that there are County-owned public parking lots located along the corridor. There are two lots that are both operated and maintained by the County located at 753 S La Verne Avenue and 922 S Fetterly Avenue. Combined, these two lots contain 195± stalls.

Figure 2 shows the location of these lots in relation to the proposed PBD corridor.

Figure 2: Public Parking Lots near Whittier Boulevard PBD



Source: Walker Consultants, 2020.

As shown in the figure above, these two lots may offer a location for long-term parkers in the district to park. For instance, from the current conditions survey, employee respondents indicated that they often park on residential streets when parking at or near their place of employment is unavailable. This is important because many of the buildings that line Whittier were built prior to zoning codes requiring that off-street parking be provided. As a result, some businesses that line the boulevard do not have their own parking and thus their employees rely on street parking. While not the only option to address the employee parking shortfall, off-street parking serves as an opportunity to carve out areas where employees may be allowed to park should capacity allow.

Off-Street Private Parking Supply

While publicly owned off-street parking falls within the purview of the County through zoning, the County has less control over the use and availability of privately-owned off-street parking. However, the presence of privately held off-street lots along Whittier Boulevard serves as an opportunity to unlock capacity for the benefit of the district as a whole. Taking a district approach to parking is important especially if benefits are going to be shared. A district approach for addressing parking issues includes looking at the private parking supply.

While an inventory of private off-street parking was not part of this study, in looking at the number of off-street parking lots that are located near Whittier Boulevard, if the County were to unlock some of that supply for use by district customers and employees (as availability allows), the PBD would be better positioned to accommodate the high demand for parking in the district.

Business Stakeholder Groups

A key feature of any parking district is the presence of an active and organized association of businesses and merchants. Typically, these are in the form of Business Improvements Districts (BIDs). In East LA there are several groups that can serve as the stewards of a PBD. One such group is the East Los Angeles Chamber of Commerce. If multiple PBDs are established in unincorporated East Los Angeles, the chamber of commerce may be best equipped to manage the benefits. However, if there is one PBD, as in the PBD along Whittier Boulevard, the Whittier Boulevard Merchants Association, composed of local merchants and business owners that are plugged into the community and have a long history of making improvements along the boulevard, may be the most appropriate entity.

In any case, whichever group is deemed most appropriate to provide community input to the County who oversee the management of parking meter-generated funds, their active role to advise on the expenditure of those funds will be key to providing improvements within the PBD.

Mix of Commercial Land Uses and Popular Destination

While there is no specific formula or mix of land uses that dictates whether a PBD will succeed or not, typically a PBD has a mix of commercial land uses that are compatible with each other, such that they all function and benefit from the parking policies and restrictions of the corridor. Most land uses on the Whittier Boulevard corridor are compatible to the short-term parking limits that are in place today and that will dictate the use of parking.

Whittier Boulevard is lined with commercial establishments that run the gamut from restaurants, retail, offices, medical services, salons/barbershops, furniture stores, and grocery stores among others. Moreover, Whittier Boulevard serves as the unofficial Central Business District (CBD) of East LA, and as such likely experiences high visitor traffic. Given its position as a focal point in the community, Whittier Boulevard's popularity lends itself to a PBD.

02 Parking Meters

Parking Meters

An analysis of the feasibility of implementing a parking benefit district (PBD) warrants a study into whether or not to install parking meters, given that the future of curb parking management appears to be moving toward mobile solutions. However, based on the community profile of unincorporated East LA, sole reliance on mobile solutions may not be the most apt solution at this time. As such, the consideration of paid parking should be based on which parking meters to install, what functionalities they should have, how many should be installed, and where, rather than mobile-only applications. This section discusses the options that are available for parking meters and the recommendation for a PBD in unincorporated East Los Angeles.

The intention of installing parking meters should not be to generate revenue for the sake of generating revenue, but rather:

1. To manage parking demand and supply within the PBD such that parking spaces are always available to customers, and
2. To improve conditions along the PBD such that customers want to visit the PBD and patronize those businesses, which in turn supports local economic development.

Parking Meter Technology

Today's customers are accustomed to convenience. As such, any parking meters considered for the PBD should reflect the conveniences that customers have come to expect.

While the concept of paying for parking at a single-space meter is ubiquitous, i.e., carry change, insert change, and return at the estimated time, the methods with which customers can now pay for parking are vastly more flexible than the traditional model, and thus offer more convenience.

Newer 'smart' parking meters have brought three key technologies to on-street parking: computers, solar power, and wireless communication. This allows customers to pay by credit card, the County to set complex rate structures, and the meters to communicate wirelessly via a central management system, providing remarkable audit control and maintenance capability.

Credit Card Acceptance

One of the major benefits of smart meters is the ability to accept credit cards. Benefits include the following:

- **Enhanced Customer Convenience**: Most motorists do not carry coins with them or keep enough coins in their vehicles to pay for parking. Most motorists do carry credit cards, enabling them to pay for parking at credit card-enabled meters.
- **Enhanced Compliance**: The added customer convenience results in a higher level of meter compliance, as most motorists will pay the parking fees when they can, but may risk receiving a ticket once they've parked but don't have enough coins to purchase the time they need.
- **Increased Revenue**: Motorists tend to purchase more time when paying with credit cards. They are no longer limited to the number of coins carried on their person or in their car. Furthermore, credit card-

accepting meters typically offer a "max" button that enables the motorist to purchase the maximum time allowed at the push of one button, rather than predicting how long they will actually be parked. Most people would rather leave unused time on the meter than risk getting a ticket for an expired meter.

- **Fewer Collections**: Credit card payments reduce the number of coins being inserted in the meter, reducing the frequency of coin collections. Conventional meter vaults hold approximately $30 in quarters, requiring the coins to be collected at least once per week and more frequently in busy areas.
- **Fewer Coins to Process**: Credit cards reduce the number of coins that need to be processed; including transporting the coins, counting and rolling the coins and depositing them into the bank. Credit card transactions typically account for 35% - 70% of all transactions, reducing coin volume by more than that percentage, as credit card transactions typically replace the higher priced coin transactions. The higher the hourly parking rate, the higher the percentage of credit card use.

A concern in unincorporated East Los Angeles may be that a significant portion of the residents do not use credit cards; however, the new meters could be equipped to take both cash and credit cards. Furthermore, the new meters would be placed in the PBD along Whittier Boulevard. The addition of credit card acceptance may be convenient to visitors of unincorporated East LA, not just residents, thus potentially resulting in a more convenient customer experience.

Complex Rate Structures and Demand-Based Pricing

Conventional parking meters, like those in place along 1st Street, have limited rate setting capabilities. Rate structures are limited to one fixed rate for one fixed time frame. Computer software programs enable smart meters (single space or multi-space) to create a variety of rate structures. Hourly rates can change from hour to hour, or by time of day, or day of week. Flat rates can also be programmed for any duration of time. Rate structures can also be changed remotely (conventional meters require a trip to each meter).

New meter technologies enable the implementation of demand-based pricing at parking meters. This is a concept that has garnered a lot of attention since Donald Shoup; Professor of Urban Planning at UCLA published "The High Cost of Free Parking" in 2004. One of Shoup's major parking policy reforms is to "set the right price for curb parking because the wrong prices produce such bad results." Shoup notes that the consequences of setting the wrong price for curb parking are traffic caused by motorists cruising for parking, air pollution as a result of vehicles cruising for parking, and wasted time.

Setting the right price for curb parking can be challenging when the technology does not easily and quickly enable price adjustments in response to changes in demand. With 'smart' meter technology however, prices can be adjusted remotely, and a demand-based pricing model can be implemented. Demand-based pricing is the concept of shifting parking demand by adjusting rates. Rates are increased when demand is so high that there are no available spaces. The intention of the rate increase is to promote turnover of parking spaces, thereby increasing availability. If there is an abundance of availability, the prices can be lowered to encourage motorists to park in low utilized areas. The right parking rate to charge is the one that will produce one to two open spaces per block. Generally, this translates to a target occupancy of 85 percent on each block.

Multi-space and single-space smart meters enable the County to implement demand-based pricing. Not only can the meters handle complex rate structures and rate changes, they also help to provide baseline data needed to determine which blocks are candidates for rate increases, and which blocks are candidates for reduced rates. The system software provides reports showing transaction details such as when motorists paid, where they paid and how much time they purchased. Once the rates are implemented, the reports will also help determine the effectiveness of the rates.

Audit Control

Conventional meters have minimal audit control. No-one knows how much money is inside them until the meters are collected. If a meter was not collected, it could go undetected. No reports are generated.

When a conventional meter vault fills, the coin slot to the vault closes, but the coin slot to the meter remains open. Coins can still be inserted into the meter, but they land on top of (or on the side of) the vault. The collector needs to pick these individual coins up by hand. If any of these coins are left, dropped, misplaced, lost, forgotten about or taken, they may not be missed. This is also the case throughout the counting process.

With the implementation of smart meters, computer software will track every payment that is made. The software tracks the date and time of all payments, how much time was purchased, and how it was paid for (coin denominations, credit card types, etc.). If any money goes missing, the auditors will know. The County will be able to see how much money is in the meter at any time by simply logging in.

Maintenance

Smart meters have self-diagnostic software that enables them to ‘report’ maintenance issues via wireless communication, enabling staff to respond immediately. Conventional meters may be out of service for days before a collector or enforcement personnel notices it and reports it.

Multi-Space vs. Single-Space Meter Technology

The ‘smart’ meter technology did not come cheaply when developed, which is why the multi-space meter was created. It wasn’t cost effective to put all of this technology into every parking space, but if one meter could cover multiple spaces, they became affordable. In the past few years, a single-space retrofit meter has become an attractive and affordable option. The computer, solar power and wireless capability have been incorporated into the single-space meter, providing most of the benefits of the multi-space meter, without requiring the customer to walk to the multi-space meter.

Following are the major differences between smart single-space meters (SSMs) and smart multi-space meters (MSMs):

- The public generally finds SSMs easier to use. SSMs are familiar and require no special instructions. MSMs require instructions; in fact, ambassadors are generally deployed to assist customers during initial rollout.
- SSMs do not require signage. Motorists see the meter and know they are expected to pay. MSMs require signage (w/arrows) advising motorists to pay at the MSM. Pay-by-space meters also require space numbers.
- SSM manufacturers charge credit card transaction fees above and beyond typical merchant processing fees – typically $0.13 per transaction. This is how they can afford to put all that technology into every meter. MSM manufacturers do not charge these fees.
- SSMs are more susceptible to vandalism and theft. MSMs are more secure and are recommended for high-risk vandalism areas.

- SSMs have smaller coin vaults and consequently need to be collected more frequently.
- MSMs, by their nature, do not allow for 'piggybacking' (parking at a meter that has time left on it from the previous parker). This can account for increased revenues of up to 10%. SSMs require sensors to zero out the meter, which also decreases battery life.
- SSMs cannot accommodate pay-by-space or mobile license plate enforcement, which are more efficient than physically inspecting every meter.

A detailed analysis of 'smart' single-space and multi-space meters follows:

Single Space Smart Meters

Single-space meter manufacturers offer a single-space 'smart' meter. The original solution was a new meter mechanism that fit into conventional meter housings, like the ones along 1st Street. The replacement mechanism fits on an existing single space meter and into the existing housing (simply remove the original dome and mechanism and replace with the new mechanism). If no meters exist, a completely new meter can be purchased.

The meter features wireless cellular communication that links each meter to a centralized management system and provides real-time credit card authorization, revenue tracking, and flexible remote rate change capabilities. The meters are solar powered and contain a rechargeable battery pack.

Figure 3: IPS Single-Space Meter

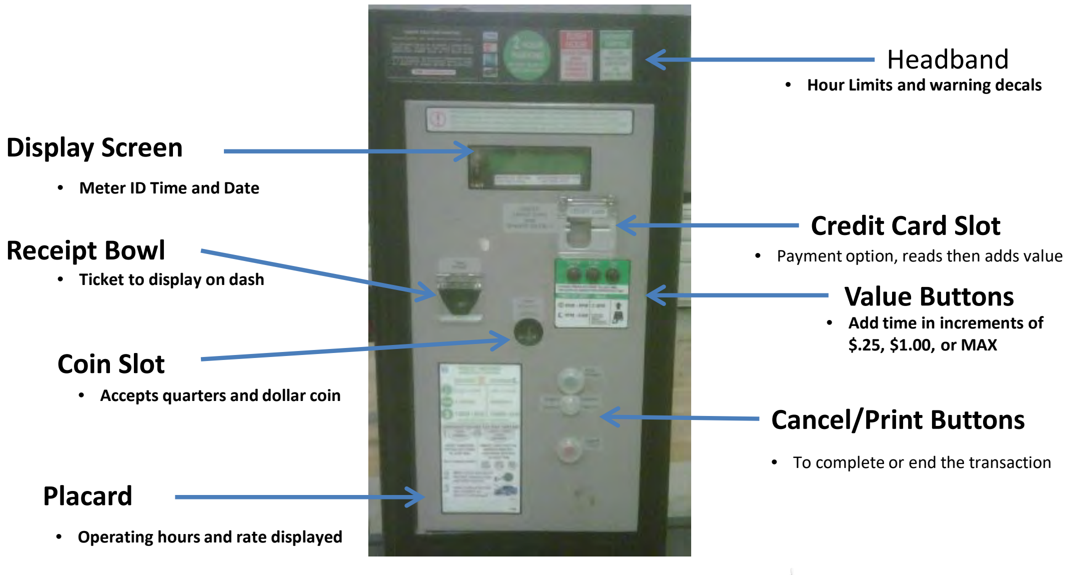
Source: utsandiego.com *Source: commlawblog.com*

Multi-Space Meters

The development of the multi-space meter (MSM) enhanced metered parking as a viable option for controlling revenue from multiple spaces with fewer devices. For on-street applications, multi-space meters usually manage eight to fifteen spaces. For surface lot or multi-level parking facility applications, one multi-space meter can manage any number of spaces, depending on the configuration and application.

Each meter is equipped with graphical and LED displays to instruct patrons; one or a combination of coin, token, banknote, credit card or smart card acceptors; a cashbox and/or bill vault to securely store money; and user interface buttons and/or a keypad. The meters are computerized, which allows for complex rate structures and strong audit and enforcement trails.

Figure 4: Multi-Space Meter Faceplate (Example)



Source: Cale

A typical installation is networked, allowing transaction and revenue data to be consolidated to a central server and viewed remotely. This allows the owner to remotely generate reports and other useful data necessary to manage the parking assets, including changing the rates and monitoring revenue.

Depending on the specific application and manufacturer, most multi-space meters can be configured for use in one of three modes of operation: pay and display, pay-by-space, or pay-by-license plate. Most multi-space meter manufacturers make one meter capable of being programmed for all three payment modes by changing the user interface (face plate) and the system software (rather than replacing the meter).

Pay and Display

In pay and display mode, patrons park the vehicle, walk to the parking meter, pay for a certain amount of time and receive a receipt. Somewhat less convenient for the patron than individual meters, in pay and display mode, the patron has to return to their vehicle to place the receipt on the dashboard. The receipt indicates the duration, location, machine number and end time for which the vehicle has paid for parking. The receipts are visually inspected during enforcement procedures, which have been found to take more effort and time as compared to the enforcement of other meter types.

Pay and Display requires that the motorist return to their car to display the receipt. This requires the meter to be relatively close to the car. On average, the meter should be within 100 feet of the parking space. A good rule of thumb is to install the meter with five parallel parking spaces on each side of it for a 1:10 meter to car ratio. For diagonal parking spaces the ratio could increase to 1:20; however, this doesn't account for fire hydrants, driveways, laneways, loading zones and other interruptions in the parking layout.

In Pay and Display mode, parking spaces do not need to be identified (striped), which has shown to allow more cars to park on each block, depending on the sizes of the cars parked at different times and the lengths of uninterrupted parking spaces.

Pay-By-Space

In pay-by-space mode, the patron is not required to return to the vehicle with a receipt. Each parking space is numbered. The patron approaches the parking meter, enters the parking space number in which the vehicle is parked and selects the amount of time desired. No receipt is needed for enforcement, but there can be a receipt for proof of transaction. Enforcement is done by viewing a web-based report of paid and/or unpaid spaces on a hand-held enforcement device or from any web-enabled computer or smart phone.

Most pay-by-space applications offer the added convenience of allowing patrons to add parking time to the meter from another meter or through their cell phone for added convenience. Pay-by-space meters are typically used in off-street applications where spaces can be easily numbered using signs or surface paint; however, they are also gaining popularity for on-street applications due to the pay-by-cell phone option, no need for the customer to return to their car with the receipt, and their improved enforcement options.

Pay-By-License Plate

In pay-by-license plate mode, the patron is not required to remember the parking space or return to the vehicle with a receipt. Instead, the patron enters the vehicle’s license plate number and selects the amount of parking time. No receipt is required for enforcement, but there can be a receipt for proof of transaction. This system can allow a patron to move the vehicle to another spot within the same meter zone without having to pay for parking again - provided there was time still remaining on the original purchase, and they were not in violation of the posted time restrictions. As in pay and display mode, parking spaces do not need to be identified (striped), which has shown to allow more cars to park on each block, depending on the sizes of the cars parked at different times and the lengths of uninterrupted parking spaces.

Enforcement can be done with a vehicle mounted license plate recognition (LPR) system that scans the license plates of all parked cars, or with a hand-held unit, either scanning or manually entering the license plate.

Mobile License Plate Recognition

Mobile license plate recognition (LPR) technology has made the enforcement of time limit, pay-by-plate, pay-by-cell, and license plate permit parking remarkably efficient and cost effective. Mobile LPR utilizes vehicle-mounted cameras that read and record license plates as an enforcement vehicle is driven on roadways, surface lots, garages, etc. A processor is installed in the vehicle’s trunk or in the floor, and a laptop is installed on the dashboard, between the front seats. The LPR cameras use a series of algorithms to convert the photographic images of license plates into text data. System software then compares the plate numbers with previous enforcement session(s) and/or databases of paid or permitted license plates, to determine if the vehicle has overstayed the time limit, if it has paid, or otherwise has a right to park in that particular location at that particular time.

Figure 5: Example of Vehicle-Mounted LPR Cameras and Dashboard

Source: Genetec

The LPR software can integrate with permit, meter, pay-by-cell and other databases such as law enforcement agencies, to not only enforce permits, time limits and paid/unpaid parkers, it can also identify stolen or otherwise significant license plates. If the LPR camera reads a plate that has overstayed the time limit or is not listed as paid or permitted, or has been otherwise identified as searchable, an audible 'ping' is generated, to alert the driver. The driver can then view the image of the license plate (or plates) to confirm accuracy and take the appropriate action.

While enforcing, mobile LPR can collect parking occupancy and frequency of visit data, as well as limited duration of stay data. Each time the mobile LPR vehicle drives past a parked vehicle, it time-stamps the image and the location, using GPS technology to identify the locations of the parking spaces and can sort the data by parking facility, street or by customized zones. Note that the system won't know the exact time that the vehicle parked or exited – it only knows that the vehicle was parked in a specific location at the time of enforcement. Throughout multiple tours, the system software calculates the total time that the vehicle was observed as parked, up until it is observed to have moved.

It's important to note that while mobile LPR is an efficient enforcement tool for permit, paid and time-limit parking, many other infractions such as no parking, ADA parking, loading zone, hydrant, etc., will still need to be manually (visually) inspected. Most enforcement officers are able to do so while driving the enforcement vehicle; however, this can impact enforcement routes and schedules.

Walker Recommendations

Multi-Space Meters with Pay-By-License Plate

In evaluating the parking meter options that are available, Walker recommends that for the Whittier Boulevard PBD the County opt for multi-space meters (MSMs). While the single-space meters (SSMs) will be familiar to unincorporated East Los Angeles residents and visitors already, given their presence along 1st Street, when all factors are considered MSMs offer specific benefits that SSMs do not. Among them are:

- More programmable options such as: pay-by-license plate, pay-by-space, pay-and-display, and pay-by-cell.

- Ability to include various payment options like cash (coins), credit cards, tokens, and mobile applications.
- With the option of pay-by-license plate, enforcement could be more efficient, which has been a particular concern of the community.
- Less pay stations than SSMs. This means less clutter on the street and more space for pedestrians or other public improvements like trees, benches, bike racks, etc. It also means less meters to remove should they need to be removed in the future.
- The future of on-street parking is moving toward mobile payments. MSMs facilitate that integration of mobile as they can already be programmed to accept mobile payment applications, and users become more accustomed to the idea of not having to pay at a meter directly in front of their vehicle.
- Ultimately, MSMs are more cost-effective than SMSs.

As shown in the next section (Opinion of Probable Cost and Revenue Analysis), MSMs are less expensive in the long run. While they have higher up-front costs, they have a lower amortized cost.

03 Cost and Revenue Analysis

Opinion of Probable Cost and Revenue Analysis

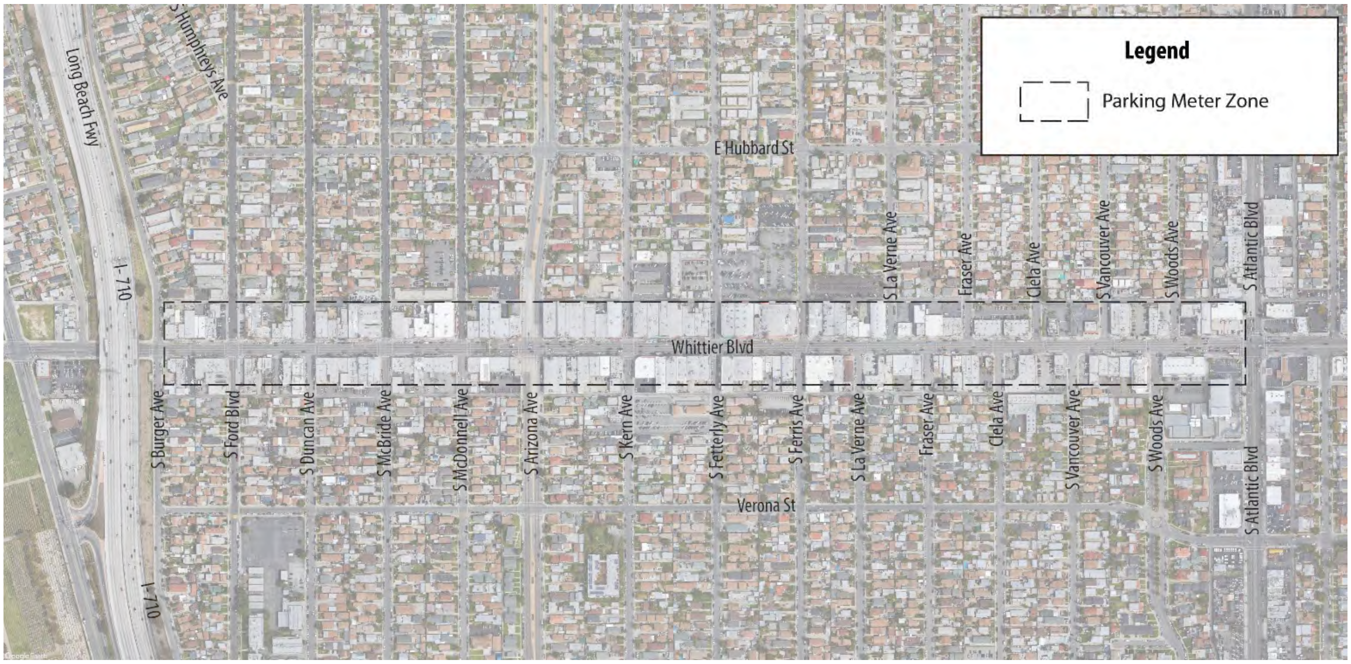
To determine the financial feasibility of a parking benefit district (PBD) in unincorporated East Los Angeles, Walker conducted an analysis of the costs and revenue that may result from implementing paid parking. It is important to note that the revenue numbers contained in this section are intended to assist decision makers regarding the benefits and costs of implementing the proposed program only. The figures included in the analysis are not intended to be used in financing documents.

Parking Meter Locations

As discussed previously, it is Walker's opinion that the most appropriate location for a PBD is Whittier Boulevard. The commercial corridor that extends from Burger Avenue to Atlantic Boulevard was observed to have the highest occupancy of any commercial corridor.

Figure 6 shows the recommended location of the PBD. The parking meters should be placed along Whittier Boulevard and along the bisecting streets where warranted.

Figure 6: Parking Meter Zone for PBD



Source: Walker Consultants, 2020.

The potential metered area (Shown in Figure 6) generally includes parking spaces on the following streets:

- Both sides of Whittier Boulevard from Burger Avenue to Atlantic Boulevard,
- The commercial "pockets" north and south of Whittier Boulevard, and on both sides (east and west) of the street on:
    - Burger Avenue east side only (north and south of Whittier),
    - Ford Boulevard
    - Duncan Avenue,
    - McBride Avenue,
    - McDonell Avenue,
    - Arizona Avenue,
    - Kern Avenue,
    - Fetterly Avenue,
    - Ferris Avenue,
    - LaVerne Avenue,
    - Fraser Avenue,
    - Clela Avenue,
    - Vancouver Avenue,
    - Woods Avenue, and
    - Atlantic Boulevard west side only (north and south of Whittier).
- With respect to the number of multi-space meters (MSM) recommended along this stretch of Whittier, Walker recommends 47 MSMs to cover the area, a ratio of approximately one meter per seven spaces. By contrast, to cover the same area with SSMs the number would be 333. This total includes only spaces that are currently time-restricted, it does not include spaces that are ADA, yellow curb, white curb, or green curb.

Cost Analysis Single-Space Meters vs. Multi-Space Meters

An important consideration for the implementation of paid parking is whether to implement single-space meters (SSM) or multi-space meters (MSM). In the previous section, Walker compared the benefits of both technologies, and ultimately recommends MSM along the proposed Whittier Boulevard PBD. In comparing the costs, MSMs are generally a more cost-effective solution. Table 1 shows the comparison of costs between installing SSM versus MSM.

Table 1: Cost Analysis Single-Space Meters (SSM) vs. Multi-Space Meters (MSM)

Cost Anlaysis Single-Space Meters (SSM) vs. Multi-Space Meters (MSM)

		Single-Space Meter		**Multi-Space Meter**		**Variance (SSM - MSM)**
A	Number of Meters	333		47		-
B	Parking Meter Costs	$1,000		$10,000		-
C	*Purchase Price Subtotal (A*B)*		*$333,000*		*$470,000*	-
D	*Spare Parts Subtotal*		*$18,000*		*$18,000*	-
E	Signs per Meter	0		2		-
F	Signage Costs	$0		$150		-
G	*Purchase Price Subtotal (A*E*F)*		*$0*		*$14,100*	-
H	*Start-Up Marketing Fees (Literature/Website) Subtotal*		*$5,000*		*$30,000*	-
I	Ticket Roll Costs per Unit	$0		$45		-
J	Ticket Rolls per Year	0		6		-
K	*Annual Ticket Roll Cost Subtotal (A*I*3.5)*		*$0.0*		*$7,400*	-
L	Credit Card Transaction Fees	$0.13		$0		-
M	Average Transactions per Day	3		21		-
N	Credit Card Days per Week	7		7		-
O	*Annual Credit Card Transaction Fees Subtotal (A*L*M*N*52 weeks)*		*$47,300*		*$0*	-
P	Monthly Management Fees Per Meter	$8		$60		-
Q	*Annual Management Fees Subtotal (A*P*12 months)*		*$32,000*		*$33,800*	-
R	Battery Costs per Unit	$30		$100		-
S	Year 3 Battery Cost	$10,000		$4,700		-
T	Year 6 Battery Cost	$10,000		$4,700		-
U	Year 9 Battery Cost	$10,000		$4,700		-
V	*Total Battery Cost - 10 Years Subtotal (S+T+U)*		*$30,000*		*$14,100*	-
	Total Cost Year 1 (C+D+G+H+K+O+Q)		**$435,300**		**$573,300**	**($138,000)**
	Five Year Cost		**$772,500**		**$742,800**	**$29,700**
	Ten Year Cost		**$1,189,000**		**$958,200**	**$230,800**

Note: Figures ($) are rounded to the nearest hundred

Source: Walker Consultants, 2020.

As shown in Table 1, the cost of implementing MSMs is higher in Year 1; however, this is because the upfront costs of purchasing 47 multi-space meters is higher than 333 single-space meters. In looking at the costs five years and ten years out, the MSMs result in a projected cost savings of $230,800±.

It is important to note that these costs do not include maintenance or collections costs, nor do they include costs for integrating a mobile payment application. Consideration for implementing the latter includes factoring in a $0.35 fee per transaction.

Rough Order of Magnitude Cost and Revenue Projections

The key in determining the feasibility of the proposed PBD, is if the district can generate sufficient revenue to cover its costs. To determine the financial feasibility of implementing a PBD in unincorporated East Los Angeles the following assumptions were used:

- Meters will be in operation thirteen hours per day (8:00 a.m. to 9:00 p.m.)
- Meters will be in operation seven days per week, minus 12 holidays throughout the year.

- An average paid occupancy of 35% during hours of enforcement is assumed throughout the year for all metered spaces. Due to:
  - Hours of low-demand during the day.
  - Price elasticity may deter some from paying for parking.
  - There is a possibility of an increase in disabled parking placard use on metered spaces.
- Parking rates are assumed to be $1.00 per hour Monday through Sunday.
- On-street parking spaces are assumed to be metered with credit card capable multi-space meter (MSM) technology.
- For on-street parking we assume roughly two MSM units per block face, likely placed near the corners to capture the “pockets” of commercial parking on residential streets. The ratio of parking meters to spaces is roughly one per every 7 parking spaces. The total number of MSMs would be ±47 parking meters.
- The cost per meter is assumed to be $10,000 per unit including installation, based on our experience.

These considerations combined are conservative projections of the average paid occupancy rate, which at times throughout the day will be higher.

- The parking rates used in the assumptions are comparable to those of other Southern California cities. For example, the City of Los Angeles charges $1.00 per hour along 1st Street in the Boyle Heights neighborhood, the City of San Fernando charges $1.25 per hour, or $0.25 per each 12 minutes, the City of Inglewood charges $1.00 per hour (plus convenience fee for mobile payments), the City of Glendale charges $1.50 per hour on-street in its downtown streets, the City of Pasadena charges $1.25 per hour in Old Pasadena and $0.75 in the area South of Dayton Street between Pasadena and Raymond Avenues.

Based on these assumptions we project $1,600± of gross revenue annually per metered on-street space. If all 333 spaces are metered, we project annual gross revenue of $534,800±. We project that annual net revenue for the PBD would be $487,600±. Table 2 shows the revenue projections for the PBD.

Table 2: Order of Magnitude Revenue Projection for Whittier Boulevard PBD

MSM Revenue Analysis	
Hourly Rate	$1.00
Estimated Revenue Per Parking Space	$4.55
Annual Revenue Per Parking Space	$1,600
Total Annual Revenue Projection	***$534,800***
Estimated Machine Cost (Installed)	$470,000
Spare Parts (Varies by meter quantities)	$18,000
Estimated MSM Signage, installed (2@$150 per MSM)	$14,100
Estimated Marketing Costs for MSM Program	$30,000
Annual Ticket Roll Cost	$7,400
Annual Mgmt. Fees	$33,800
Total MSM Implementation Cost	***$573,300***
Payback Period (# of Months)	13
Annual CC Processing Fees (i.e. 50% of Revenue x 5%)	$13,400
Annual Net after Mgmt. Fees and CC Processing Fees	**$487,600**
Five Year Net	**$1,864,800**
Ten Year Net	**$4,303,000**

Note: Figures ($) are rounded to the nearest hundred

Source: Walker Consultants, 2020.

We project that a paid parking program would provide a positive annual revenue source to the parking system's operating budget.

Additional Considerations

Multi-Space Meters in County Lots

Consideration should be given to implementing paid off-street parking as well. It is possible that when meters are installed on Whittier Boulevard the County lots that are located in the district may fill more regularly with customers, employees, or any other users avoiding paid parking. If demand patterns are such that these lots are regularly at capacity, the County may consider installing multi-space meters in these lots as well to encourage turnover and availability. While generally the price of the meters would be lower as compared to the off-street, consideration should be given for maintaining a target occupancy on off-street parking as well.

Mobile App Integration

The future of parking appears to be shifting toward mobile payments or Pay-by-Cell (PbC). PbC has been around for several years now and is improving as cell technology and connectivity improves. There are examples around the country in which municipalities have bypassed installing parking meters altogether and relied solely on mobile payments. However, given that many in the community still rely on cash transactions, we have not included the mobile app recommendation at this time.

It is important to note that multi-space meters offer a more seamless integration to mobile apps should the community consider mobile in the future. The cost to integrate a mobile application into the parking system may vary by vendor and application, but generally all vendors charge setup fees, and most importantly transaction fees. The revenue models of the vendors are based on transaction fees. These fees are typically $0.35 per transaction. Some municipalities choose to absorb these fees whiles other pass these costs on to the customers.

Traffic Calming Measures

Because the on-street parking supply is vital to the success of the businesses along Whittier Boulevard, the County should study ways in which traffic calming measures could be implemented within the PBD. Under current conditions, observed traffic speeds are not conducive to the vision of a PBD. A PBD, in order to attract customers should be comfortable for motorists and pedestrians to navigate. The speed at which traffic typically runs along Whittier also makes it difficult for customers to parallel park on the boulevard. Implementing traffic calming measures may help with slowing speeds down such that it is not a deterrent to customers wanting to patronize businesses within the PBD.

04

Parking Benefit District Implementation

Attributes of a High-Performing Parking Benefit District

Based on our experience, some parking districts flourish while others stagnate. The ones that flourish have a common set of attributes that enable them to be high performing parking districts.

- **Parking Management Mission:** The intent of a parking district is typically to provide a positive parking experience for those who visit the commercial area which the parking district serves. This entails having an adequate number of spaces to serve the different user groups that will park in the area at different times of day, different days of the week and throughout the year. It also requires good customer service, both in terms of staffing as well as the condition of the facilities, signage and any equipment. From a cost standpoint, this requires examining both supply-side and demand-side approaches. The parking system must be integrated into the overall transportation policy goals of the County. A parking system is ultimately about providing the public with access to a given destination. Forward thinking parking districts may recognize and encourage this broader mission.

- **Parking District Objectives:** A high performing parking district will have a defined set of objectives. These objectives should be consistent with and support the County's overall Parking Management Mission.

- **Supportive and Engaged Constituents:** In order for the parking district to accomplish its objectives, its constituents (which may include property owners, business owners, parking users, and residents) need to support the mission and be engaged in the direction of the program. Engagement of constituents is more likely to build support than a parking district directed solely within local government, particularly when difficult decisions related to time restrictions and other regulations, enforcement policies, expenditures and possibly setting a price for some parking is involved. An actively engaged parking committee, advising or overseeing with regard to the policies of a parking district, should also engage in regular meetings to monitor the effectiveness of parking policies, occupancy rates, revenue, expenses and plan for the future.

- **Strong Financial Condition:** In order to meet the parking district's objectives, adequate funding to maintain existing programs and in some cases, to fund future parking, is necessary. This requires fiscal responsibility by the agency administering the program as well as an awareness of when potential financial issues should be addressed with parking district constituents.

- **Political Support:** Elected officials need to support the parking district's objectives in order for it to succeed. Providing political support will also help generate support and engagement amongst constituents. Garnering support is likely easier when a parking district is considered within the context of a County's overall transportation policy goals.

Strategy for Implementing a Parking Benefit District

In order to implement a high performing parking district, we offer the following considerations for implementation. This section outlines a strategy for the County to pursue implementation of the Whittier Boulevard parking benefit district (PBD). In accordance with recommendations in Task 4, consideration for a PBD will follow only after the following have been addressed:

- Enforcement issues, as identified in Task 3, have been addressed and enforcement is operating as efficiently as it can to maintain acceptable parking conditions on the street.
- An agency is in place, whether a third party or within the County, that can administer and manage or oversee the PBD.

Gather Stakeholder Buy-In

The first step in implementing a parking benefit district (PBD) is to gather stakeholder buy-in. The most important buy-in needs to come from the merchants and business groups that are located within the proposed district. Along Whittier Boulevard these may be the Whittier Boulevard Merchants Association and/or the East Los Angeles Chamber of Commerce. The County should perform outreach to parking district stakeholders to engage them in setting or adjusting parking district objectives. The stakeholders should also have a say in defining the boundary of the PBD and in defining how revenues should be spent.

Outreach may consist of direct outreach through the mail and email as well as public meetings in which constituents gather with County staff. Developing buy-in to objectives will ensure support for the PBD. Periodic outreach needs to be performed to ensure that the district is meeting objectives and if not, consideration should be given regarding whether to adjust the district and its objectives.

With businesses onboard, the next step would be to gather political support. Given that the County is looking to address the parking issues that impact the unincorporated East Los Angeles community, once support from the businesses is earned, political support will follow.

Develop a Mission Statement and Plan

Effective parking districts today use comprehensive management and financial policies to address clearly stated objectives in the service of a broader mission. Comprehensiveness is defined in several ways, including an approach to on-street and off-street parking spaces as one parking system, both in management and financial terms. Policies approaches are informed if not overseen by a parking committee made up of commercial district stakeholders who have an interest in both the proper management of the district and the solvency of the parking system.

Often these parking districts are tied to a parking enterprise fund that require that revenue from parking cover all defined expenses. Paid parking, which was prevalent in the commercial districts of many communities in the middle part of the last century, has reemerged as a financial contributor but more importantly as a parking demand management strategy, for the purpose of ensuring parking turnover in customer parking areas, often while providing flexibility in the length of stay, as well as encouraging long-term parkers to use parking spaces in more peripheral locations.

Identify or Create a Commission to Oversee PBD

An important feature of the district will be the identification of the group to be in charge of the PBD revenue, spending priorities, and parking policies. In the case of Old Pasadena, the City created the Old Pasadena PMZ Advisory Commission which consists of business and property owners and is overseen by City staff. Many of the business owners were also members of the local business improvement district (BID).

In unincorporated East Los Angeles, there is no shortage of business stakeholders and merchants, such as the Whittier Boulevard Merchants Association and the East Los Angeles Chamber of Commerce. The County would need to work with the businesses to establish a commission to oversee the PBD. A County liaison to the commission is typically required.

Enabling Code Language

The County of Los Angeles Municipal Code currently allows for preferential parking districts (PPD), but there is no mention of parking benefit districts or zones. As such, the County would need to draft code language enabling the creation of such districts. The boundaries of the district should be defined, as should a process for establishing parking rates.

Furthermore, language should be developed regarding the creation of PBD commission, and should include:

- Membership policies, including appointment of members and terms
- Qualifications needed to be part of the commission
- Elections
- Record-keeping
- Reporting

Establish a Set of Objectives

The parking district needs to have a defined set of objectives that have been vetted by and are available to the public. The objectives should support the County's Parking Management Mission which in turn should support the overall transportation policy goals, including those related to transportation demand management (TDM) and promotion of non-single occupant vehicle modes.

Some example objectives for the parking district are:

- Provide visitors with convenient and available parking via paid parking and permit parking to residents/employees
- Ensure that parking revenues stay local in the district to fund improvements determined by property owners and merchants in the district
- Improvements to be funded by parking revenues are [to be determined by property owners and merchants in the district]

- Provide parking to support new development in the district
- Provide funding to operate and maintain parking in the district

Key Performance Indicators

To measure the performance of the PBD, a set of key performance indicators (KPIs) should be developed. The KPIs should be designed to measure performance in meeting the objectives of the PBD. The following are examples of KPIs.

- **Occupancy Targets:** Given the issues of highly occupied, and thus unavailable, curb parking along the Whittier Boulevard corridor, it is important to set an occupancy target. The purpose of which is to ensure that there is available parking for customers. Typically, a target of 85 percent occupancy is ideal. An 85 percent occupancy indicates that the spaces are being used, but that there are also some spaces available for arriving customers.

- **Payment Methods**: With the installation of new meter technology, tracking of payment methods will become more important. The ability to pay with credit card and possibly by mobile application may render the use of coins obsolete. If it is the case that the majority of revenue is generated from credit cards and mobile payments, then the County could consider removing the coin payment option. There would be a resulting cost-savings as coin collection contracts will no longer be needed, leakage would be eliminated, and potential injury claims from coin collection operations would be avoided.

- **Total and Net Revenue**: This is a general measure of how the district is performing. The intention of tracking this information is not for measuring increases in revenue, but rather in measuring the solvency of the district to ensure that costs are covered such that the district can continue to offer a pleasant parking experience for customers.

Ensure Accountability and Transparency

Provide on-going outreach and annual reporting to share parking district operating results and financial condition. County staff responsible for managing the parking district should be available for constituents to contact with any concerns or suggestions regarding the operation. Through outreach, constituents should have the ability to voice concerns about the operation and whether the parking district is meeting their needs and its objectives.

Develop a First-Class Parking Operation

In order to serve the parking district's constituents and to meet overall Parking Management Mission, the operation of the parking in the district needs to be handled in a first-class manner.

- **Maintenance** of parking spaces needs to be routine and done on an on-going basis to avoid potentially large and catastrophic one-time expenses.
- **Upkeep** of the parking district so that it is clean and attractive to those using the parking system. An unkempt parking district is not inviting to parkers and creates a perception of disrepair and lack of safety.
- **Safety** to ensure that parkers are not injured by hazards.
- **Security** to ensure that parkers are not dissuaded from parking due to criminal activity.

- **Signage** to direct parkers to available parking. Once parked signage should direct parkers to nearby attractions/points of interest and also provide clear and concise instructions for payment, if applicable.
- **Technology** may be employed to create a cost-effective and user-friendly system for those parking in the parking district. For example, mobile payments may ease the burden of extending length of stay.
- **Enforcement** is required to ensure that parking district objectives in line with the Parking Management Mission are being met. Without effective enforcement, abuse occurs which becomes a detriment to all users of the parking district.

Marketing Plan

People are generally resistant to change. Strong public relations are imperative to the successful implementation of paid parking; therefore, Walker recommends considering a public relations campaign to introduce the new meter program.

Based on other cities' experience and successful installations of paid parking with new meter systems, the following list provides examples of communications activities prior to, during, and after installation:

- Conduct community outreach meetings with stakeholders.
- Issue a press release announcing plans for the new meters, with a focus on the positives of increased turnover, space availability, ability to pay by credit card, etc.
- Deploy a website with press releases, project updates, meter instructions and "frequently asked questions and answers".
- Brand the parking program so that visitors can identify the parking district and relevant signs.
- Sponsor a contest for creating the logo. Finalists could be shown on local TV, on-line (on Facebook) and in the newspaper. The public could vote on the winner, generating publicity and gaining buy-in from the public. This will not only provide a new logo, but will also provide interest/buzz/consciousness-raising.
- Design, publish, and distribute a parking guide, including a parking map and brochure describing the locations and availability of on-street and off-street parking, including free, paid, short-term and long-term parking.
- Display a 'sample' meter in a public area for people to see, touch, and feel prior to implementation.
- Post signage on or next to the meters that shows the public that the meter revenue funds improvements in the district.
- Carefully train all related staff on all aspects of the program so they can easily assist motorists and communicate a consistent message regarding the details of the program.
- Develop and distribute informational and instructional handouts (brochures and/or fliers) illustrating how to use the meters.
- Develop a directional video for local television and/or YouTube. Incorporate humor! For example, show a local politician or celebrity struggling, only to have a child show how easy the meter is to use. Ask local schools to recruit students to create the video (for college credit?).
- Recommend that meter patrons photograph their license plate as a memory aid. Walker does not recommend key chains with a place to record the plate #, due to the risk associated with misplaced keys (the finder has the plate #).

- Publicize and recommend pay-by-cell (phone) as an easy alternative to using the meters. Pay-by-plate has a steep learning curve. Motorists won't know their license plates and may enter the wrong number anyway. Bypassing the meter bypasses the potential for frustration and complaints. This can be highlighted in a promotional video, as well as on the County's website, press releases, brochures, etc.
- Issue another press release one-week prior to the initial installation.
- Conduct a ribbon-cutting and first-use ceremony to officially welcome the new meters.
- Utilize trained 'parking ambassadors' to assist motorists with their use during the first few weeks they're deployed.
- Provide warnings rather than fines for a short period of time following meter deployment.
- Even after the 'break-in period', Walker recommends issuing courtesy warnings for first-time meter violations. This softer approach will be well received by the public and is a reasonable response to a motorist who inadvertently overstays a parking session. This could re-set on an annual basis, so that everyone gets forgiven one time (or even two-times) per year.
- On the other hand, the penalty should be more severe for the repeat violator, as a third or fourth offense is no longer an honest mistake – it is a disregard of the County's parking regulations. Walker recommends incrementally increasing the fine after three violations in one year, so that the penalty for each violation after three violations becomes more punitive. The original fine is not having the desired effect on the habitual offender. Incremental fines may at some point convince the motorist to comply with the rules. A historical analysis of citations issued should be done to confirm that the incremental fines make up for the lost revenue due to courtesy warnings for first offenders.

Off-Street Parking Supply (Public and Private)

The implementation of paid parking along Whittier Boulevard may shift parking demand to other areas. If employees are parking along the boulevard, they will likely look elsewhere for somewhere to park. One option is to have a designated area for employees to be able to park off-street. The County owns two lots along Whittier Boulevard at 753 S La Verne Avenue and 922 S Fetterly Avenue. Employees can be offered the option to park in these lots for a permit fee. The permits could then be checked by enforcement staff via license plate recognition software.

Should there be a need for more off-street parking, the County could consider methods by which to incorporate the private off-street supply into the district. One approach is in the form of leasing underutilized private off-street lots for public use. For example, the City of San Clemente's Parking Lot Lease Program does just that. When the City studied its parking supply it was found that although the public parking lots were at or near capacity there was a surplus of 400 spaces in the private parking lots. Rather than constructing new parking resources, which is expensive, San Clemente developed the Parking Lot Lease Program. The cost is equivalent to maintaining a parking structure without the capital costs for the purchase of land and improvements.

To emulate San Clemente's Parking Lot Lease Program, the County would likely need to persuade property owners of the benefits of leasing their private parking lots. However, if the County is able to identify several strong incentives that property owners want, they may find success in expanding the public parking capacity of the district.

Preferential Parking Permit District (Residential Permits)

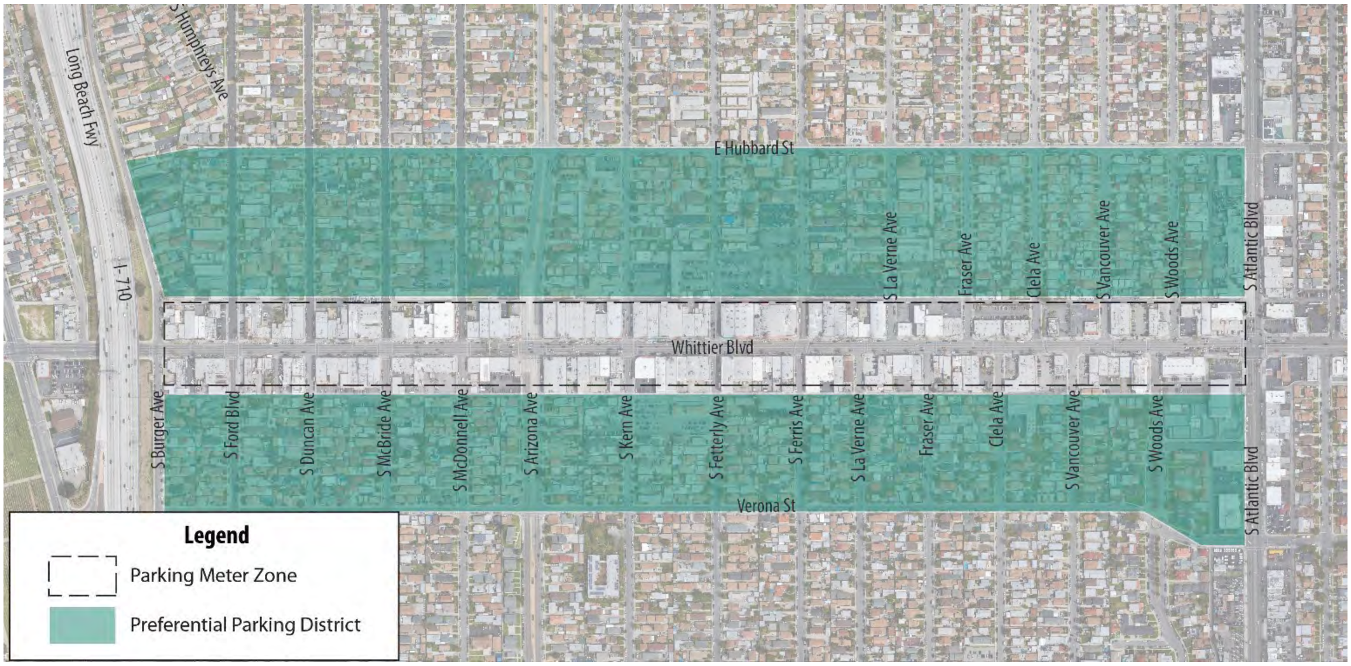
An important consideration in implementing the parking benefit district (PBD) is the impact to the surrounding residential neighborhoods. As such, Walker also recommends that the County consider a preferential parking permit district (PPD) in the residential areas near the proposed Whittier Boulevard PBD.

A parking permit district is typically a geographically defined area where parking is actively managed via permits to allow for on-street parking use by residents, businesses, and transient/short term parkers. Parking permits are required to park in designated areas on the streets within the district. It is customary to charge a fee and require that the vehicle be registered to an address within the district.

A preferential parking district (PPD) is a type of parking permit district that has posted regulations that limit parking without permits in an effort to reduce impacts of non-resident parking. PPDs can also help to manage residential demand, by limiting the number of permits that can be obtained per household.

To better manage on-street parking demand, Walker recommends the implementation of a PPD program in the Whittier Blvd East zone, shown in Figure 7. This zone was selected due to its proximity to Whittier Blvd, the location of the proposed parking benefit district. The PPD should be in place in the residential areas only (shown in teal), not the commercial areas along Whittier Blvd (shown in the dotted outline).

Figure 7: Whittier Blvd Preferential Parking District Zone



Source: Walker Consultants, 2020.

Hours of Enforcement

Parking in residential areas within the Whittier Blvd East study area should be restricted to permit parking only during all hours of the day. A PPD permit should not exempt parkers from street sweeping parking restrictions. PPD permits should not exempt any vehicle from parking at "no parking" zones, parking meters, pay stations, or loading zones.

Number of Permits and Permit Fee

To better understand how many permits that can be allocated, Walker conducted a Geographic Information System mapping analysis to determine the number of on-street parking spaces (parking inventory) per block within the Whittier Blvd East study area. The results of this analysis indicated that there is an average of 0.70 spaces per housing unit. Therefore, if each household obtained a parking permit in the Whittier Blvd East study area, there would be a shortage of parking spaces. This analysis demonstrates that in order to manage on-street parking demand, it is important to establish a limit on the number of parking permits that can be obtained for each household and to charge to obtain a permit. The goal is to provide permits for residents who need to park on the street due to lack of parking availability off-street.

Walker recommends that there be no more than three parking permits allowed for each household. The permit rates should be graduated so that the price of the second and third permit is higher than the price of the first permit.

Walker's recommended PPD permit rates are summarized in Table 3.

Table 3: Recommended Parking Permit Rates

	Annual Rate
1st PPD permit	$15
2nd PPD permit	$100
3rd PPD permit	$250

Source: Walker Consultants, 2020.

Walker recommends that unincorporated East LA provides an income assistance program for those in need of a permit, but cannot afford one, such as households with incomes below the poverty line.

All permit fees should contribute toward administration of the PPD program.

PDD Technology

Walker recommends that the County transition towards a credentialing system centered around enforcement using license plate recognition (LPR).

The County should engage a qualified and reputable parking technology vendor to develop web-based applications that will enable participants in the PPD to complete and submit permit applications online or via mobile application:

- The vendor's solution should allow for residents to update information on vehicles.
- The vendor's solution should seamlessly integrate into the software used by parking enforcement.
- The County's agreement with the vendor should establish requirements for data security and liability for data breaches.
- The County's agreement with the vendor should clearly establish ownership of data and limitations on how the data are used.

Obtaining a Permit

Residents should be required to provide the following documentation to obtain a permit:

- Valid driver's license
- Valid vehicle registration that matches the address of the resident that qualifies for the permit

Residents should be able to obtain permits either via an online system, as described above, or in person at a County facility.

Establishing new PPD Zones

Walker recommends that a process by which to designate new PDD zones is established. Consistent with the practices of many cities in Southern California, residents should be required to submit a petition or formal request with a majority in support of establishing a permit district. County staff should then conduct a study and work with the community to establish the parameters and restrictions of the proposed PPD district.

Benefits and Challenges of a PPD

Benefits

- PPDs can help to manage on-street parking in residential areas
- PPDs limit parking on-street by non-residents to provide more parking for residents and guests.
- PPDs can promote an enhanced quality of life in neighborhoods by reducing noise, traffic hazards, and reducing litter.
- The program often results in fewer instances of residents having their driveway blocked, trash cans moved, or late-night noise problems.

Challenges

- Residents must apply for and renew permits, which is an administrative burden.
- Residents are required to pay for parking permits, when parking was free before.
- Permits give residents of a specific area the ability to park within the limits of that area, but do not guarantee space availability.
- The program limits or disallows parking for customers and businesses.
- The process requires time and effort to establish and manage the permit district(s).
- For an effective PPD, consistent and frequent enforcement is required, which is costly.

- Technology is required to promote an effective and efficient program. As with any technology, there can be challenges such as up-front costs, learning curves for staff using the technology, software/hardware issues, and on-going expenses.

05 Benefits and Adverse Consequences

Benefits and Adverse Consequences of Implementing a Parking Benefit District (PBD)

Any consideration of policy changes that may impact the parking system in unincorporated East Los Angeles warrants an analysis of benefits and adverse consequences. It is important to consider how any prospective changes may affect local residents, business owners, and visitors of unincorporated East Los Angeles. As such, the following section presents the potential impacts of the parking benefit district (PBD) proposed along Whittier Boulevard.

Benefits

Businesses

- A new source of revenue by way of paid parking to pay for improvements along the Whittier Boulevard commercial corridor.
- The revenue generated within the district would be returned to the district.
- Local control over revenue, spending priorities, and parking policies.
- Increased on-street parking availability along the corridor, effectively allowing for more customer parking.
- Public improvement projects as a result of new revenue source.
- More efficient enforcement if using a mounted license plate recognition system.

Visitors

- Increased availability of on-street parking.
- Convenience of payment for parking (e.g., credit card, mobile, coin)
- A more attractive commercial corridor if revenues are spent on amenities that are a benefit to the public.

Residents

- Improved commercial corridors for shopping.
- Increased enforcement tours through commercial corridors and neighborhoods
- Increased availability of on-street parking along Whittier.
- Protection from long-term parkers that are not residents of the neighborhood, with implementation of a residential parking permit district.

Adverse Consequences and Challenges

Businesses

- Employees would need to find somewhere to park that is not on-street along Whittier Boulevard, or on nearby residential streets. However, off-street parking in the district, private and public, can provide some relief. Additionally, revenue generated from the district can help support transportation demand management (TDM) programs such as, paying for transit passes for employees in the district, creating a vanpool or carpool program, paying for parking permits for employees, parking cash out, etc.
- There may be a customer learning period as they get accustomed to paid parking at a multi-space meter. For this reason, Walker recommends an initial period in which parking ambassadors are on the ground showing customers how to pay for parking.
- One of the key issues along Whittier Boulevard is the presence of catering trucks and street vendors with vehicles parked on the boulevard. The implementation of paid parking for the purpose of encouraging turnover is likely going to impact the current status quo with how these businesses operate. While this issue extends beyond parking, from a parking perspective there may be opportunities for these businesses to continue operating in the district. For example, the County can create a zone approach where a truck can only park in a zone for a specified amount of time. After the time has elapsed they would need to move to a different zone. Best practice dictates that short-term spaces be available to customers, and so catering trucks and vendors should not occupy these spaces. However, if there are no viable alternative options, they will need to pay the meter and abide by the time limits. The County should consider developing code language to prevent catering vehicles from re-parking on the same block after the time limit has elapsed. Ultimately, the County, Whittier Boulevard businesses, and catering truck and street vending businesses can meet and confer regarding options that are agreeable to all parties.

Visitors

- No longer free on-street parking.
- May be a learning curve for customers to use pay-by-plate.
- If the County does not address the speed at which vehicles travel along Whittier Boulevard, motorists may be less inclined to back-into a parallel space comfortably. The County could address this by slowing vehicles down along the PBD stretch of Whittier Boulevard. Traffic calming measure can include, different street paving, pedestrian crosswalks that light up when a pedestrian is at the crosswalk (this signals motorists to slow down and stop), and a lower speed limit, among others.

Residents

- No longer free parking environment.
  - Paid parking implemented along Whittier Boulevard.
  - Permit parking implemented in the residential areas surrounding Whittier Boulevard.
- Because paid parking will be in place on Whittier, there is the potential from spillover onto residential streets from customers who do not want to pay for parking. However, there are two ways in which to mitigate this impact. The first is by implementing a two-hour time limit on all residential streets immediately

surrounding Whittier Boulevard. This ensures that customers do not stay parked long-term. The second is the availability of off-street district parking to serve as an additional choice for customers.

- Residential permits will have to have limits, and in themselves permit programs do not guarantee that there will be more available on-street parking in residential neighborhoods. Especially since on-street parking in the Whittier Boulevard residential district contains on average .7 on-street spaces per residential unit.

Whittier Bl Proposed Rezoning to Mixed Use - sto

Street A	Street N	Year Built	Architect	Historic Designation ID	Notes	APN	Other A	Contractor		sq ft
4701	Whittier	1/10/1929		Historic Designation	Original Owner M. Wood	5240002026	4703		764-766 S Arizona	
4709	Whittier	1927		P-19-190084, LA33717A, LA-12467	Fotofobia 6Y 2009 (K. A. Craw	5240002027		George Miller		
4717	Whittier	1928			Early Owner O Comer	5240002028		Frank Chutuk	4713-4715	9000
4719	Whittier	4/12/1929			Original Owner Mr. Crest	5240002012	4721	Nick Artukovich		7152
4723	Whittier	11/18/1930			Original Owner Jno Ressen	5240002013	4725	Thomas Haverty Co.	4727	5000
4729	Whittier	9/5/1934			Original Owner John Strub	5240002014	4735	Colich and Radich		9000
4751	Whittier	10/5/1933	Norstrom & Anderson 1938		OO Watson E & Dudley F Jarr	5240003012	4757	HCE	758-766 S. Kern	9000
4759	Whittier	?9/29/30			OO? HH Jarritt	5240003013			4759-4763	7500
4765	Whittier	5/24/1929				5240003014				3400
4765	Whittier	5/24/1929			OO Charles Hildesheim	5240003015		M Vuskich	4765-4771	11600
4775	Whittier	9/1/1931			OO Mrs. Lasky	5240003016	4779	Vuksich & Gabrich		5000
4781	Whittier	6/14/1929			CJ Hildeshone (Charles J. Held	5240003017	4783	Frank Owens		6800
4801	Whittier	12/30/1937			Sontag Co.	5240006011	4805	Bob Bosnyak	768 Fetterly	8458
4815	Whittier	11/18/1931			Charles J. Hildesheim	5240006012		Vuksich & Gabrich	4811-4813	11480
4819	Whittier	1/25/1932			HH Schnakenberg	5240006013		Eastside HC Sewer		
4831	Whittier	5/7/1929	Morgan Walls & Clements		I Waitzman	5240006014	4823-48	Sanderson &Owens		21582
4901	Whittier	3/12/1935		1st Use Gas Station	OO John Laer	5240007010	4901-49	Colich and Radich	899 S Ferris	8930
5301	Whittier Bl			P-19-190087	Chase Bank, Mutual Chase Bank 6Y 2012 (K. A. Crawford), 1958 2S2, 6Y BERD Washington Mutual					
6039	Whittier Bl			19-176639	Amelias Dress Shop 1915 2S2, 3S BERD					
6135	Whittier Bl			P-19-190290	Pacific Bell Switch Building 6Y 2013 (K.A. Crawford)					
6333	Whittier Bl			19-176536	Gas Station 1926 5S2 BERD					
6421	Whittier Bl			P-19-176527,	2S2 1979 (GELA Cultural Heritage Survey Team, Casa Garcia Tamale Building; 1928 2S2, 3S BERD					
6537	Whittier Bl			P-19-191698	Historic Building 6Y 2010 (Barbara Lamprecht)					

Whittier Bl Proposed Rezoning to Mixed Use - sto

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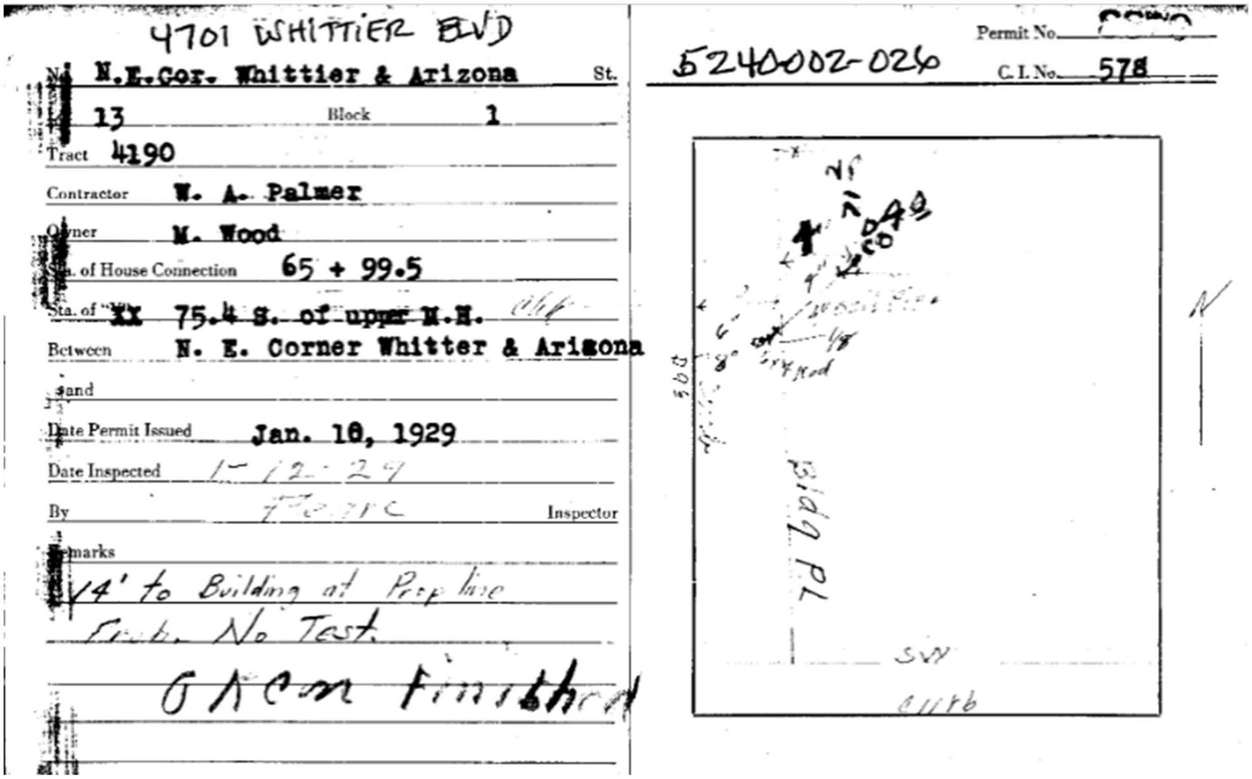
6537	Whittier Bl			P-19-191698	Historic Building 6Y 2010 (Barbara Lamprecht)					

WHITTIER BLVD EXHIBIT



4701 WHITTIER BLVD

No. N.E.Cor. Whittier & Arizona St.

Lot 13 Block 1

Tract 4190

Contractor W. A. Palmer

Owner M. Wood

Sta. of House Connection 65 + 99.5

Sta. of "XX 75.4 S. of upper M.H.

Between N. E. Corner Whitter & Arizona

and

Date Permit Issued Jan. 18, 1929

Date Inspected 1-12-29

By Pierce Inspector

Remarks

4' to Building at Prop line

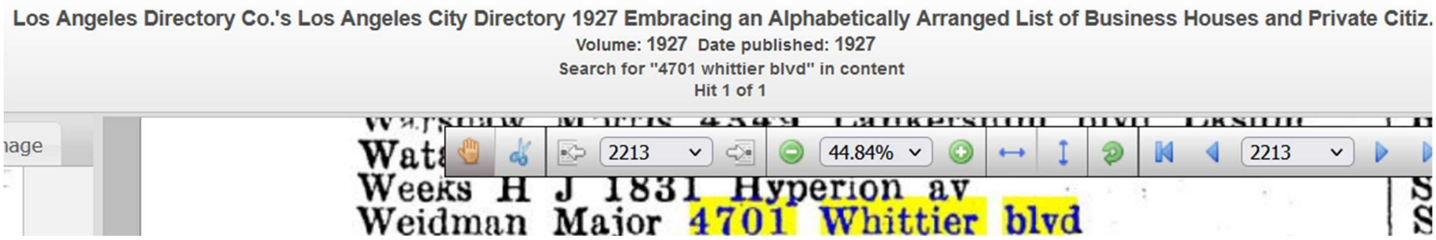
Fresh. No Test.

O K on Finished

5240002-026

Permit No.

C. I. No. 578



Los Angeles Directory Co.'s Los Angeles City Directory 1927 Embracing an Alphabetically Arranged List of Business Houses and Private Citiz.

Volume: 1927 Date published: 1927

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Hit 1 of 1

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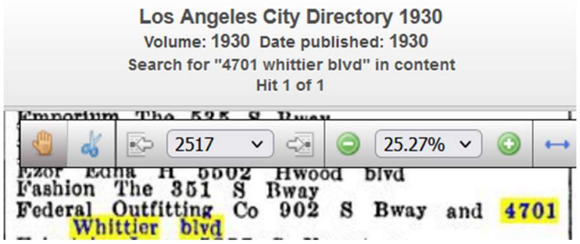
Weidman Major 4701 Whittier blvd



Los Angeles City Directory 1930

Volume: 1930 Date published: 1930

Search for "4701 whittier blvd" in content

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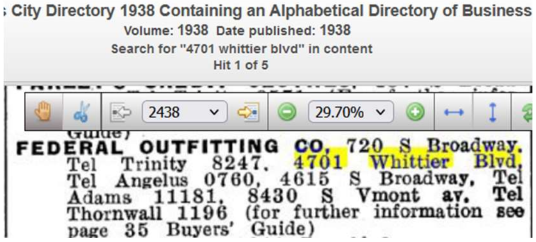
Ezor Edna H 5502 Hwood blvd

Fashion The 351 S Bway

Federal Outfitting Co 902 S Bway and 4701 Whittier blvd



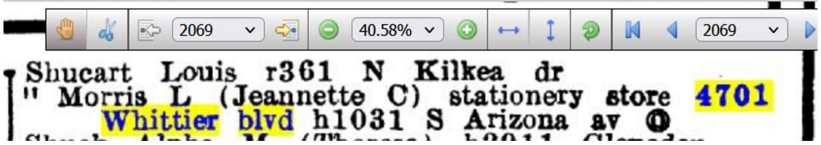
City Directory 1938 Containing an Alphabetical Directory of Business

Volume: 1938 Date published: 1938

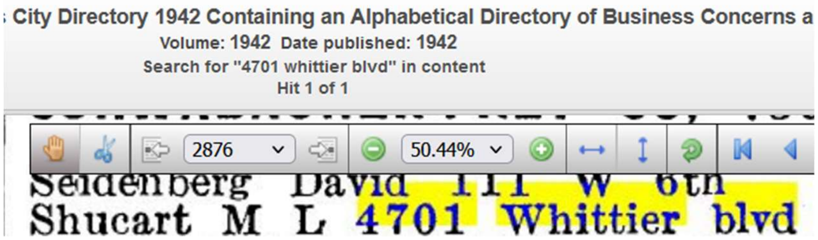
Search for "4701 whittier blvd" in content

Hit 1 of 5

FEDERAL OUTFITTING CO, 720 S Broadway, Tel Trinity 8247, 4701 Whittier Blvd, Tel Angelus 0760, 4615 S Broadway, Tel Adams 11181, 8430 S Vmont av, Tel Thornwall 1196 (for further information see page 35 Buyers' Guide)



Shucart Louis r361 N Kilkea dr
" Morris L (Jeannette C) stationery store 4701 Whittier blvd h1031 S Arizona av Ⓞ


City Directory 1942 Containing an Alphabetical Directory of Business Concerns a

Volume: 1942 Date published: 1942

Search for "4701 whittier blvd" in content

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Seidenberg David 111 W 6th
Shucart M L 4701 Whittier blvd


Whittier Bl
4701
4703
Outlet
© 2023 Google

2018


Whittier Bl
BIKE SHOP
FOR LEASE
626-945-5544
909-569-2496
Myrtle's Outlet
© 2022 Google

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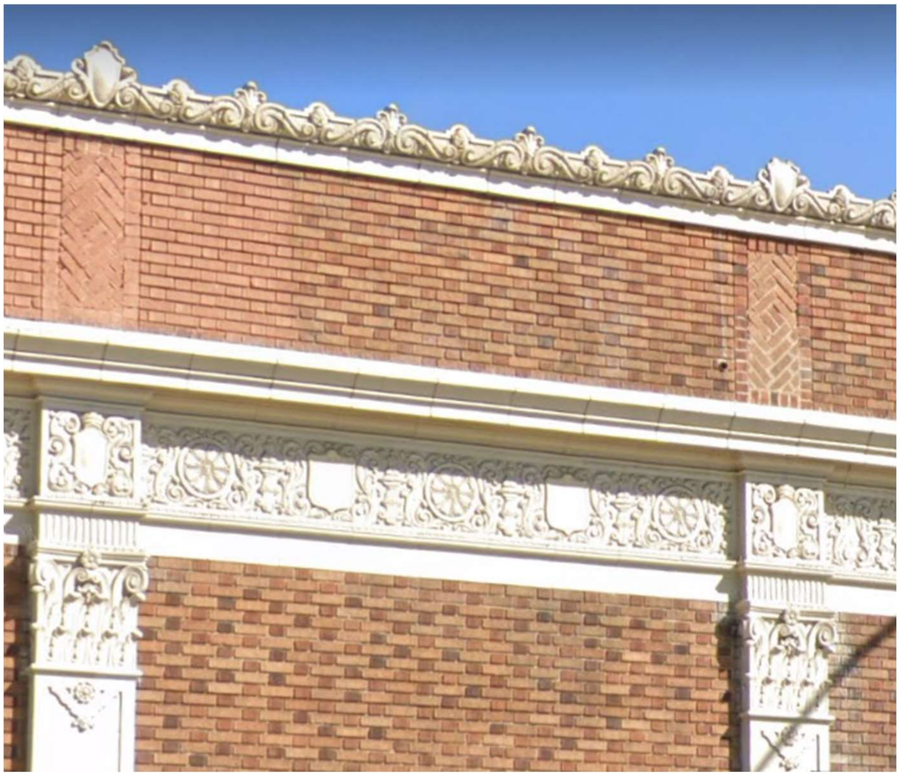


PLAZA
CENTER
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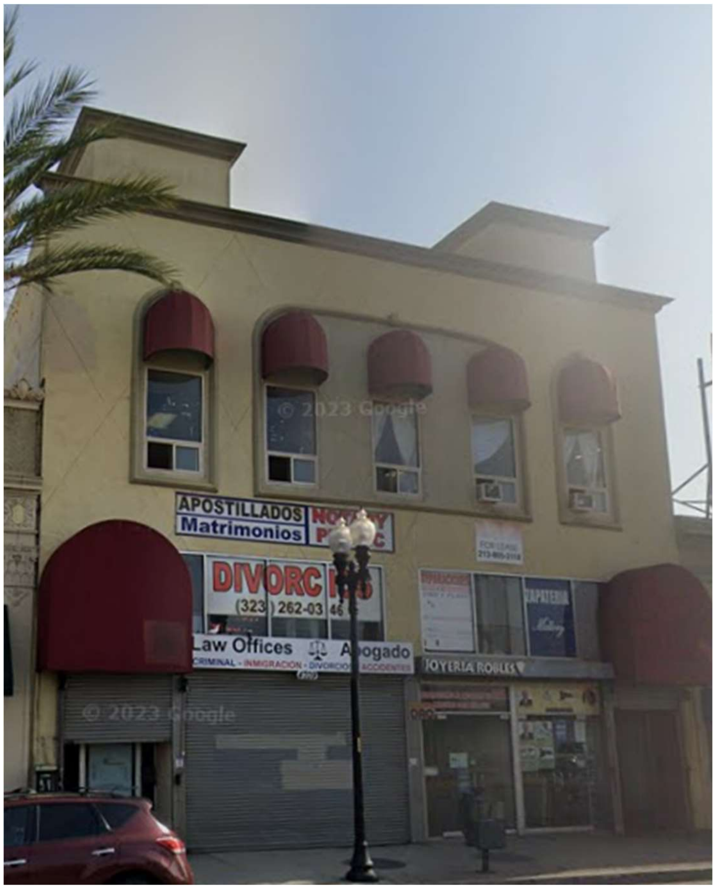
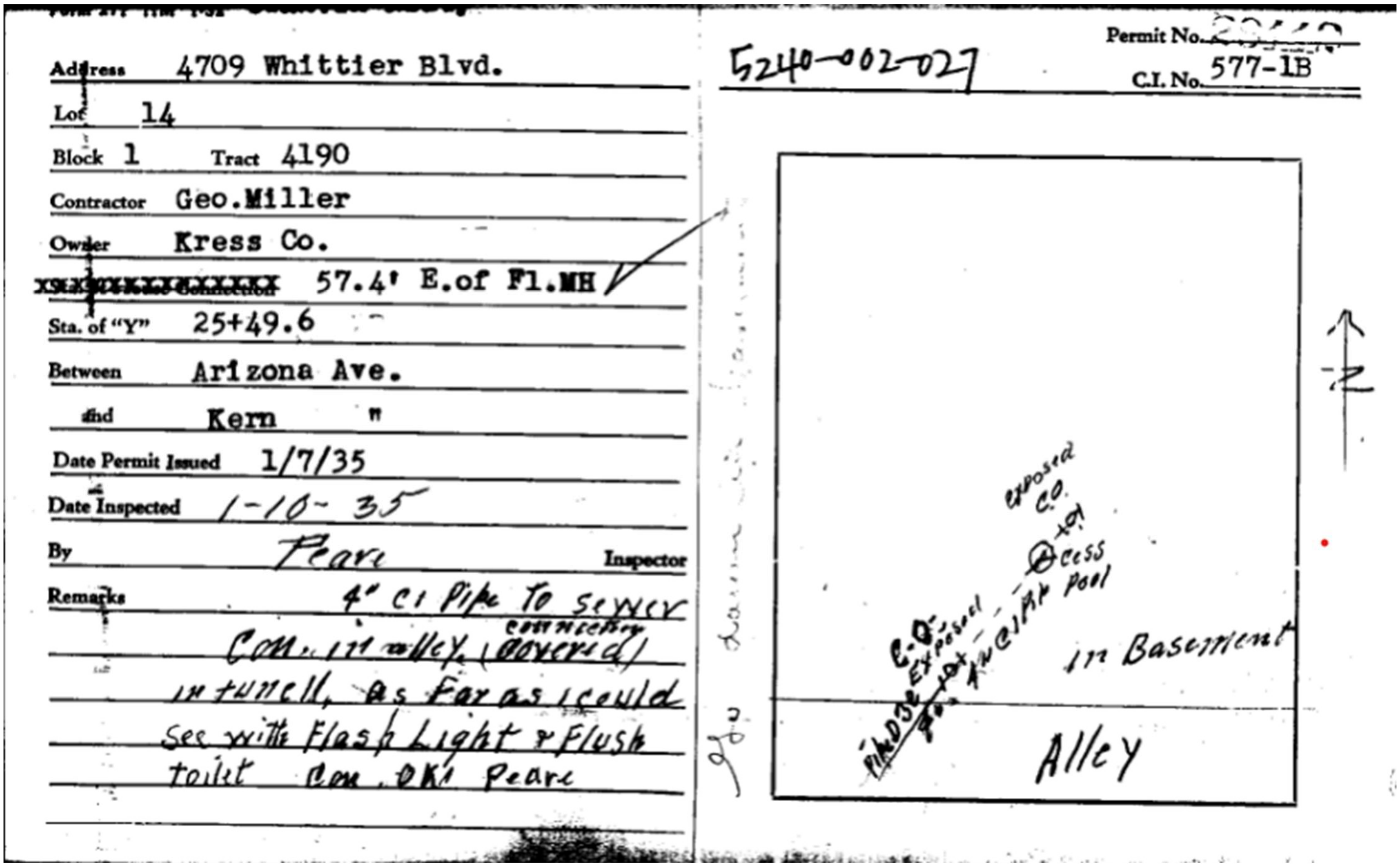




Permit No. [illegible]

5240-002-027

C.I. No. 577-1B

Address 4709 Whittier Blvd.

Lot 14

Block 1 Tract 4190

Contractor Geo.Miller

Owner Kress Co.

~~XXXXXXXXXXXXXXX~~ 57.4' E.of Fl.MH

Sta. of "Y" 25+49.6

Between Arizona Ave.

and Kern "

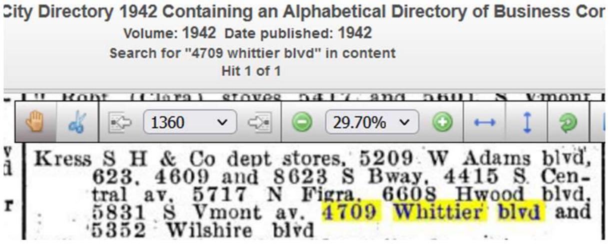
Date Permit Issued 1/7/35

Date Inspected 1-10-35

By Peare Inspector

Remarks 4" C I Pipe To sewer connecting Con. in alley, (covered) in tunell, As Far as I could see with Flash Light & Flush toilet Con. OK! Peare

2007



City Directory 1942 Containing an Alphabetical Directory of Business Cor
Volume: 1942 Date published: 1942
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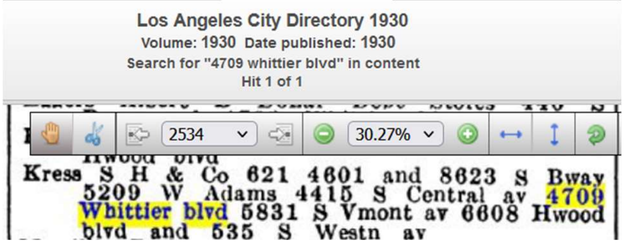
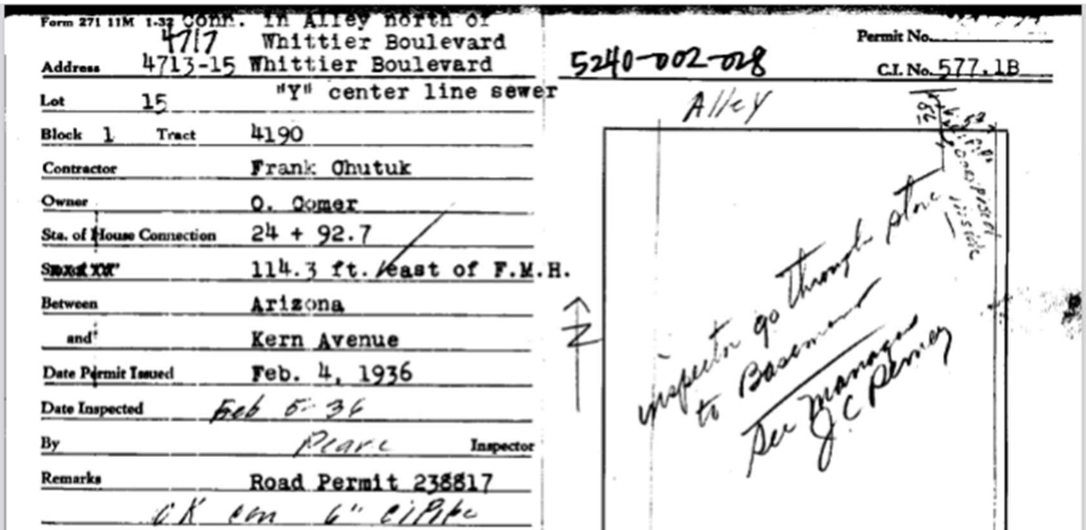
Kress S H & Co dept stores, 5209 W Adams blvd, 623, 4609 and 8623 S Bway, 4415 S Central av, 5717 N Figra, 6608 Hwood blvd, 5831 S Vmont av, 4709 Whittier blvd and 5352 Wilshire blvd



Los Angeles City Directory 1930
Volume: 1930 Date published: 1930
Search for "4709 whittier blvd" in content
Hit 1 of 1

Kress S H & Co 621 4601 and 8623 S Bway 5209 W Adams 4415 S Central av 4709 Whittier blvd 5831 S Vmont av 6608 Hwood blvd and 535 S Westn av


Form 271 11M 1-32 Conn. in Alley north of
4717 Whittier Boulevard

Address 4713-15 Whittier Boulevard

5240-002-028

Permit No.

C.I. No. 577.1B

Lot 15 "Y" center line sewer

Block 1 Tract 4190

Contractor Frank Chutuk

Owner O. Comer

Sta. of House Connection 24 + 92.7

S[illegible] 114.3 ft. east of F.M.H.

Between Arizona

and Kern Avenue

Date Permit Issued Feb. 4, 1936

Date Inspected Feb 5-36

By Pearc Inspector

Remarks Road Permit 238817

OK con 6" C I Pipe

Brooks Clothing was located at 4717 Whittier Blvd. See Current View above. Photo at left from taken around 1937 by Herman J. Schultheis. From LAPL collection.

Below is where the Safeway Market was located at 4721 Whittier Blvd


Rigo's Studio
DIGITAL PHOTO & VIDEO 323-980-0883
OUTLET STORE
Ropa • Electronicos • Furniture
WE SELL HAND SANITIZER
SE VENDE DESINFECTANTE DE MANO
WE SELL MASK
VENDEMOS MASCARILLAS

Con. in Alley

No. 4719 + 4721 Whittier Blvd. St.

5240-002-012

Permit No. [illegible]

C.I. No. 77 -- 1b

Lot 7 Block 1

Tract 1774

Contractor Nick Artukovich

Owner Mr. Crest

Sta. of House Connection 2[illegible] + 41.8

Sta. of "XX 138.0 W. of lower M. H. Chk

Between Kern

and Arizona

Date Permit Issued April 12, 1929

Date Inspected 4-17-29

By [illegible] Inspector

Remarks Lean + [illegible] not Reinforced)

[illegible]

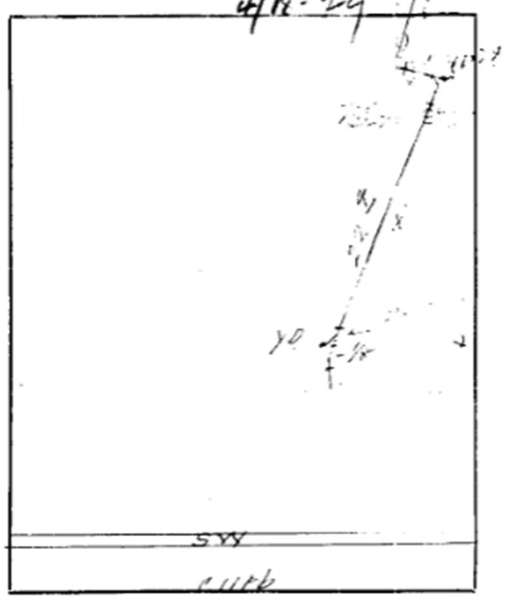
Job OK 4-18-29 1.35 Am

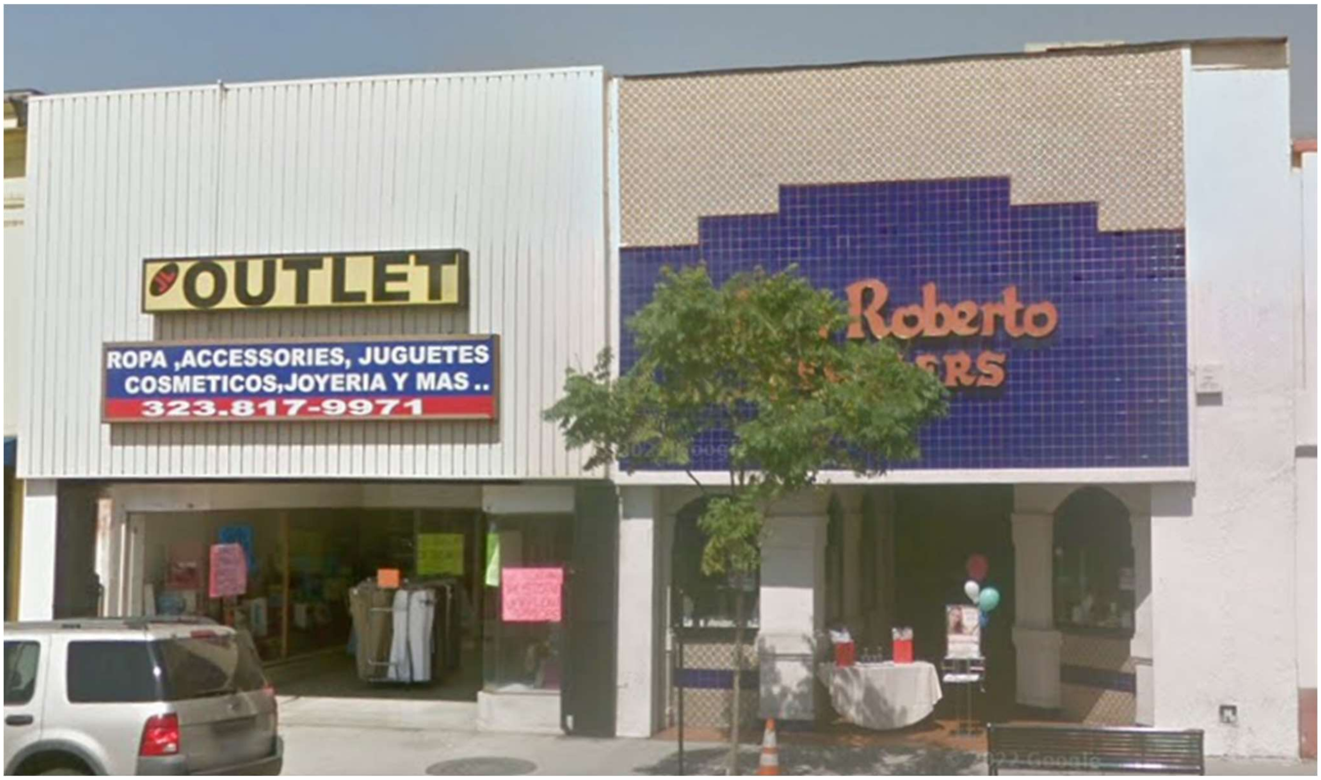
4-17-29 11:10 Am

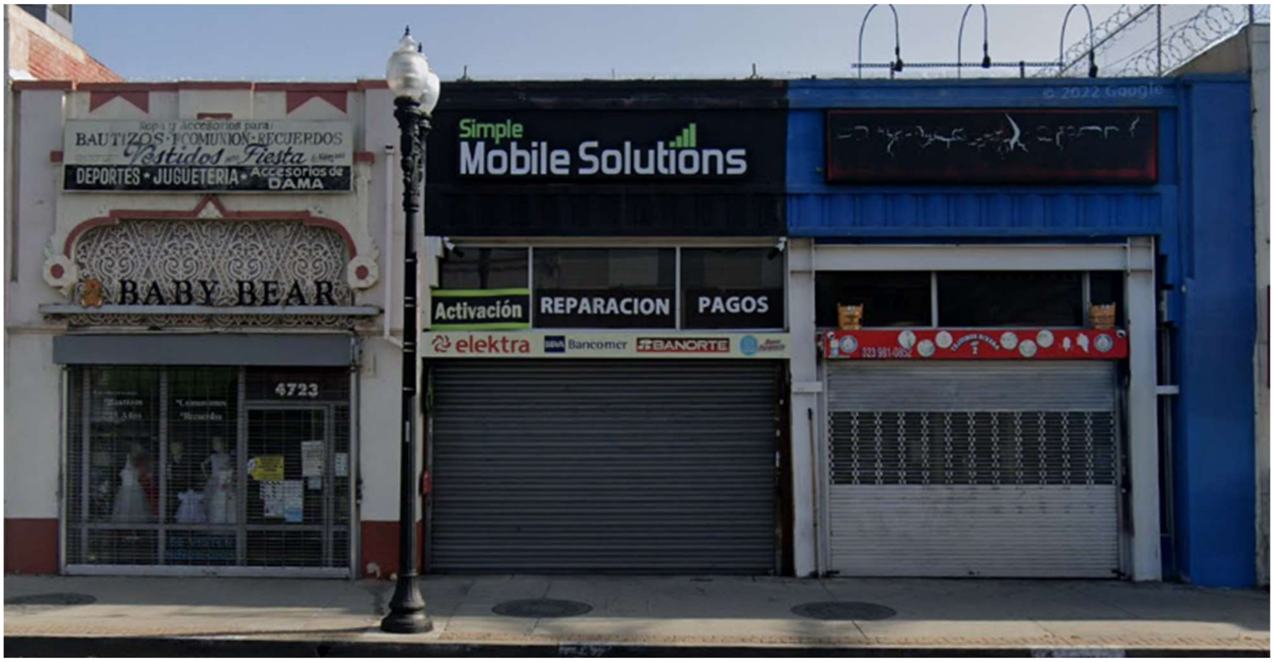
TIME ARR. ON JOB 10[illegible]

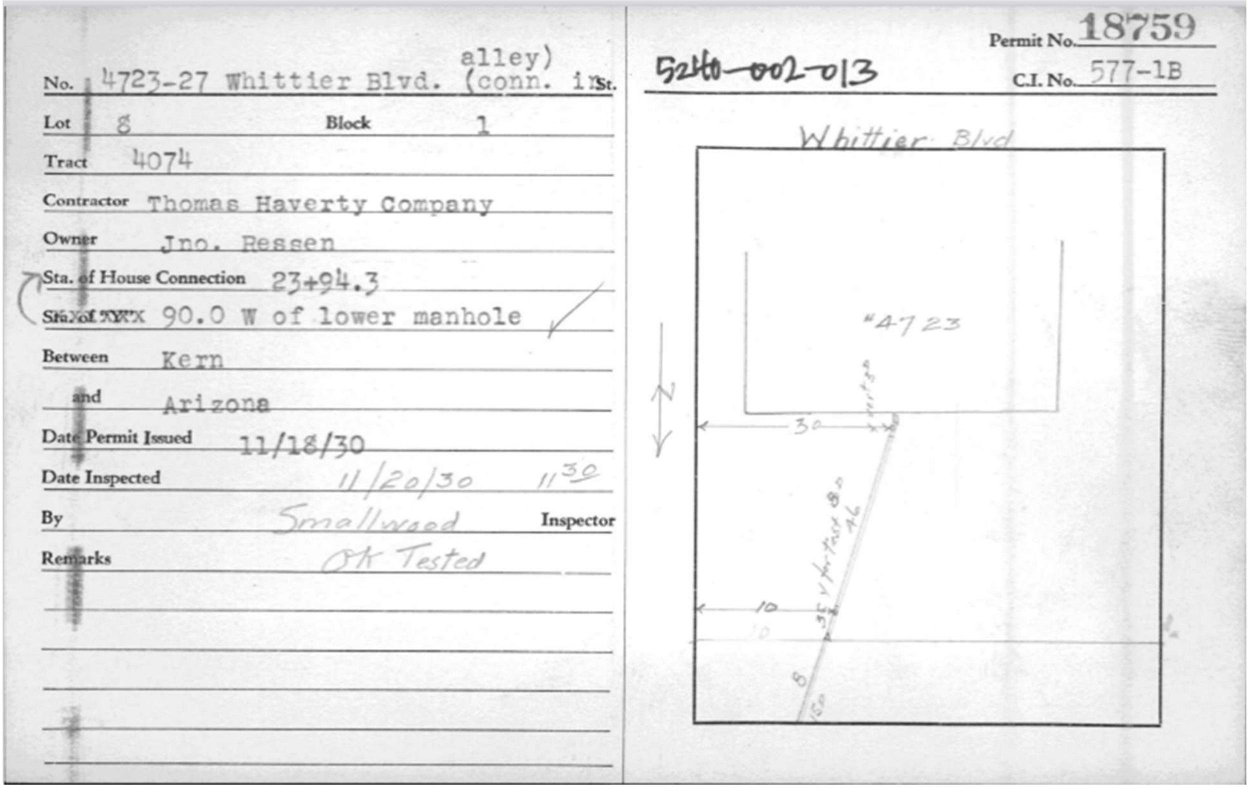
1210

4/18-29




OUTLET
ROPA ,ACCESSORIES, JUGUETES
COSMETICOS,JOYERIA Y MAS ..
323.817-9971
Roberto
ERS





Permit No. 18759

5240-002-013

C.I. No. 577-1B

No. 4723-27 Whittier Blvd. (conn. in alley) St.

Lot 8 Block 1

Tract 4074

Contractor Thomas Haverty Company

Owner Jno. Ressen

Sta. of House Connection 23+94.3

Sta. of XXXX 90.0 W of lower manhole ✓

Between Kern

and Arizona

Date Permit Issued 11/18/30

Date Inspected 11/20/30 11 30

By Smallwood Inspector

Remarks OK Tested

Form 271 11M 1-32

Permit No. 28385

5240-002-014

C.I. No. 577-8A

Address 4729-33 Whittier Blvd.

Lot 9

Block 1 Tract 4074

Contractor Colich and Radich

Owner John Strub

Sta. of House Connection 0 + 87.3

Sta. of "Y" 6.7 ft. No. of upper MH ✓

Between Whittier

and Hubbard Ave.

Date Permit Issued 9-5-34

Date Inspected 9/6/34

By Inspector

Remarks OK TESTED - BAL OF WORK ALL PLUMBING INSIDE BLDG

Form 271 11M 1-32 CONN IN ALLEY

Permit No. 28384

C.I. No. 577-1B

Address 4729-33 Whittier Blvd.

Lot 9

Block 1 Tract 4074

Contractor Colich and Radich

Owner John Strub

Sta. of House Connection Saddle OK

Sta. of "Y" XXXX 52± ft.N. of MH at Kern Ave. ✓

Between Kern

and Arizona Avenue

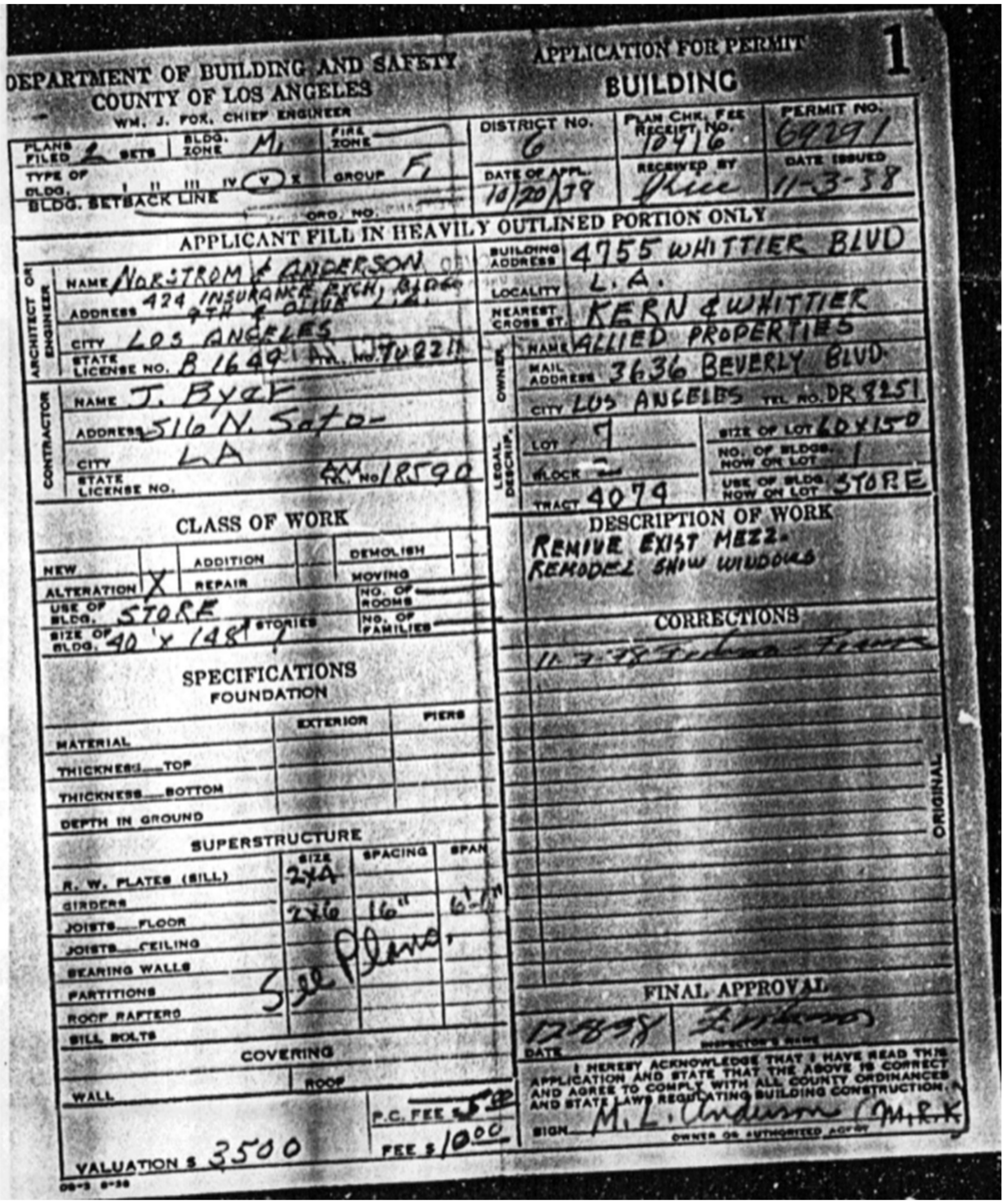
Date Permit Issued 9-5-34

Date Inspected 9/6/34

By Inspector

Remarks OK-SADDLE-6" BEND & REDUCER BAL OF WORK ALL PLUMBING INSIDE BLDG -


Outlet
4729
4735
Martha Zamora
& More
WOM NS FASHION
&
CELL P ONE ACCESORIES
CLUB
T-SHIRTS WHO SALE OUTLET
Dickies
© 2022 Goo



DEPARTMENT OF BUILDING AND SAFETY
COUNTY OF LOS ANGELES
WM. J. FOX, CHIEF ENGINEER

APPLICATION FOR PERMIT
BUILDING

1

PLANS FILED 2 SETS
BLDG. ZONE M1
FIRE ZONE
TYPE OF BLDG. I II III IV [✓ V] X
GROUP F1
BLDG. SETBACK LINE
ORD. NO.
DISTRICT NO. 6
PLAN CHK. FEE RECEIPT NO. 10416
PERMIT NO. 69291
DATE OF APPL. 10/20/38
RECEIVED BY Price
DATE ISSUED 11-3-38

APPLICANT FILL IN HEAVILY OUTLINED PORTION ONLY

ARCHITECT OR ENGINEER
NAME Norstrom & Anderson
ADDRESS 424 Insurance Exch. Bldg. 7th & Olive L.A.
CITY LOS ANGELES
STATE LICENSE NO. B 1649 TEL. NO. WY 0221

CONTRACTOR
NAME J. Byar
ADDRESS 516 N. Soto
CITY LA
STATE LICENSE NO. TEL. NO. AN 18590

BUILDING ADDRESS 4755 WHITTIER BLVD
LOCALITY L.A.
NEAREST CROSS ST. KERN & WHITTIER

OWNER
NAME ALLIED PROPERTIES
MAIL ADDRESS 3636 BEVERLY BLVD.
CITY LOS ANGELES TEL. NO. DR 8251

LEGAL DESCRIP.
LOT 7
BLOCK 2
TRACT 4079
SIZE OF LOT 60 X 150
NO. OF BLDGS. NOW ON LOT 1
USE OF BLDG. NOW ON LOT STORE

CLASS OF WORK
NEW
ALTERATION X
ADDITION
REPAIR
DEMOLISH
MOVING
USE OF BLDG. STORE
SIZE OF BLDG. 40' x 148' STORIES 1
NO. OF ROOMS
NO. OF FAMILIES

DESCRIPTION OF WORK
REMOVE EXIST MEZZ.
REMODEL SHOW WINDOWS

CORRECTIONS
11-7-38 [illegible]

SPECIFICATIONS
FOUNDATION

	EXTERIOR	PIERS
MATERIAL		
THICKNESS—TOP		
THICKNESS—BOTTOM		
DEPTH IN GROUND		

SUPERSTRUCTURE

	SIZE	SPACING	SPAN
R. W. PLATES (SILL)	2x4		
GIRDERS			
JOISTS—FLOOR	2x6	16"	6'-1"
JOISTS—CEILING			
BEARING WALLS			
PARTITIONS			
ROOF RAFTERS			
SILL BOLTS			

See Plans.

COVERING
WALL
ROOF

P.C. FEE $5.00
FEE $10.00
VALUATION $ 3500

FINAL APPROVAL
12-8-38
DATE
INSPECTOR'S NAME

I HEREBY ACKNOWLEDGE THAT I HAVE READ THIS APPLICATION AND STATE THAT THE ABOVE IS CORRECT AND AGREE TO COMPLY WITH ALL COUNTY ORDINANCES AND STATE LAWS REGULATING BUILDING CONSTRUCTION.

SIGN M. L. Anderson (M.R.K.)
OWNER OR AUTHORIZED AGENT

ORIGINAL

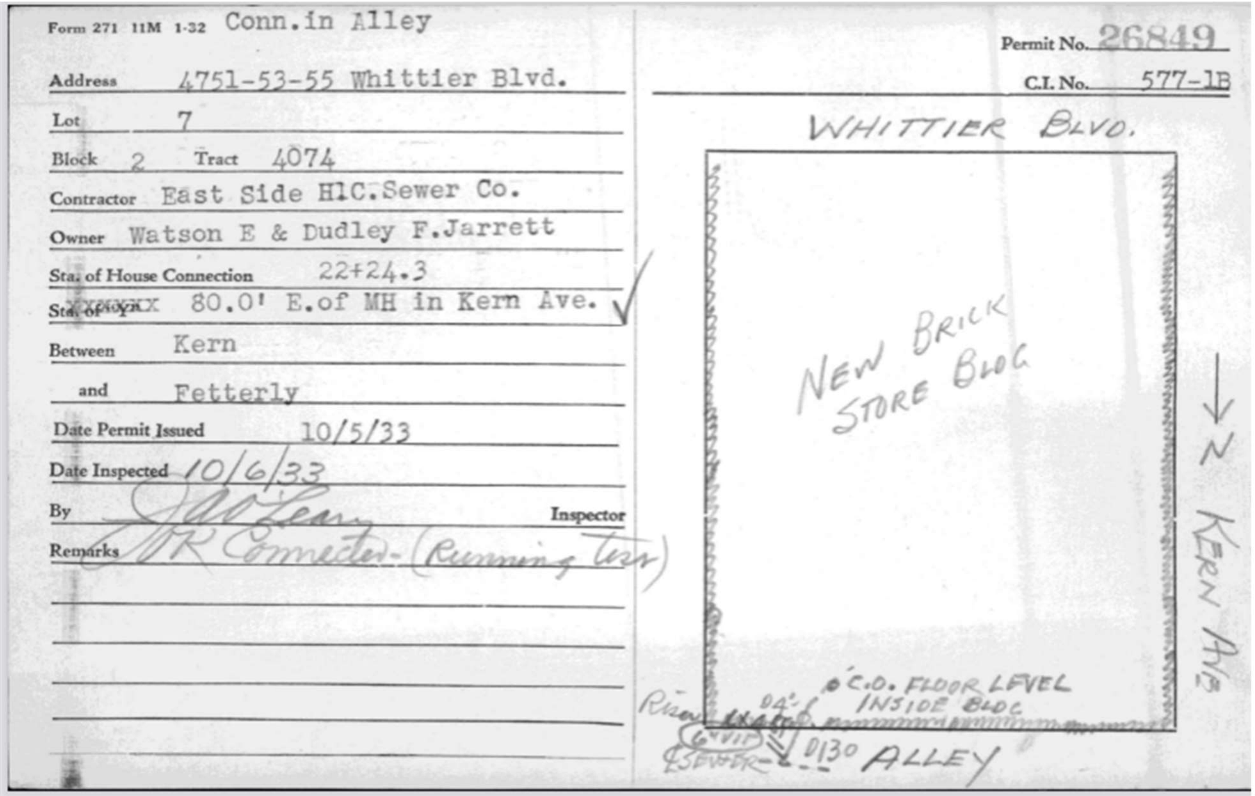
BS-3 6-38

Alvan Norstrom and Milton Anderson joined forces in the 1920s to create a design team that specialized in commercial and industrial structures throughout Southern California, although they were also known for their less common residential work, It is known that Norstrom & Anderson designed some significant branches for the Pacific Southwest Bank in Los Angeles and Pasadena.

Alvan Edward Norstrom, a San Francisco native, was bom on May 26, 1895. He moved to Los Angeles around 1920 and procured a draftsman position with Wilshire Decorators located at, 145 North Western Avenue. By 1924, he had gone into business for himself as Norstrom Architectural Services located at 112 West 9* Street, Room 1111. By 1928, Mr. Norstrom was working for architect John M. Cooper. It was there he got to know Milton Anderson who was also employed by Cooper. That year, Norstrom & Anderson, Architects and Engineers was established in downtown Los Angeles at 649 South Olive Sheet, Room 608. They later moved to 318 West 9lb Street, Room 424. Mr. Norstrom lived with his wife Marie at 1294 Mullen Avenue and later at 2028 Edendale Place and 5323 Harcouxt Avenue.

Milton Lawrence Anderson was bom in Iowa on November 15, 1895, He also arrived in Los Angeles around 1920 and went to work immediate!) in Cooper's office as a draftsman. Mr. Anderson and his wife Glynda resided at 2880 Edgebill Drive and later at 4635 Brynhurst Avenue. By the 1950s, they had moved to San Marino. Mr. Anderson joined the Southern California Chapter of the American Institute of Architects in 1947. (From: http://clkrep.lacity.org/onlinedocs/2019/19-0800_misc_07-12-2019.0001.pdf)

Norstrom and Anderson



Form 271 11M 1-32 Conn.in Alley

Permit No. 26849

C.I. No. 577-1B

Address 4751-53-55 Whittier Blvd.

Lot 7

Block 2 Tract 4074

Contractor East Side HlC.Sewer Co.

Owner Watson E & Dudley F.Jarrett

Sta. of House Connection 22+24.3

Sta. of "Y" XXXXXX 80.0' E.of MH in Kern Ave. ✓

Between Kern

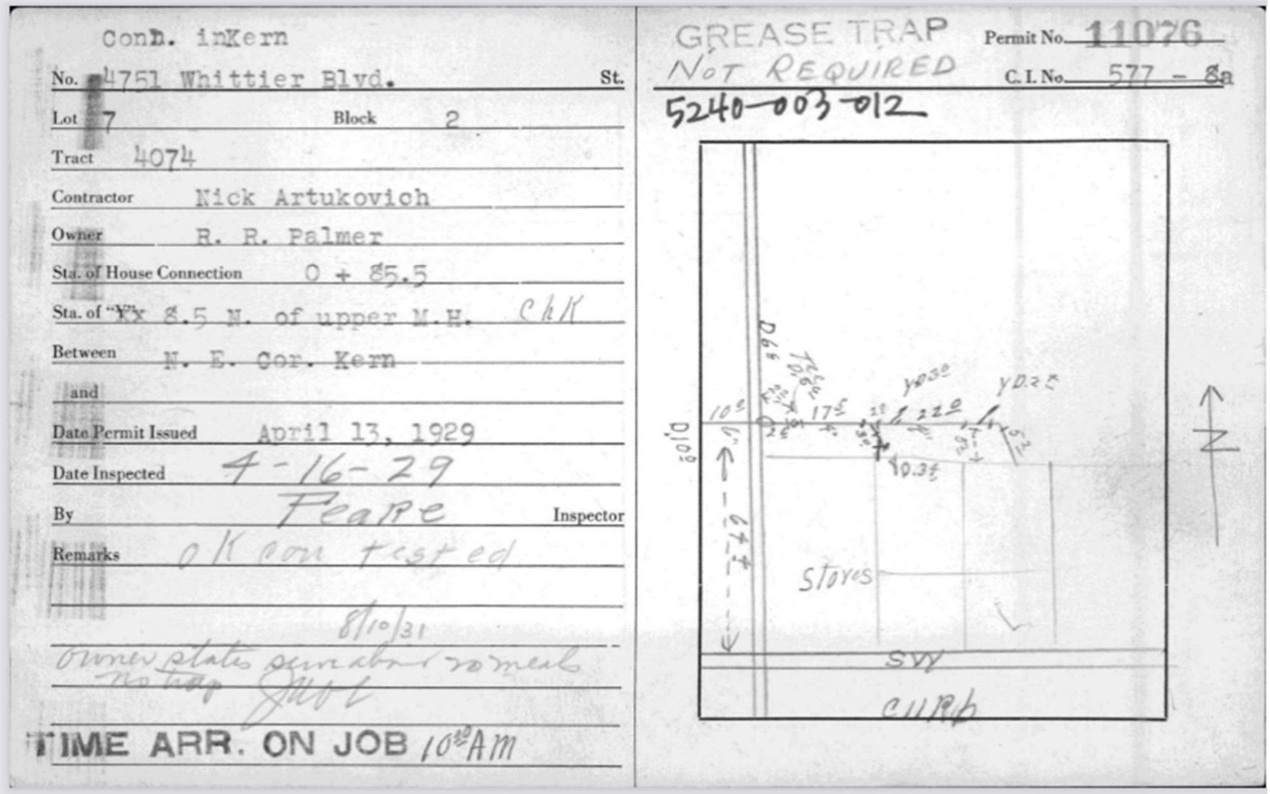
and Fetterly

Date Permit Issued 10/5/33

Date Inspected 10/6/33

By J.A. O'Leary Inspector

Remarks OK Connected - (Running test)



Conn. inKern

GREASE TRAP NOT REQUIRED

Permit No. 11076

C.I. No. 577 - 8a

5240-003-012

No. 4751 Whittier Blvd. St.

Lot 7 Block 2

Tract 4074

Contractor Nick Artukovich

Owner R. R. Palmer

Sta. of House Connection 0 + 85.5

Sta. of "Y" 8.5 N. of upper M.H. ChK

Between N. E. Cor. Kern

and

Date Permit Issued April 13, 1929

Date Inspected 4-16-29

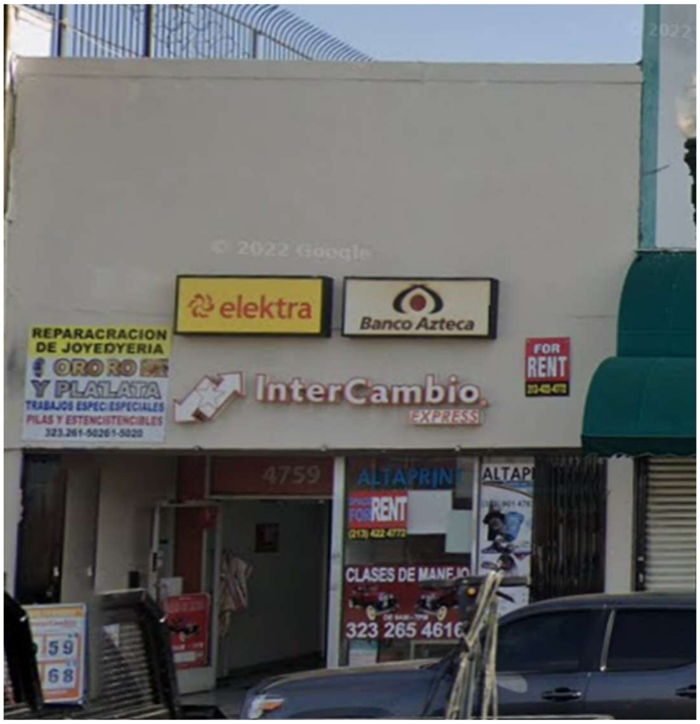
By Peare Inspector

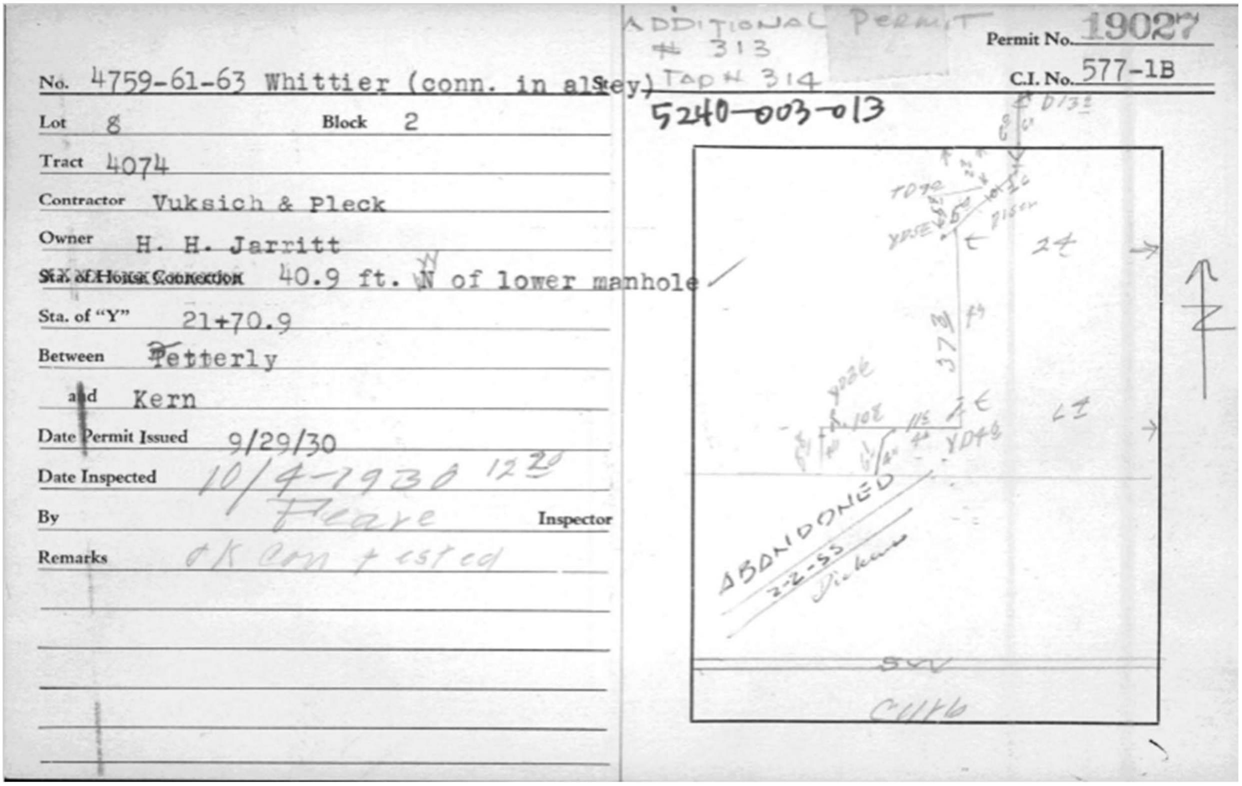
Remarks OK con tested

8/10/31

Owner states serve abt 20 meals no trap JMcL

TIME ARR. ON JOB 10^30 AM





ADDITIONAL PERMIT
313
TAP # 314

Permit No. 19027

C.I. No. 577-1B

No. 4759-61-63 Whittier (conn. in alley)

5240-003-013

Lot 8 Block 2

Tract 4074

Contractor Vuksich & Pleck

Owner H. H. Jarritt

Sta. of House Connection 40.9 ft. W of lower manhole

Sta. of "Y" 21+70.9

Between Fetterly

and Kern

Date Permit Issued 9/29/30

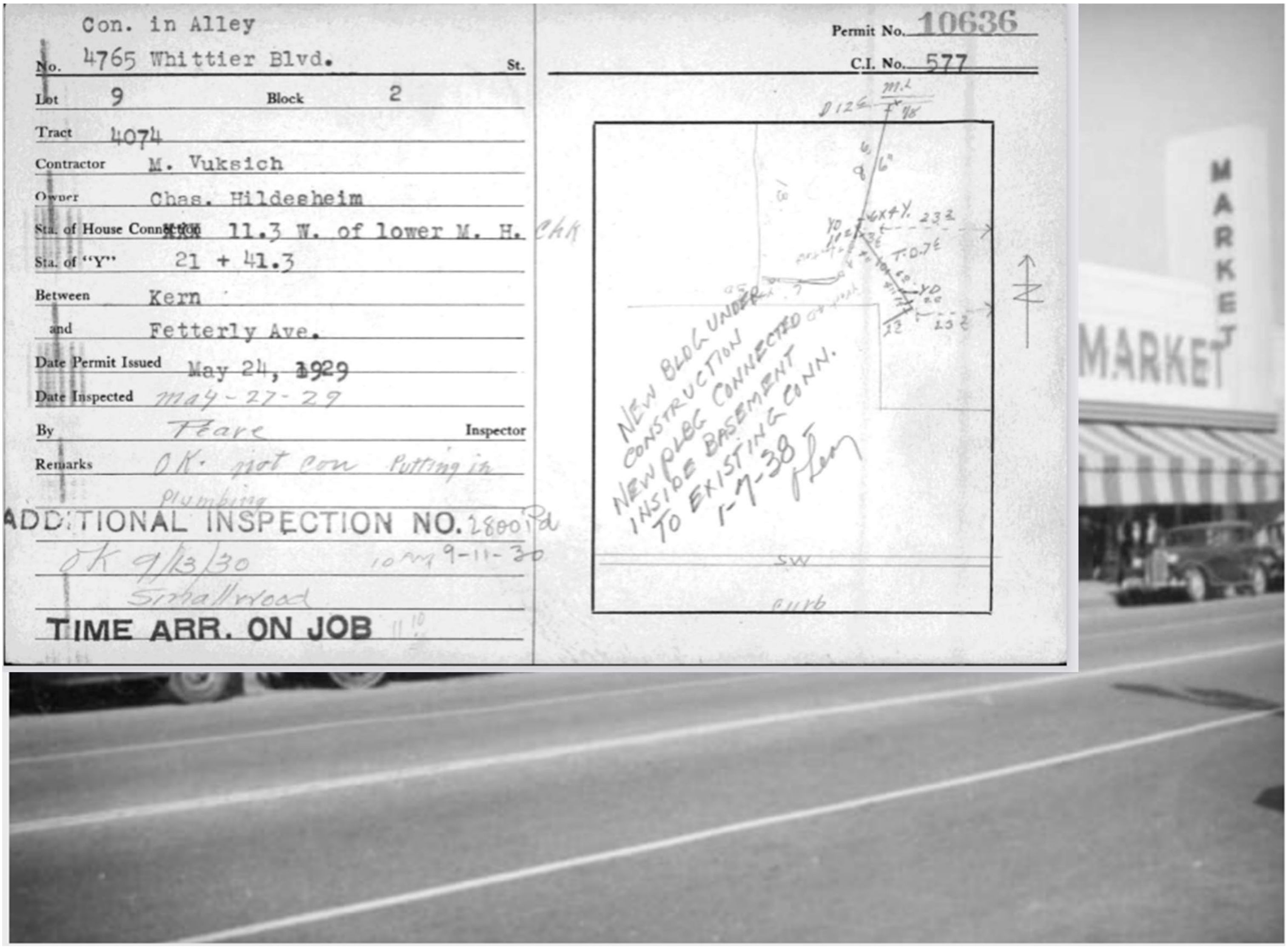
Date Inspected 10/4-1930 12²⁰

By Fleare Inspector

Remarks OK Con tested

ABANDONED
2-2-55

Cars park in front of the Late Moderne style Belvedere Gardens Market, located at 4769 Whittier Boulevard



Con. in Alley

Permit No. 10636

C.I. No. 577

No. 4765 Whittier Blvd. St.

Lot 9 Block 2

Tract 4074

Contractor M. Vuksich

Owner Chas. Hildesheim

Sta. of House Connection 11.3 W. of lower M. H. Chk

Sta. of "Y" 21 + 41.3

Between Kern

and Fetterly Ave.

Date Permit Issued May 24, 1929

Date Inspected May - 27 - 29

By Peare Inspector

Remarks OK. not con Putting in plumbing

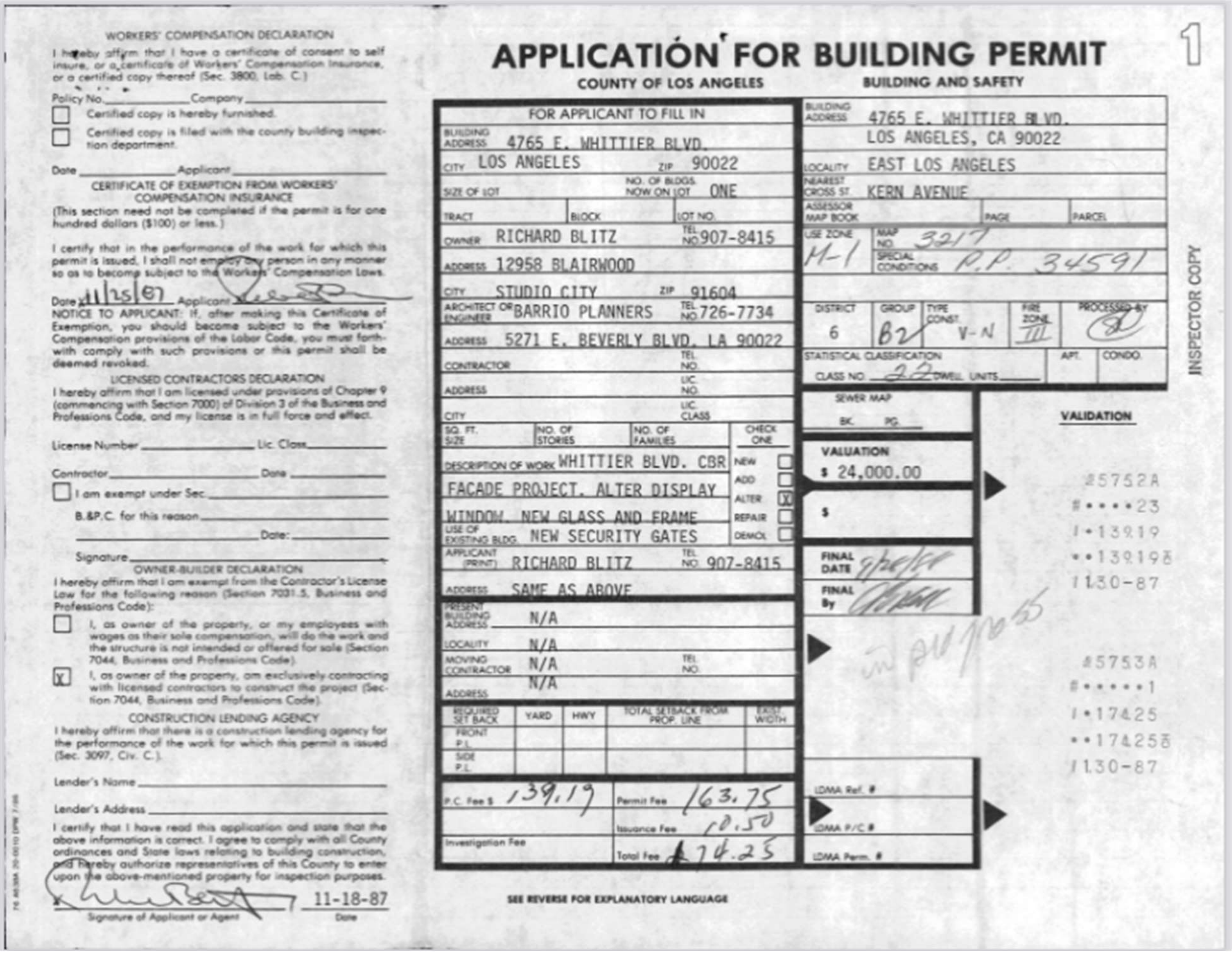
ADDITIONAL INSPECTION NO. 2800 Pd

OK 9/13/30 10 M 9-11-30

Smallwood

TIME ARR. ON JOB 11 10

NEW BLDG UNDER CONSTRUCTION NEW PLBG CONNECTED INSIDE BASEMENT TO EXISTING CONN. 1-7-38 Flem



WORKERS' COMPENSATION DECLARATION

I hereby affirm that I have a certificate of consent to self insure, or a certificate of Workers' Compensation Insurance, or a certified copy thereof (Sec. 3800, Lab. C.)

Policy No.________ Company________

☐ Certified copy is hereby furnished.

☐ Certified copy is filed with the county building inspection department.

Date ________ Applicant ________

CERTIFICATE OF EXEMPTION FROM WORKERS' COMPENSATION INSURANCE

(This section need not be completed if the permit is for one hundred dollars ($100) or less.)

I certify that in the performance of the work for which this permit is issued, I shall not employ any person in any manner so as to become subject to the Workers' Compensation Laws.

Date 11/25/87 Applicant

NOTICE TO APPLICANT: If, after making this Certificate of Exemption, you should become subject to the Workers' Compensation provisions of the Labor Code, you must forthwith comply with such provisions or this permit shall be deemed revoked.

LICENSED CONTRACTORS DECLARATION

I hereby affirm that I am licensed under provisions of Chapter 9 (commencing with Section 7000) of Division 3 of the Business and Professions Code, and my license is in full force and effect.

License Number ________ Lic. Class ________

Contractor ________ Date ________

☐ I am exempt under Sec. ________

B.&P.C. for this reason ________

________ Date: ________

Signature ________

OWNER-BUILDER DECLARATION

I hereby affirm that I am exempt from the Contractor's License Law for the following reason (Section 7031.5, Business and Professions Code):

☐ I, as owner of the property, or my employees with wages as their sole compensation, will do the work and the structure is not intended or offered for sale (Section 7044, Business and Professions Code).

☒ I, as owner of the property, am exclusively contracting with licensed contractors to construct the project (Section 7044, Business and Professions Code).

CONSTRUCTION LENDING AGENCY

I hereby affirm that there is a construction lending agency for the performance of the work for which this permit is issued (Sec. 3097, Civ. C.).

Lender's Name ________

Lender's Address ________

I certify that I have read this application and state that the above information is correct. I agree to comply with all County ordinances and State laws relating to building construction, and hereby authorize representatives of this County to enter upon the above-mentioned property for inspection purposes.

X ________ 11-18-87
Signature of Applicant or Agent — Date

APPLICATION FOR BUILDING PERMIT

COUNTY OF LOS ANGELES — **BUILDING AND SAFETY**

1

INSPECTOR COPY

FOR APPLICANT TO FILL IN

BUILDING ADDRESS 4765 E. WHITTIER BLVD.
CITY LOS ANGELES ZIP 90022
SIZE OF LOT — NO. OF BLDGS. NOW ON LOT ONE
TRACT — BLOCK — LOT NO.
OWNER RICHARD BLITZ TEL. NO. 907-8415
ADDRESS 12958 BLAIRWOOD
CITY STUDIO CITY ZIP 91604
ARCHITECT OR ENGINEER BARRIO PLANNERS TEL. NO. 726-7734
ADDRESS 5271 E. BEVERLY BLVD. LA 90022
CONTRACTOR — TEL. NO.
ADDRESS — LIC. NO.
CITY — LIC. CLASS
SQ. FT. SIZE — NO. OF STORIES — NO. OF FAMILIES

CHECK ONE: NEW ☐ ADD ☐ ALTER ☒ REPAIR ☐ DEMOL. ☐

DESCRIPTION OF WORK WHITTIER BLVD. CBR FACADE PROJECT. ALTER DISPLAY WINDOW. NEW GLASS AND FRAME
USE OF EXISTING BLDG. NEW SECURITY GATES
APPLICANT (PRINT) RICHARD BLITZ TEL. NO. 907-8415
ADDRESS SAME AS ABOVE

PRESENT BUILDING ADDRESS N/A
LOCALITY N/A
MOVING CONTRACTOR N/A TEL. NO.
ADDRESS N/A

REQUIRED SET BACK	YARD	HWY	TOTAL SETBACK FROM PROP. LINE	EXIST. WIDTH
FRONT P.L.				
SIDE P.L.				

P.C. Fee $ 139.19
Permit Fee 163.75
Issuance Fee 10.50
Investigation Fee
Total Fee 174.25

SEE REVERSE FOR EXPLANATORY LANGUAGE

BUILDING ADDRESS 4765 E. WHITTIER BLVD.
LOS ANGELES, CA 90022
LOCALITY EAST LOS ANGELES
NEAREST CROSS ST. KERN AVENUE
ASSESSOR MAP BOOK — PAGE — PARCEL
USE ZONE M-1 — MAP NO. 3217
SPECIAL CONDITIONS P.P. 34591
DISTRICT 6 — GROUP B2 — TYPE CONST. V-N — FIRE ZONE III — PROCESSED BY
STATISTICAL CLASSIFICATION CLASS NO. 22 DWELL. UNITS ____ APT. — CONDO.
SEWER MAP BK. ____ PG. ____
VALUATION $ 24,000.00
$
FINAL DATE [illegible]
FINAL By

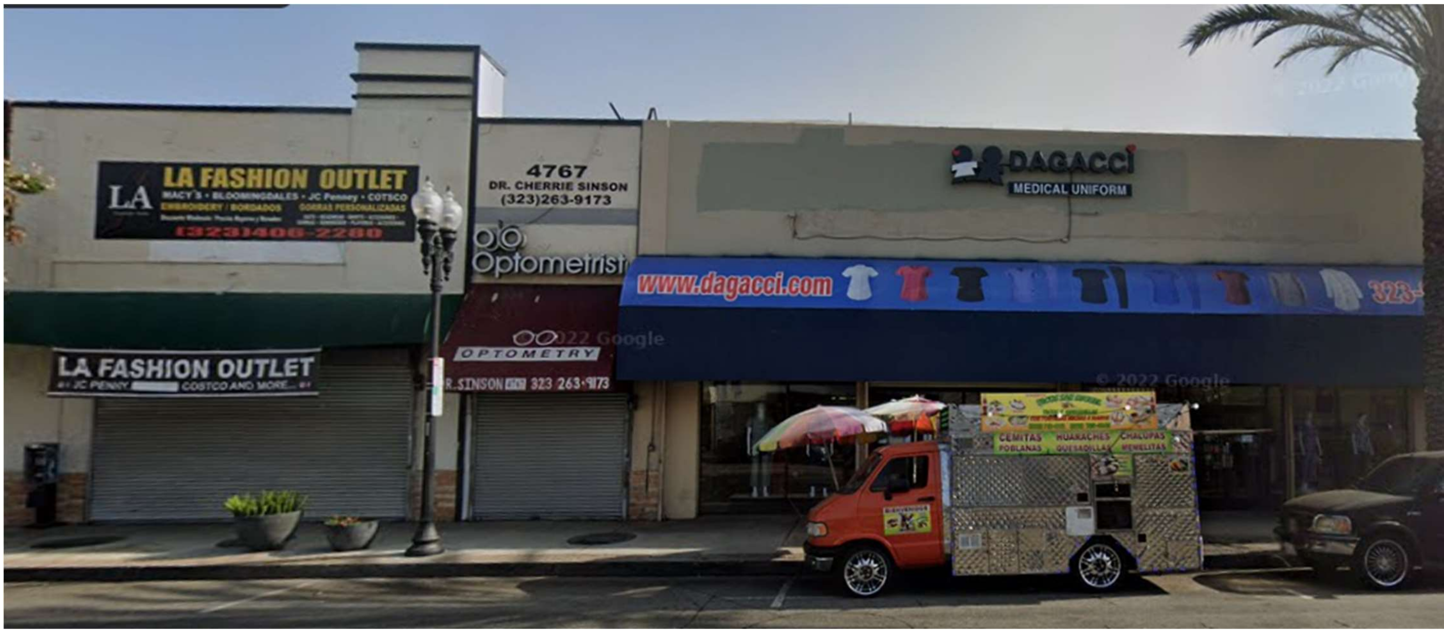
[illegible]

LDMA Ref. #
LDMA P/C #
LDMA Perm. #

VALIDATION

#5752A
#•••••23
/•139.19
••139.19δ
/1.30-87

#5753A
#••••••1
/•174.25
••174.25δ
/1.30-87


LA FASHION OUTLET
MACY'S • BLOOMINGDALES • JC Penney • COTSCO
EMBROIDERY / BORDADOS
GORRAS PERSONALIZADAS
(323)406-2280
4767
DR. CHERRIE SINSON
(323)263-9173
Optometrist
OPTOMETRY
R. SINSON 323 263-9173
LA FASHION OUTLET
JC PENNEY
COSTCO AND MORE...
DAGACCI
MEDICAL UNIFORM
www.dagacci.com
CEMITAS POBLANAS
HUARACHES QUESADILLAS
CHALUPAS MEMELITAS
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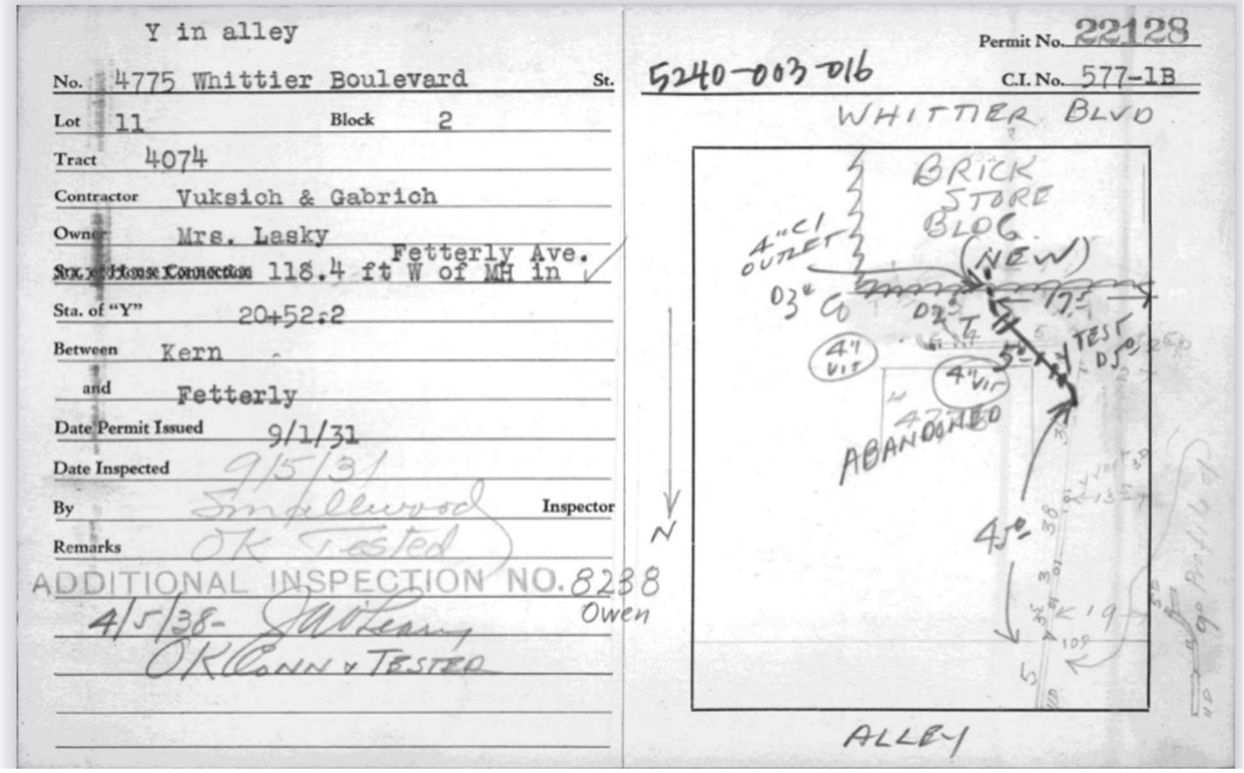


Y in alley

No. 4775 Whittier Boulevard St. 5240-003-016

Permit No. 22128

C.I. No. 577-1B

Lot 11 Block 2

Tract 4074

Contractor Vuksich & Gabrich

Owner Mrs. Lasky

~~Sta. of House Connection~~ 118.4 ft W of MH in Fetterly Ave. ✓

Sta. of "Y" 20+52.2

Between Kern

and Fetterly

Date Permit Issued 9/1/31

Date Inspected 9/5/31

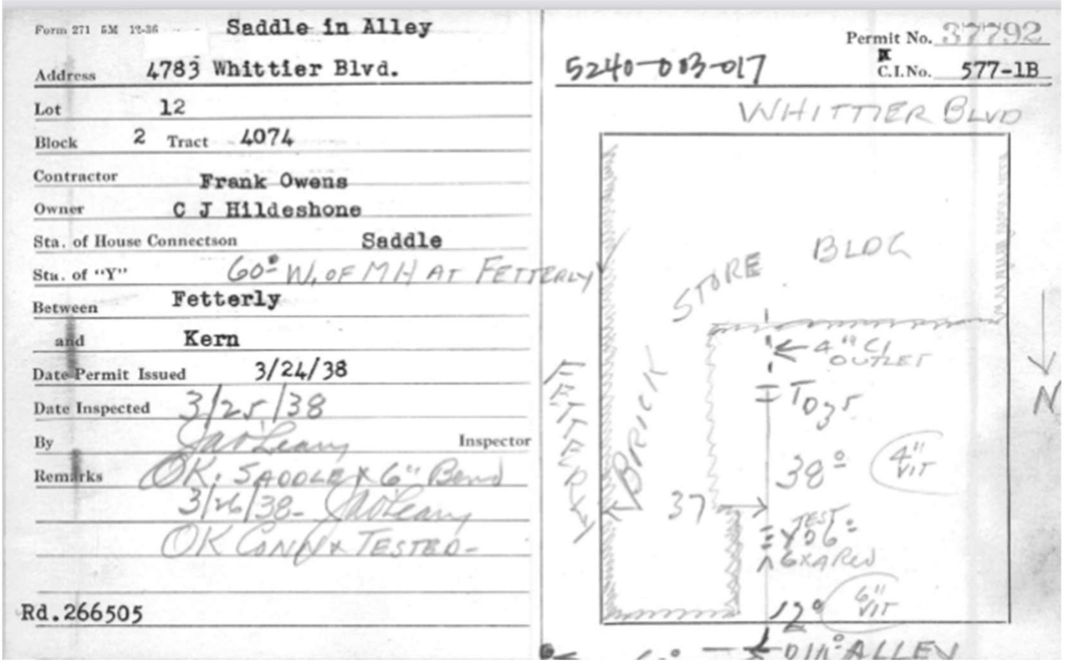
By Smallwood Inspector

Remarks OK Tested

ADDITIONAL INSPECTION NO. 8238 Owen

4/5/38- J. A. O'Leary

OK Conn & Tested



Form 271 5M 12-36 Saddle in Alley

Permit No. 37792

Address 4783 Whittier Blvd.

5240-013-017

C.I.No. 577-1B

Lot 12

Block 2 Tract 4074

Contractor Frank Owens

Owner C J Hildeshone

Sta. of House Connectson Saddle

Sta. of "Y" 60° W. of MH at Fetterly

Between Fetterly

and Kern

Date Permit Issued 3/24/38

Date Inspected 3/25/38

By JaMcLeany Inspector

Remarks OK. Saddle & 6" Bend

3/26/38- JaMcLeany

OK Conn & Tested-

Rd.266505

Conn in Fetterly

[redacted]

No. 4789 Whittier Blvd St.

Lot 12 Block 2

Tract 4074

Contractor Mike Vuksich

Owner Chas J. Heldeshrien

Sta. of House Connection 0 + 84.1

Sta. of "Y" 9.9 ft N. of F.M.H. ✓

Between Kern

and Fetterly

Date Permit Issued June 14, 1929

Date Inspected 6/19/29

By Smallwood Inspector

Remarks OK Tested

ADDITIONAL INSPECTION NO. 2603 Pd 7-5-30

OK 7/7/30 12^30

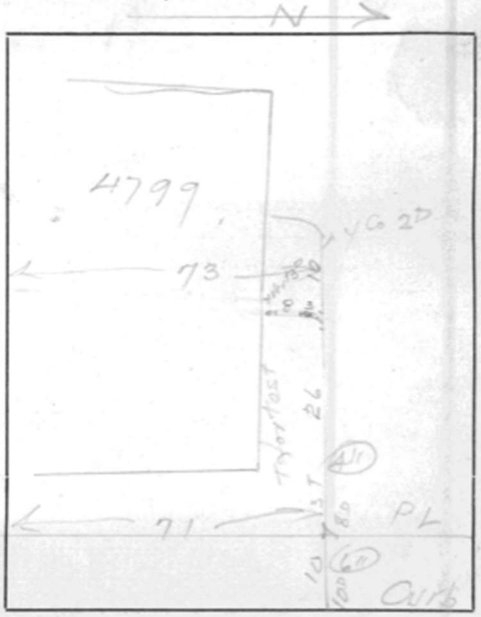
Smallwood

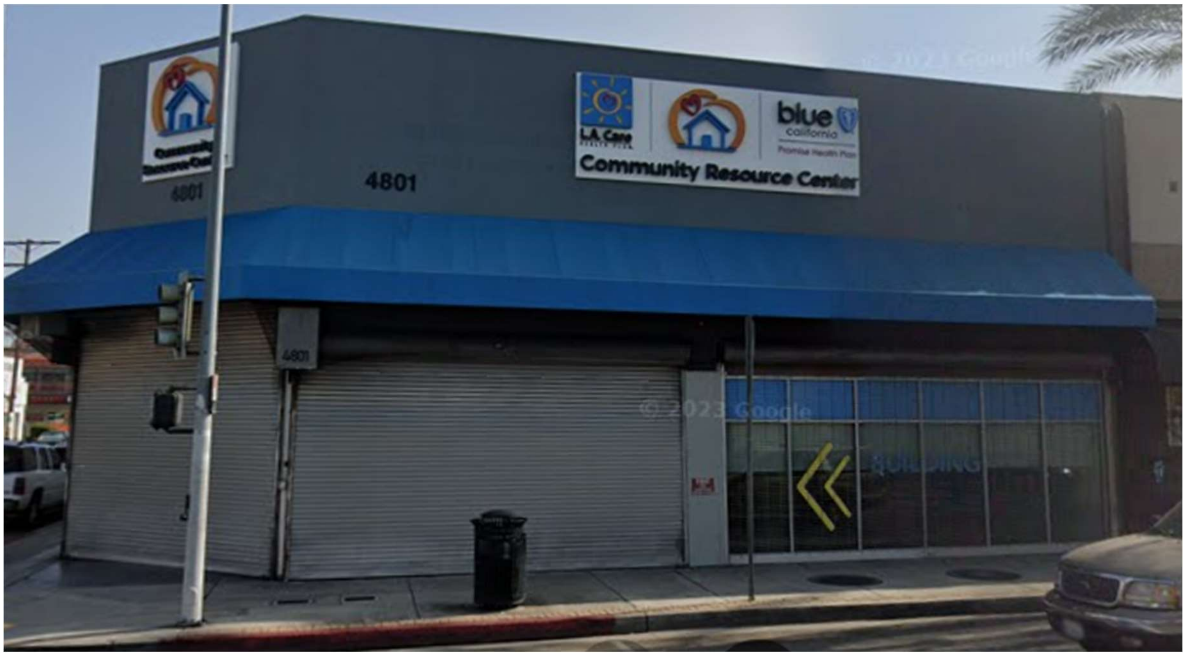
TIME ARR. ON JOB 2 PM

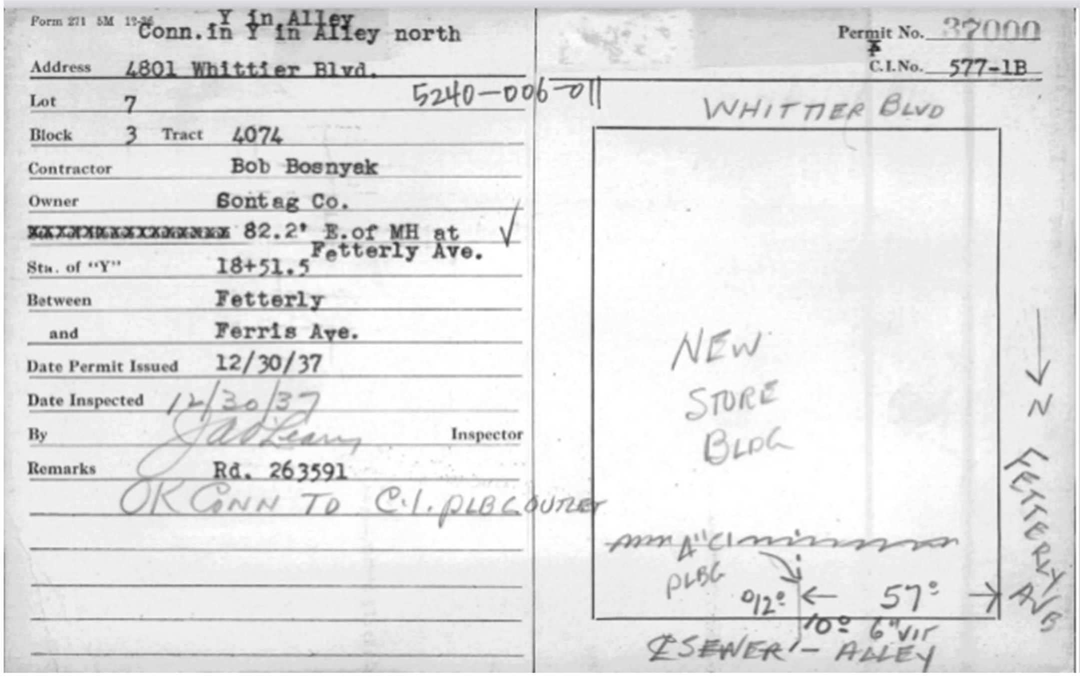
5240-003-017

Permit No. 10883

C. I. No. 577 - 9a







Form 271 5M 12-36

Y in Alley
Conn.in Y in Alley north

Permit No. 37000

C.I.No. 577-1B

Address 4801 Whittier Blvd.

Lot 7 5240-006-011

Block 3 Tract 4074

Contractor Bob Bosnyak

Owner Sontag Co.

~~XXXXXXXXXXXXXXX~~ 82.2' E.of MH at Fetterly Ave. √

Sta. of "Y" 18+51.5

Between Fetterly

and Ferris Ave.

Date Permit Issued 12/30/37

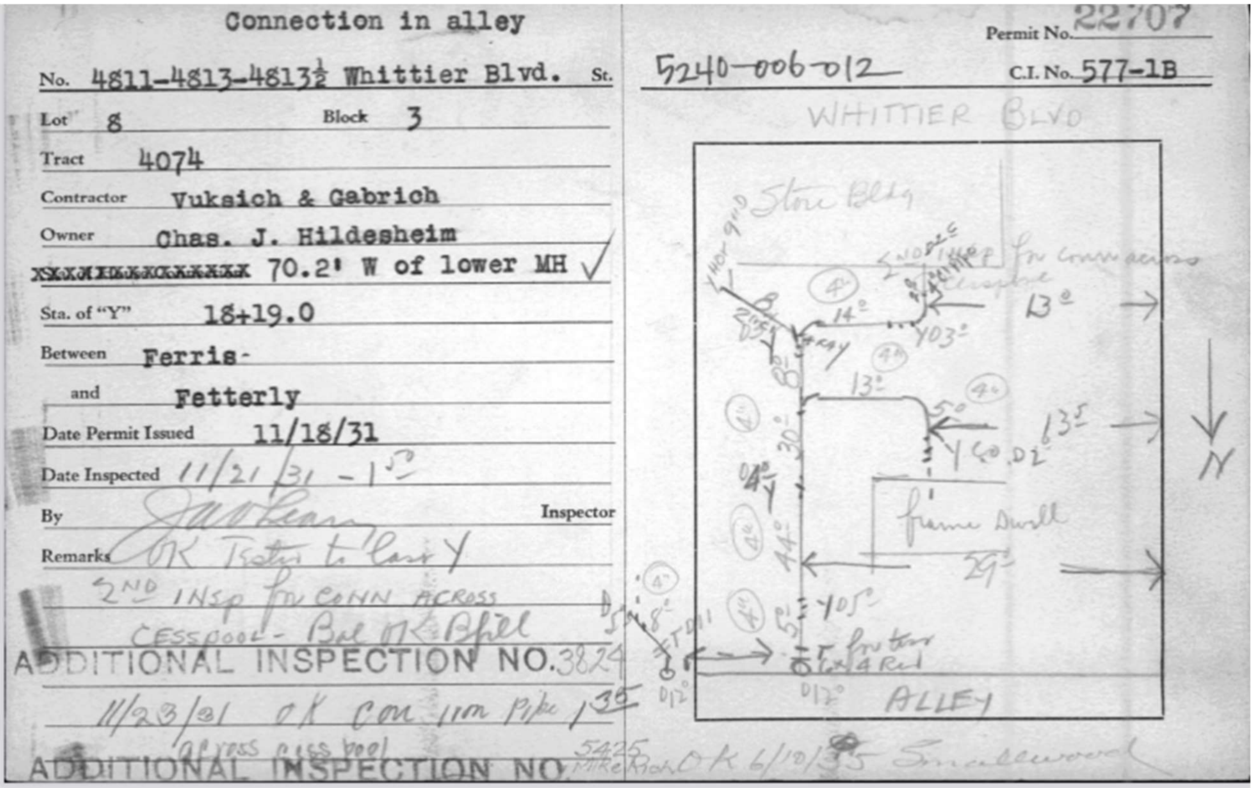
Date Inspected 12/30/37

By J A Leary Inspector

Remarks Rd. 263591

OK CONN TO C.I. PLBG OUTLET

2007



Connection in alley

Permit No. 22707

No. 4811-4813-4813½ Whittier Blvd. St.

5240-006-012

C.I. No. 577-1B

Lot 8

Block 3

Tract 4074

Contractor Vuksich & Gabrich

Owner Chas. J. Hildesheim

~~XXXXXXXXXXXXXX~~ 70.2' W of lower MH ✓

Sta. of "Y" 18+19.0

Between Ferris-

and Fetterly

Date Permit Issued 11/18/31

Date Inspected 11/21/31 - 1⁵⁰

By J. A. Lean Inspector

Remarks OK Tester to last Y

2ND INSP for CONN ACROSS

CESSPOOL - Bal OK Bfill

ADDITIONAL INSPECTION NO. 3824

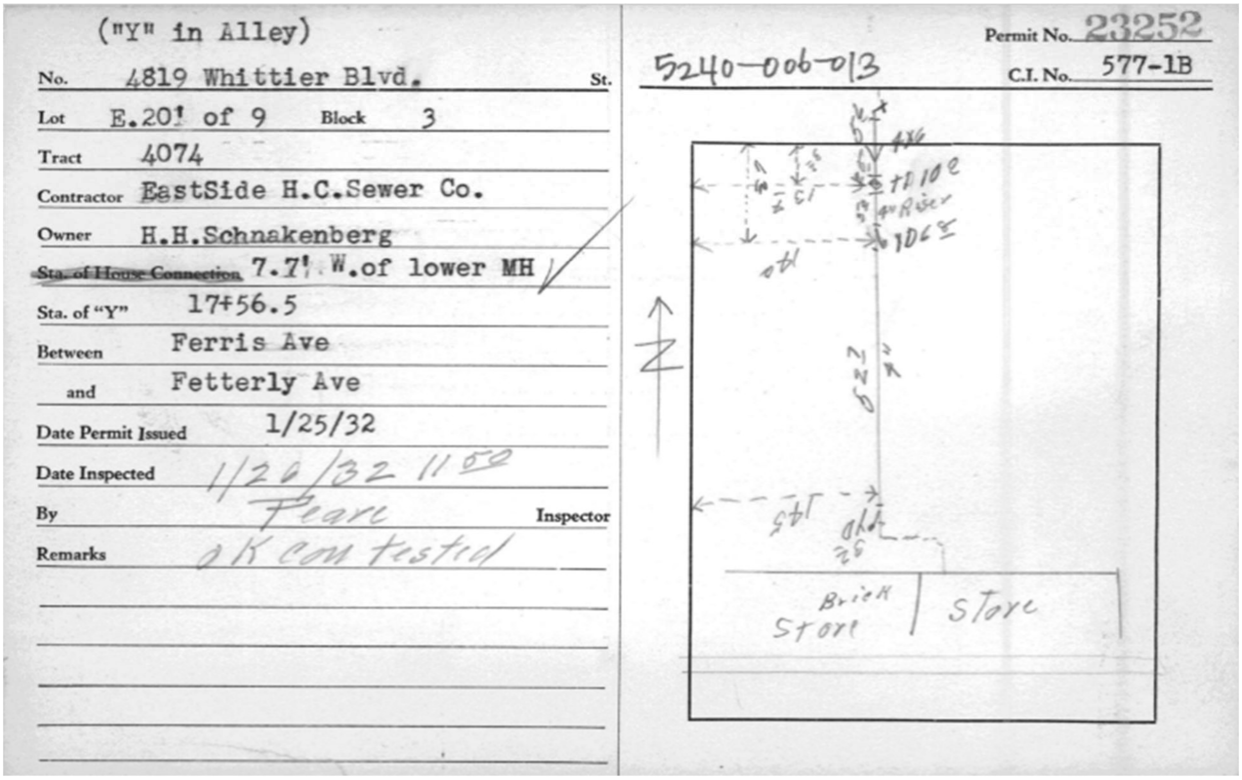
11/23/31 OK Con 11m Pipe 1³⁵

across cess pool

ADDITIONAL INSPECTION NO. 5425

Mike Rich OK 6/10/35 Smallwood

present



("Y" in Alley)

No. 4819 Whittier Blvd. St.

Lot E.20' of 9 Block 3

Tract 4074

Contractor EastSide H.C.Sewer Co.

Owner H.H.Schnakenberg

~~Sta. of House Connection~~ 7.7' W.of lower MH

Sta. of "Y" 17+56.5

Between Ferris Ave

and Fetterly Ave

Date Permit Issued 1/25/32

Date Inspected 1/20/32 1150

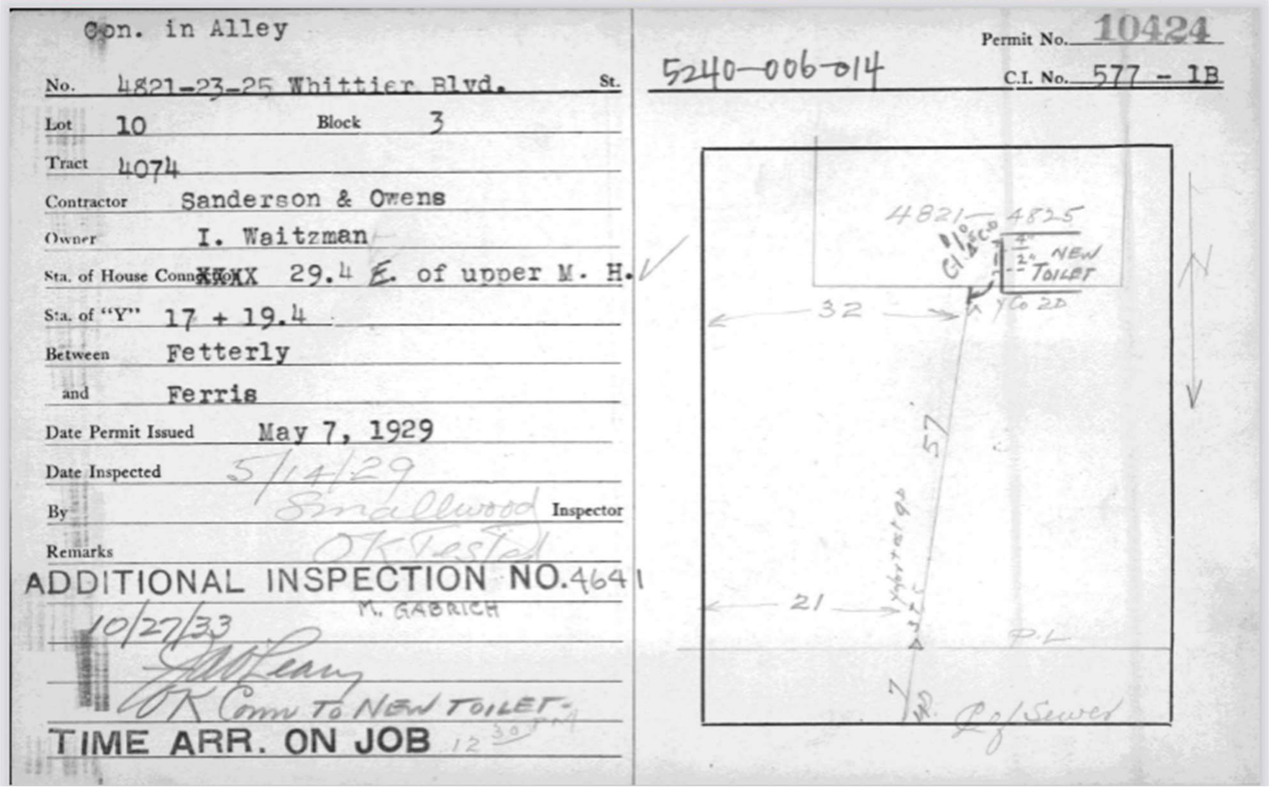
By Pearc Inspector

Remarks oK con tested

Permit No. 23252

5240-006-013

C.I. No. 577-1B



Con. in Alley

Permit No. 10424

No. 4821-23-25 Whittier Blvd. St.

5240-006-014

C.I. No. 577 - 1B

Lot 10 Block 3

Tract 4074

Contractor Sanderson & Owens

Owner I. Waitzman

Sta. of House Conn~~XXXX~~ 29.4 E. of upper M. H. ✓

Sta. of "Y" 17 + 19.4

Between Fetterly

and Ferris

Date Permit Issued May 7, 1929

Date Inspected 5/14/29

By Smallwood Inspector

Remarks OK Tested

ADDITIONAL INSPECTION NO. 4641

M. GABRICH

10/27/33

OK Conn To NEW TOILET -

TIME ARR. ON JOB 12 30 PM

DEPARTMENT OF BUILDING
COUNTY OF LOS ANGELES

APPLICATION FOR PERMIT
BUILDING

1

PLANS FILED 2-SETS	BLDG. ZONE M,	FIRE ZONE —	DISTRICT No. 6	PLAN CHK. FEE RECEIPT No. 5648	PERMIT No. 50155
TYPE OF BLDG. I II [✓ III] IV V X		GROUP F,	DATE OF APPL. 9-28-37	RECEIVED BY Phillips	DATE ISSUED 9-28-37
BLDG. SETBACK LINE —		ORD. NO. —			

APPLICANT FILL IN HEAVILY OUTLINED PORTION ONLY

ARCHITECT OR ENGINEER

NAME Morgan Walls & Clem

ADDRESS 210 W 7th st.

CITY Los Angeles.

STATE LICENSE NO. B813 TEL. No. Tr 7071

CONTRACTOR

NAME H M Baroch

ADDRESS 625 So Olive L.

CITY Los Angeles.

STATE LICENSE NO. TEL. No. Tr 5475

BUILDING ADDRESS 4825 Whittier Blvd

LOCALITY Belvedere

NEAREST CROSS ST. Ferris

OWNER

NAME Belvedere Improv. Co

MAIL ADDRESS SAME

CITY LA. TEL NO.

LEGAL DESCRIP.

LOTS 10-11-12	SIZE OF LOT 160x150
BLOCK 3	NO. OF BLDGS. NOW ON LOT —
TRACT 4074	USE OF BLDG. NOW ON LOT —

CLASS OF WORK

NEW	☒	ADDITION		DEMOLISH	
ALTERATION		REPAIR		MOVING	

USE OF BLDG. Retail Store MARKET NO. OF ROOMS —

SIZE OF BLDG. 150x160 STORIES 1 No. OF FAMILIES —

DESCRIPTION OF WORK

Construction of Steel Frame Canopy.

SPECIFICATIONS
FOUNDATION

	EXTERIOR	PIERS
MATERIAL		
THICKNESS TOP		
THICKNESS BOTTOM		
DEPTH IN GROUND		

SUPERSTRUCTURE

	SIZE	SPACING	SPAN
R. W. PLATES (SILL)			
GIRDERS			
JOISTS FLOOR			
JOISTS CEILING			
BEARING WALLS			
PARTITIONS			
ROOF RAFTERS			
SILL BOLTS			

See Plans

COVERING

WALL ROOF

I HEREBY ACKNOWLEDGE THAT I HAVE READ THIS APPLICATION AND STATE THAT THE ABOVE IS CORRECT AND AGREE TO COMPLY WITH ALL COUNTY ORDINANCES AND STATE LAWS REGULATING BUILDING CONSTRUCTION.

SIGN Morgan Wall & Clem
OWNER OR AUTHORIZED AGENT

CORRECTIONS

9-29-37- Erikson Fra

ORIGINAL

VALUATION $ 1,000.00

P.C. FEE $ —

FEE $ 4.00

FINAL APPROVAL

12-31-37 Erikson
DATE INSPECTOR'S NAME

DB-3 7-37

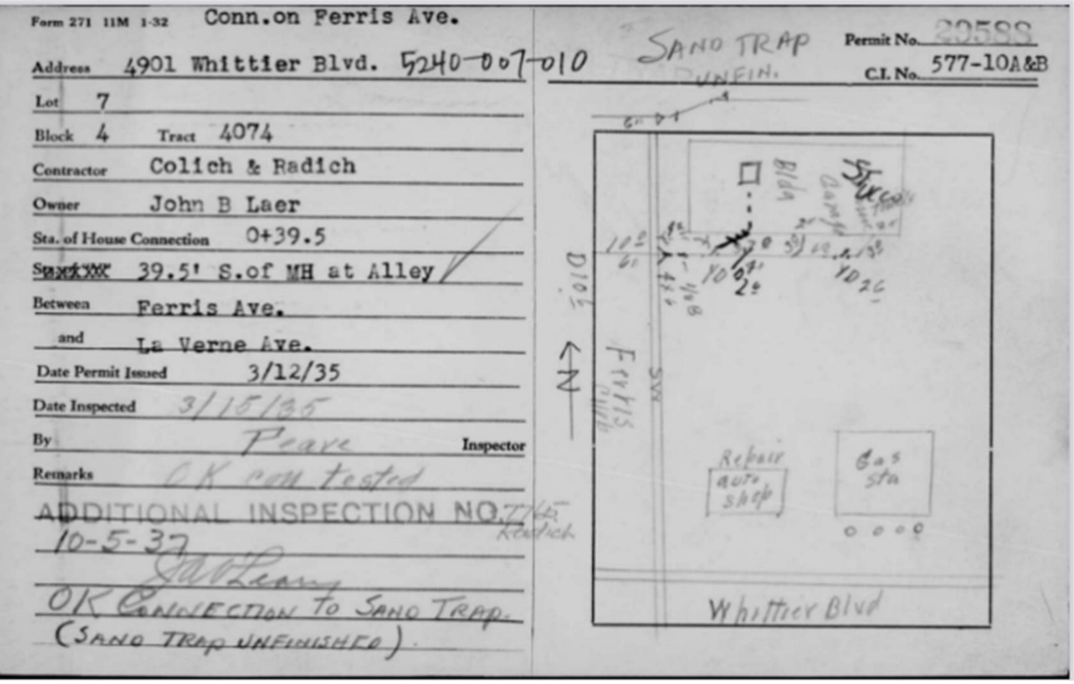
Morgan, Walls & Clements

Morgan, Walls & Clements played a leading role in creating the architectural landscape of early Los Angeles. One of the oldest and most prolific firms in the city, the company designed many of Los Angeles' landmark buildings dating back to the late 1800s.

Known for working in various Spanish revival styles in their earlier years, the firm became one of the city's most prominent practitioners of Art Deco and Streamline architecture in the late 1920s and 1930s. Their trove of Los Angeles landmarks includes theatres such as the El Capitan and Mayan, the beloved (and now-demolished) Richfield Tower, Malibu's Adamson House, and the Wiltern Theatre.

The firm was originally established in 1890 as Morgan and Walls, with partners Octavius W. Morgan (1850-1922) and John A. Walls (1860-1922). Morgan had previously partnered with architect Ezra Kysor, who co-designed L.A.'s first cathedral, St. Vibiana (1876). Walls was a native of Buffalo, New York who moved to Los Angeles in 1887. From: https://www.laconservancy.org/architects/morgan-walls-and-clements

Morgan Walls & Clements developed a steel frame in 1937. See permit at left.



Form 271 11M 1-32 Conn.on Ferris Ave.

Address 4901 Whittier Blvd. 5240-007-010

SANO TRAP UNFIN.

Permit No. 29588

C.I. No. 577-10A&B

Lot 7

Block 4 **Tract** 4074

Contractor Colich & Radich

Owner John B Laer

Sta. of House Connection 0+39.5

~~**Sewer**~~ 39.5' S.of MH at Alley

Between Ferris Ave.

and La Verne Ave.

Date Permit Issued 3/12/35

Date Inspected 3/15/35

By Peave **Inspector**

Remarks OK con tested

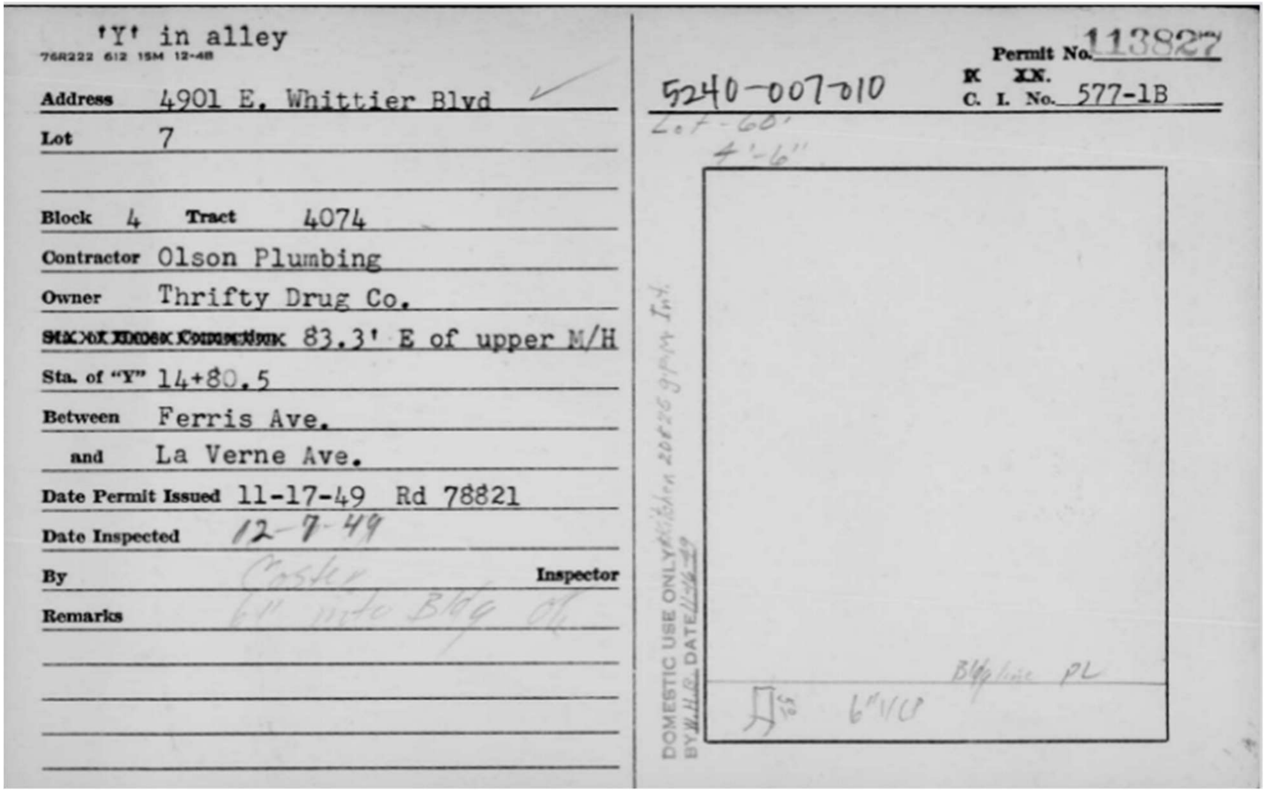
ADDITIONAL INSPECTION NO. 7765 Radich

10-5-37

JA Leary

OK CONNECTION TO SANO TRAP.

(SANO TRAP UNFINISHED).



'Y' in alley

76R222 612 15M 12-48

Address 4901 E. Whittier Blvd

5240-007-010

Permit No. 113827

~~**R XX.**~~

C. I. No. 577-1B

Lot 7

Block 4 **Tract** 4074

Contractor Olson Plumbing

Owner Thrifty Drug Co.

~~**Sta. of House Connection**~~ 83.3' E of upper M/H

Sta. of "Y" 14+80.5

Between Ferris Ave.

and La Verne Ave.

Date Permit Issued 11-17-49 Rd 78821

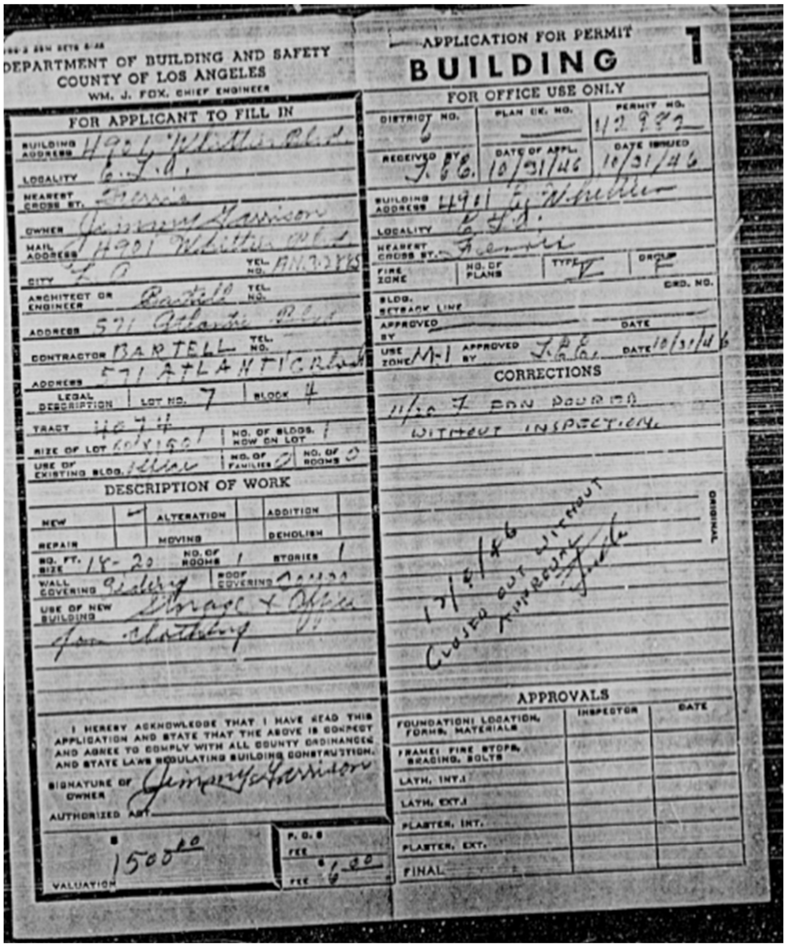
Date Inspected 12-7-49

By Coster **Inspector**

Remarks 6" into Bldg OK

DOMESTIC USE ONLY Kitchen 20 & 25 gpm Int.

BY W.H.R. DATE 11-16-49



166-2 25M SETS 8-46

DEPARTMENT OF BUILDING AND SAFETY
COUNTY OF LOS ANGELES
WM. J. FOX, CHIEF ENGINEER

APPLICATION FOR PERMIT
BUILDING
1

FOR APPLICANT TO FILL IN

BUILDING ADDRESS 4901 Whittier Blvd.
LOCALITY E.L.A.
NEAREST CROSS ST. Ferris
OWNER Jimmy Harrison
MAIL ADDRESS 4901 Whittier Blvd.
CITY L.A. TEL. NO. AN.3-3785
ARCHITECT OR ENGINEER Bartell TEL. NO.
ADDRESS 571 Atlantic Blvd.
CONTRACTOR BARTELL TEL. NO.
ADDRESS 571 ATLANTIC Blvd.
LEGAL DESCRIPTION LOT NO. 7 BLOCK 4
TRACT 4074
SIZE OF LOT 60'x150' NO. OF BLDGS. NOW ON LOT 1
USE OF EXISTING BLDG. [illegible] NO. OF FAMILIES 0 NO. OF ROOMS 0

DESCRIPTION OF WORK

NEW ✓ ALTERATION ADDITION
REPAIR MOVING DEMOLISH
SQ. FT. SIZE 18-20 NO. OF ROOMS 1 STORIES 1
WALL COVERING Siding ROOF COVERING [illegible]
USE OF NEW BUILDING Storage & Office for clothing

I HEREBY ACKNOWLEDGE THAT I HAVE READ THIS APPLICATION AND STATE THAT THE ABOVE IS CORRECT AND AGREE TO COMPLY WITH ALL COUNTY ORDINANCES AND STATE LAWS REGULATING BUILDING CONSTRUCTION.

SIGNATURE OF OWNER Jimmy Harrison
AUTHORIZED AGT.

VALUATION $1500.00
P. C. $ FEE
FEE $6.00

FOR OFFICE USE ONLY

DISTRICT NO. 6 PLAN CK. NO. — PERMIT NO. 112982
RECEIVED BY T.E.E. DATE OF APPL. 10/31/46 DATE ISSUED 10/31/46
BUILDING ADDRESS 4901 E. Whittier
LOCALITY E.L.A.
NEAREST CROSS ST. Ferris
FIRE ZONE NO. OF PLANS TYPE V GROUP F
ORD. NO.
BLDG. SETBACK LINE
APPROVED BY DATE
USE ZONE M-1 APPROVED BY T.E.E. DATE 10/31/46

CORRECTIONS

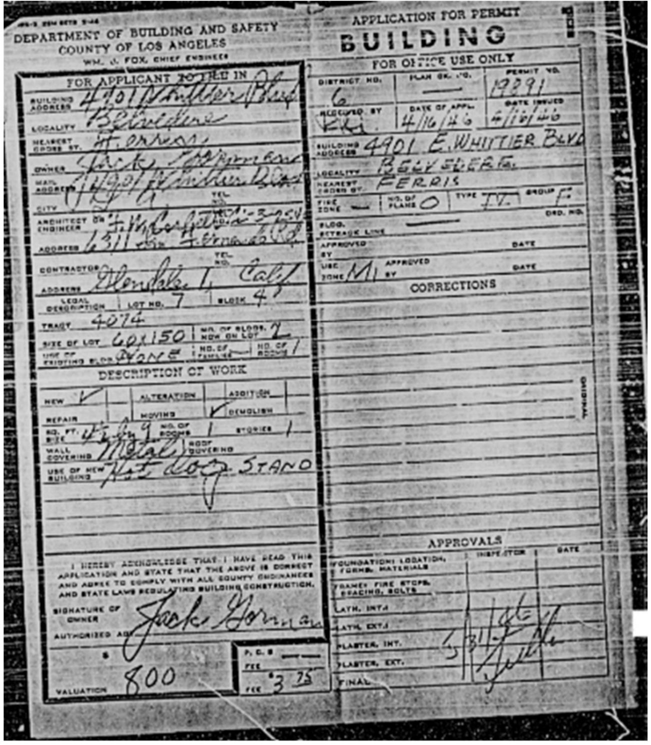
11/20 7 FDN POURED WITHOUT INSPECTION

12/9/46 CLOSED OUT WITHOUT APPROVAL

ORIGINAL

APPROVALS

	INSPECTOR	DATE
FOUNDATION: LOCATION, FORMS, MATERIALS		
FRAME: FIRE STOPS, BRACING, BOLTS		
LATH, INT.:		
LATH, EXT.:		
PLASTER, INT.		
PLASTER, EXT.		
FINAL		



166-2 25M SETS 2-46

DEPARTMENT OF BUILDING AND SAFETY
COUNTY OF LOS ANGELES
WM. J. FOX, CHIEF ENGINEER

APPLICATION FOR PERMIT
BUILDING
1

FOR APPLICANT TO FILL IN

BUILDING ADDRESS 4901 Whittier Blvd
LOCALITY Belvedere
NEAREST CROSS ST. Ferris
OWNER Jack Gorman
MAIL ADDRESS 4901 Whittier Blvd
CITY L.A. TEL. NO.
ARCHITECT OR ENGINEER [illegible] TEL. NO. [illegible]
ADDRESS 631 So. Fernando Rd
CONTRACTOR TEL. NO.
ADDRESS Glendale 1, Calif
LEGAL DESCRIPTION LOT NO. 7 BLOCK 4
TRACT 4074
SIZE OF LOT 60x150 NO. OF BLDGS. NOW ON LOT 2
USE OF EXISTING BLDG. NONE NO. OF FAMILIES — NO. OF ROOMS 1

DESCRIPTION OF WORK

NEW ✓ ALTERATION ADDITION
REPAIR MOVING ✓ DEMOLISH
SQ. FT. SIZE 4½ by 9 NO. OF ROOMS 1 STORIES 1
WALL COVERING Metal ROOF COVERING
USE OF NEW BUILDING Hot Dog STAND

I HEREBY ACKNOWLEDGE THAT I HAVE READ THIS APPLICATION AND STATE THAT THE ABOVE IS CORRECT AND AGREE TO COMPLY WITH ALL COUNTY ORDINANCES AND STATE LAWS REGULATING BUILDING CONSTRUCTION.

SIGNATURE OF OWNER Jack Gorman
AUTHORIZED AGT.

VALUATION $ 800
P. C. $ — FEE
FEE $3.75

FOR OFFICE USE ONLY

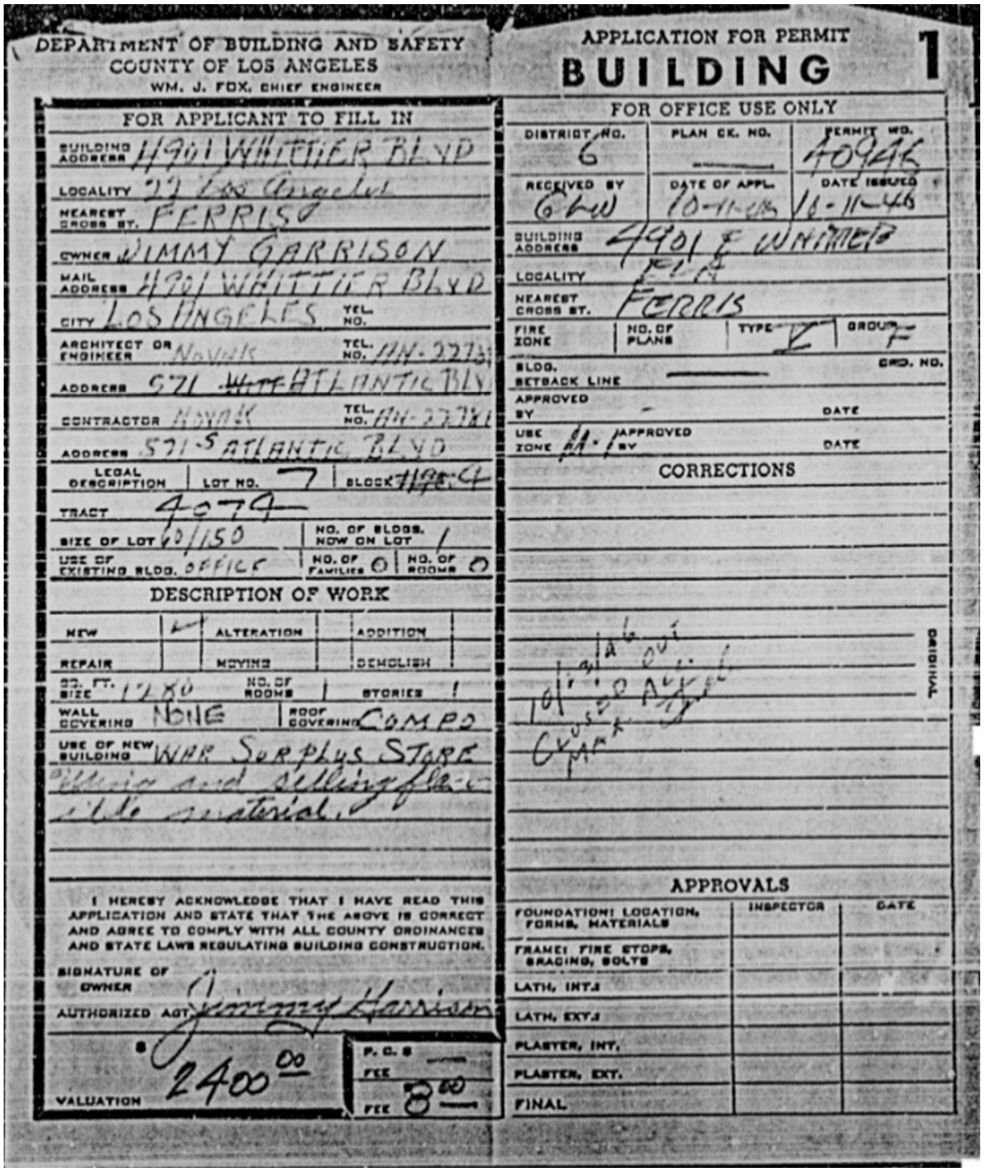
DISTRICT NO. 6 PLAN CK. NO. — PERMIT NO. 19891
RECEIVED BY K.K. DATE OF APPL. 4/16/46 DATE ISSUED 4/16/46
BUILDING ADDRESS 4901 E. WHITTIER BLVD
LOCALITY BELVEDERE
NEAREST CROSS ST. FERRIS
FIRE ZONE — NO. OF PLANS 0 TYPE IV GROUP F
ORD. NO.
BLDG. SETBACK LINE —
APPROVED BY DATE
USE ZONE M1 APPROVED BY DATE

CORRECTIONS

ORIGINAL

APPROVALS

	INSPECTOR	DATE
FOUNDATION: LOCATION, FORMS, MATERIALS		
FRAME: FIRE STOPS, BRACING, BOLTS		
LATH, INT.:		
LATH, EXT.:		
PLASTER, INT.	5/31/46	
PLASTER, EXT.		
FINAL		



DEPARTMENT OF BUILDING AND SAFETY
COUNTY OF LOS ANGELES
WM. J. FOX, CHIEF ENGINEER

APPLICATION FOR PERMIT
BUILDING **1**

FOR APPLICANT TO FILL IN

BUILDING ADDRESS 4901 WHITTIER BLVD
LOCALITY 22 Los Angeles
NEAREST CROSS ST. FERRIS
OWNER JIMMY GARRISON
MAIL ADDRESS 4901 WHITTIER BLVD
CITY LOS ANGELES TEL. NO.
ARCHITECT OR ENGINEER Novak TEL. NO. AN-22731
ADDRESS 571 ~~West~~ ATLANTIC BLV
CONTRACTOR NOVAK TEL. NO. AN-22781
ADDRESS 571 S ATLANTIC BLVD

LEGAL DESCRIPTION	LOT NO. 7	BLOCK [illegible]

TRACT 4074
SIZE OF LOT 60/150 NO. OF BLDGS. NOW ON LOT 1
USE OF EXISTING BLDG. OFFICE NO. OF FAMILIES 0 NO. OF ROOMS 0

DESCRIPTION OF WORK

NEW	✓	ALTERATION		ADDITION	
REPAIR		MOVING		DEMOLISH	

SQ. FT. SIZE 1280 NO. OF ROOMS 1 STORIES 1
WALL COVERING NONE ROOF COVERING COMPO
USE OF NEW BUILDING WAR SURPLUS STORE
[illegible] and selling fla-[illegible] material.

I HEREBY ACKNOWLEDGE THAT I HAVE READ THIS APPLICATION AND STATE THAT THE ABOVE IS CORRECT AND AGREE TO COMPLY WITH ALL COUNTY ORDINANCES AND STATE LAWS REGULATING BUILDING CONSTRUCTION.

SIGNATURE OF OWNER
AUTHORIZED AGT. Jimmy Harrison

$ 2400.00
VALUATION

P. C. $ —
FEE
FEE 8.00

FOR OFFICE USE ONLY

DISTRICT NO. 6	PLAN CK. NO. —	PERMIT NO. 40946
RECEIVED BY GLW	DATE OF APPL. 10-11-46	DATE ISSUED 10-11-46

BUILDING ADDRESS 4901 E WHITTIER
LOCALITY ELA
NEAREST CROSS ST. FERRIS

FIRE ZONE	NO. OF PLANS	TYPE V	GROUP F

BLDG. SETBACK LINE — ORD. NO.
APPROVED BY — DATE
USE ZONE M-1 APPROVED BY DATE

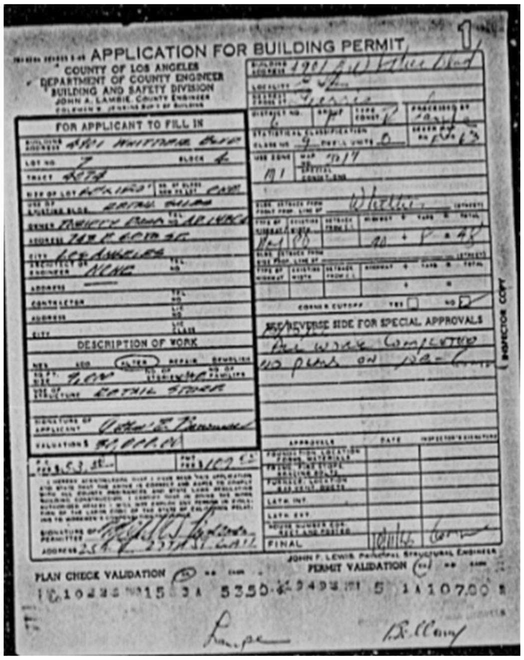
CORRECTIONS

10/11/46 [illegible]

ORIGINAL

APPROVALS

	INSPECTOR	DATE
FOUNDATION: LOCATION, FORMS, MATERIALS		
FRAME: FIRE STOPS, BRACING, BOLTS		
LATH, INT.:		
LATH, EXT.:		
PLASTER, INT.		
PLASTER, EXT.		
FINAL		



APPLICATION FOR BUILDING PERMIT

1

COUNTY OF LOS ANGELES
DEPARTMENT OF COUNTY ENGINEER
BUILDING AND SAFETY DIVISION
JOHN A. LAMBIE, COUNTY ENGINEER

FOR APPLICANT TO FILL IN

BUILDING ADDRESS 4901 WHITTIER BLVD
LOT NO. 7 BLOCK 4
TRACT 5074
SIZE OF LOT 50 x 150' NO. OF BLDGS NOW ON LOT ONE
USE OF EXISTING BLDG. RETAIL [illegible]
OWNER THRIFTY DRUG TEL. NO.
ADDRESS
CITY LOS ANGELES
ARCHITECT OR ENGINEER NONE TEL. NO.
ADDRESS
CONTRACTOR TEL. NO.
ADDRESS LIC. NO.
CITY LIC. CLASS

DESCRIPTION OF WORK

NEW ADD [✓ ALTER] REPAIR DEMOLISH
SQ. FT. SIZE NO. OF STORIES NO. OF FAMILIES
USE OF STRUCTURE RETAIL STORE
SIGNATURE OF APPLICANT
VALUATION $

P.C. FEE $53.50 PMT. FEE $107.00

SIGNATURE OF PERMITTEE
ADDRESS

BUILDING ADDRESS 4901 E. Whittier Blvd
LOCALITY
NEAREST CROSS ST.
DISTRICT NO. 6 GROUP F TYPE CONST. V PROCESSED BY
STATISTICAL CLASSIFICATION CLASS NO. 9 DWELL. UNITS 0 CHECKED BY
USE ZONE M1 MAP
SPECIAL CONDITIONS
BLDG. SETBACK FROM FRONT PROP. LINE OF Whittier (STREET)

TYPE OF HIGHWAY	EXISTING WIDTH	SETBACK FROM C.L.	HIGHWAY + YARD = TOTAL
Maj	80		40 + 8 = 48

BLDG. SETBACK FROM SIDE PROP. LINE OF (STREET)

TYPE OF HIGHWAY	EXISTING WIDTH	SETBACK FROM C.L.	HIGHWAY + YARD = TOTAL
			+ =

CORNER CUTOFF YES ☐ NO ☑

SEE REVERSE SIDE FOR SPECIAL APPROVALS

All work completed
no plans on job

APPROVALS	DATE	INSPECTOR'S SIGNATURE
FOUNDATION LOCATION FORMS MATERIALS		
FRAME, FIRE STOPS, BRACING BOLTS		
FURNACE LOCATION GAS VENT DUCTS		
LATH INT.		
LATH EXT.		
HOUSE NUMBER COR. SET AND POSTED		
FINAL		

INSPECTOR COPY

JOHN F. LEWIS, PRINCIPAL STRUCTURAL ENGINEER

PLAN CHECK VALIDATION PERMIT VALIDATION

10228 15 3A 5350 5 1A10700

Fw: Re Agenda Item # 8 , September 13th Hearing on Metro Area Plan

DRP Public Comment <comment@planning.lacounty.gov>
Mon 9/11/2023 4:23 PM
To:Tina Fung <tfung@planning.lacounty.gov>;Leon Freeman <lfreeman@planning.lacounty.gov>;Patricia Hachiya <phachiya@planning.lacounty.gov>
Cc:Elida Luna <ELuna@planning.lacounty.gov>

1 attachments (11 MB)
Studies on Pollution and Health.pdf;

FYI - Comment regarding Metro Planning Area.

Regards,

Rafael

From: claramsolis@earthlink.net <claramsolis@earthlink.net>
Sent: Monday, September 11, 2023 4:17 PM
To: DRP Public Comment <comment@planning.lacounty.gov>
Subject: Re Agenda Item # 8 , September 13th Hearing on Metro Area Plan

CAUTION: External Email. Proceed Responsibly.

Dear Regional Planning Commissioners:

Please find attached as studies related to air and noise pollution on health. Please consider them as part of the comment process for the Metro Area Plan and Final PEIR

Clara Solis

Review Article on Pollutional Haze

Air particulate matter and cardiovascular disease: the epidemiological, biomedical and clinical evidence

Yixing Du[1,2]*, Xiaohan Xu[3]*, Ming Chu[1]*, Yan Guo[1], Junhong Wang[1]

[1]Department of Gerontology, [2]Department of Neurology, [3]Department of Thoracic Surgery, the First Affiliated Hospital of Nanjing Medical University, Nanjing 210029, China

Contributions: (I) Conception and design: J Wang; (II) Administrative support: Y Guo; (III) Provision of study materials or patients: J Wang, Y Du; (IV) Collection and assembly of data: M Chu, X Xu; (V) Data analysis and interpretation: Y Du, X Xu, J Wang; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

*These authors contributed equally to this work.

Correspondence to: Dr. Junhong Wang. Department of Gerontology, the First Affiliated Hospital of Nanjing Medical University, Nanjing 210029, China. Email: cnjjh2000@aliyun.com.

Abstract: Air pollution is now becoming an independent risk factor for cardiovascular morbidity and mortality. Numerous epidemiological, biomedical and clinical studies indicate that ambient particulate matter (PM) in air pollution is strongly associated with increased cardiovascular disease such as myocardial infarction (MI), cardiac arrhythmias, ischemic stroke, vascular dysfunction, hypertension and atherosclerosis. The molecular mechanisms for PM-caused cardiovascular disease include directly toxicity to cardiovascular system or indirectly injury by inducing systemic inflammation and oxidative stress in peripheral circulation. Here, we review the linking between PM exposure and the occurrence of cardiovascular disease and discussed the possible underlying mechanisms for the observed PM induced increases in cardiovascular morbidity and mortality.

Keywords: Particulate matter (PM); cardiovascular disease; morbidity; mortality

Submitted Jun 19, 2014. Accepted for publication Oct 28, 2015.
doi: 10.3978/j.issn.2072-1439.2015.11.37
View this article at: http://dx.doi.org/10.3978/j.issn.2072-1439.2015.11.37

Introduction

Air pollution has now emerged as a leading problem for environmental health in the world. Especially in developing countries, it has become more serious than ever before. The potentially detrimental to health of air pollution has long been recognized, and many large epidemiological studies have clearly demonstrated the strong association between air pollution exposure and increased morbidity and mortality (1-3). Air pollutants include gaseous pollutants (e.g., carbon mono oxide, oxides of nitrogen, ozone and sulfur dioxide) and particulate matters (PMs). The relationship between respiratory vulnerability and air pollution has been well documented, and much attention has now been focused on the air pollution-induced cardiovascular risk in the past 15 years (4-6). Of those air pollutants, the ambient PM has become a major concern for cardiologists and specialists in environmental medicine. There is a mounting epidemiological, biomedical and clinical evidence that indicates the effects of ambient PM on cardiovascular health (5,7,8). In this review we summarize the main findings on the impact of PM particles on cardiovascular system and discuss the underlying molecular mechanisms of the effects of PM particles on cardiac muscle and vasculature.

The definition and composition of ambient particulate matter (PM)

Ambient PM is defined as the material suspended in the air in the form of minute solid particles or liquid droplets, which are derived from both human and natural activities. It is a heterogeneous mixture with varying size and chemical composition. In terms of their potential influence on health, they are classified as PM10, PM2.5 and ultrafine particles (UFPs) subgroup according to their diameter. PM10 includes coarse particles with the aerodynamic diameter (AD) from 2.5 to 10 μm. The PM10 particles come from road and agricultural dust, tire wear emission, construction and demolition works or the mining operations (8). In addition, the natural activity such as wildfires and windblown dust are also the sources for PM10. Compared to PM10, the primary contributors of PM2.5 mainly come from the traffic and industry includes fuel combustion from power plant and oil refinery or the brake emissions of mobile. PM2.5 indicates those fine particles with AD less than 2.5 μm. Based on numerous epidemiological studies and large clinical observation, the PM2.5 has been considered as the main culprit of the adverse cardiovascular effects of air pollution on human health (5,6). UFPs include those particles diameters less than 0.1 μm, and the primary sources of UFPs are tailpipe emissions from mobile sources. Theoretically, PM10 particles preferentially deposit in the upper airways, meanwhile the PM2.5 and UFPs particles are much more easier to reach the smallest airways and alveoli and UFPs may further penetrate the alveolar-capillary membrane, which eventually spread into the systemic circulation. It has been reported that the UFPs particles can be found in remote organs (9). This finding may indicate that UFPs could induce specific organ toxic effects. In addition, the secondary particular matters, ambient aerosols appear when ambient particles interact with atmospheric gases (ozone, sulfur and nitric oxides and carbon monoxide) (8). Each of those aerosols can have independent and potentially synergistic or antagonistic effects with each other and with PM; however, at present, the cardiovascular health impact of exposure to combinations of those air pollutants is not well understood (5).

Pathophysiological mechanisms linking particulate matter (PM) particles and cardiovascular disease

In the past 15 years, numerous studies and in-depth reviews have demonstrated that PM particles play a significant role in the process of cardiovascular disease. *Table 1* summarizes the most recent studies [2014-2015] on PM-induced short-term and long-term cardiovascular effects. There is a strong link between the PM particles and the deaths caused due to cardiovascular diseases (4,21,28,31-33), and several pathways have recognized that can explain the link between PM particles and cardiovascular diseases, the first is the direct pathway. In this way, PM2.5, in particular UFPs directly translocate into the blood stream and remote target organ, and the other two pathways are indirect. For the indirect pathways, the one is mediated by pulmonary oxidative stress and inflammatory response, which is less acute and occur after several hours or days of inhalation (6,34). Interaction on the autonomic nervous system via specific lung receptors is an another indirect pathway well documented by many authors (6,8).

Direct actions of ultrafine particles (UFPs) on cardiovascular system

Due to the size, charge, chemical composition of UFPs, it is much easier to cross the pulmonary epithelium and the lung-blood barrier than PM10 and other coarse particulate. Thus, the translocation of UFPs into the blood stream and specific organ has been documented in animal studies (35-39). This exposure, even at low concentration, can translocate into blood steam and remote organ to cause potential cumulative toxicity (39). The translocation of UFPs to the blood stream has detrimental effects on cardiovascular system. After deposit on vascular endothelium, the UFPs can aggravate the local oxidative stress and inflammation, resulting the atherosclerotic plaque instability, and finally may lead to thrombus formation (40). Furthermore, increased ejection fraction and premature ventricular beats was observed in rats intravenously injected with UFPs isolated from ambient air (41). This inotropic effect of UFPs may be harmful to coronary heart disease patients, which increase the oxygen demand of the diseased hearts and aggravate the ischemic symptom. However, the *in vitro* results of UFPs on cardiac performance demonstrated that the UFPs have the cardiac depression effects, which can cause myocardial stunning and cardiac function deterioration (42). The seemed contradictable *in vivo* and *in vitro* results might be explained as the difference in circulation-mediated or direct cardiotoxicity of UFPs in these two models (8). Although not observed in human beings so far, these studies still indicated that UFPs has the cardiotoxicity effects and can directly affect the cardiac performance.

Indirect pathways of particulate matter (PM) particulates on cardiovascular system

Increased oxidative stress and activated inflammatory pathway in pulmonary due to exposure to PM particulate play a substantial role in this indirect pathway. Considerable

Table 1 The representative recent studies [2014-2015] on the short-term and long-term effects of exposure to PMs on cardiovascular system

Studies	Study population	Main findings
Short-term exposure studies		
Li *et al*. (10)	Case-crossover study in eight Chinese large cities	An increase of 10 μg/m^3 in 2-day moving average concentrations of PM10, SO_2 and NO_2, was significantly associated with increases of daily CHD mortality
MONICA/KORA study (11)	Case-crossover study of 15,417 MI cases in Germany	An association between short-term PMs concentration and numbers of MI, especially for nonfatal and recurrent events
MCAPS (12)	12-year of time series study in USA	Daily variation in PM10-2.5 is associated with emergency hospitalizations for cardiovascular diseases among elderly population (≥65 years)
MED-PARTICLES project (13)	Case-crossover study in ten southern European cities	Wildfires and PM10 were associated with increased cardiovascular mortality in urban residents
Chang *et al*. (14)	Case-crossover study in Taiwan from 2006-2010	Higher levels of PM2.5 enhance the risk of hospital admissions for CVD on cool days (<25 ℃)
EPHT program (15)	Case-crossover study in seven US states within the CDC EPHT network	Multiple cardiovascular outcomes in addition to AMI may be impacted by particulate air pollution in state-wide
MINAP (16)	Case-crossover study of over 400,000 MI events in England and Wales	The strong associations with air pollution were observed with selected non-MI CVD outcomes, while no clear evidence was found for pollution effects on STEMIs
Zhao *et al*. (17)	Time-series study of 56,940 outpatient in China	A 10 μg/m^3 increase in the present-day concentrations of PM10, SO_2, and NO_2 corresponded to increases of 0.56%, 2.07%, and 2.90% in outpatient arrhythmia visits
Raza *et al*. (18)	Case-crossover study of 5,973 cases in Stockholm county from 2000-2010	Short-term exposure (in 2 h) to moderate levels of O_3 is associated with an increased risk of out-of-hospital cardiac arrest (OHCA)
Bell *et al*. (19)	Time-series study of aged persons from four countries in USA	PM2.5 total mass and PM2.5 road dust were associated with increased cardiovascular hospitalizations, as were the PM2.5 constituent calcium, black carbon, vanadium, and zinc
Long-term exposure studies		
MESA project (20)	Time-series study in USA from 2000 to 2012	Long-term exposure to air pollution is related to the markers of inflammation and fibrinolysis
Qin *et al*. (21)	Cross-sectional study of 24,845 adults in Northeastern metropolitan China	Being overweight and obese may enhance the effects of air pollution on the prevalence of CVDs
Wolf *et al*. (22)	Cohort study of 100,166 persons in European followed on average for 11.5 years	A 100 ng/m³ increase in PM10 and a 50ng/m³ increase in PM2.5 were associated with a 6% and 18% increase in coronary events
Wong *et al*. (23)	Cohort study of 66,820 aged persons in Hong Kong followed for 4 years	Mortality HRs per 10 μg/m^3 increase in PM2.5 were 1.22 for cardiovascular causes and 1.42 for ischemic heart disease
Chan *et al*. (24)	Cross-sectional study of 43,629 women in USA	Long-term PM2.5 and NO_2 exposures were associated with higher blood pressure (BP)
Pope *et al*. (25)	Cross-sectional study of 669,046 participants in USA	Long-term exposure may contribute to the development or exacerbation of cardiometabolic disorders, increasing risk of CVD, and cardiometabolic disease mortality
Kim *et al*. (26)	Cross-sectional study of 5,488 MESA participants in USA	Long-term concentrations of sulfur and OC, and possibly silicon, were associated with CIMT
Wilker *et al*. (27)	Cohort study of 5,112 participants in the Framingham Offsprings.	Higher levels of spatially PM2.5 at participant residences are associated with impaired conduit artery and microvascular function in middle-aged and elderly adults
Weichenthal *et al*. (28)	Cohort study of 83,378 participants in the USA	Rural PM2.5 may be associated with cardiovascular mortality in men, but not in women
Beelen *et al*. (29)	A joint analysis of data from 22 European cohorts consisted of 367,383 participants	Most hazard ratios for the association of air pollutants with mortality from overall CVD and with specific CVDs were approximately 1.0
Zhou *et al*. (30)	Prospective cohort study of 71,431 middle-aged Chinese men	Each 10 μg/m^3 PM10 was associated with a 1.8% increased risk of cardiovascular mortality

PM, particulate matter; MI, myocardial infarction.

evidence has proved that particulate air pollutants can trigger an inflammation related cascade when they deposit in the lung (43-46). Increased circulating level of pro-inflammatory cytokines such as CRP, IL-6, IL-8 and IL-1β were observed in healthy subjects when exposure to ambient PMs (46-50). Similar results have been reported in *in vivo* animal models and *in vitro* cellular models (51,52). Systemic inflammatory is a well-known risk factor for atherosclerosis progression, and those pro-inflammatory mediators are close related to increased blood coagulability and endothelial dysfunction and which finally can exacerbate myocardial ischemia. In addition, ROS-dependent mechanism was shown to involved in the PM particulates triggered pro-inflammatory pathway (47). Increased amounts of ROS were reported in rat lung and heart by means of *in situ* chemiluminescence after exposure to PMs (47). ROS was shown to be linked to atherosclerosis, vascular dysfunction, cardiac arrhythmias and myocardial injury (53,54).

Other mechanisms for particulate matter (PM)-induced cardiovascular disorders

In addition to the sizes of PMs, the quality of PMs (components) also played an important role in PM-related harmful effects. The components of PMs varies spatially and temporally, which includes health hazardous metals, such as copper, lead, iron, nickel and chromium originate from industrial combustion processes or traffic combustion. Other gaseous pollutants (e.g., CO, NO_2, NO_X, O_3 and SO_2 etc.) have also been demonstrated to be close related to the adverse outcomes of cardiovascular disease (10,17,18,24,26).

Furthermore, PM particulates are thought to stimulate autonomic nervous system (55), impairing autonomic balance and favoring sympathetic tone (56). The over activated sympathetic tone is closely related to increased cardiovascular risk through induction of pro-hypertensive vasoconstriction and the predisposition to arrhythmias (56). Recently, microRNAs (miRNAs) have emerged as attractive candidates to explore the impact of PM exposures on cardiovascular system (57,58). Experimental and clinical studies indicated that PMs can modulate those miRNAs involved in processes of systemic inflammation, endothelial dysfunction and atherosclerosis. Meanwhile, SNPs in miRNA-processing genes may also modify the associations between ambient pollution and cardiovascular disease (58,59). However, further work remains need to be addressed include linking specific PM exposures to subsequent health outcomes based on established miRNA expression profiles and experimentally validating putative downstream targets of the deregulated miRNAs.

The linking between ambient particulate matters (PMs) and cardiovascular disease

Cardiovascular (CV) mortality and particulate matter (PM) particulates exposure

The positive relationship between CV mortality and PM particulates exposure has been proved in many large time-series and case-crossover studies. Even a 10 μg/m^3 increase in short-term (<24 h) PM2.5 level increases the relative risk (RR) of daily cardiovascular mortality by ~0.4% to 1.0% (60). In addition, several landmark time-series studies have been conducted worldwide in recent years to address the daily PM-related CV and all-cause mortality. One of the largest was the National Morbidity, Mortality and Air Pollution Study (NMMAPS) (61,62). The APHEA (Air pollution and Health: A European Approach) and APHEA-2 projects investigated the relationship between short-term PM exposure and CV mortality in multiple European cities (63,64). Those large studies revealed that PM particulates including the coarse particulates, PM10, were significantly associated with daily all-cause and CV mortality. Similar time-series studies conducted in Asia countries (China, Thailand and Indian) further confirmed the relationship between the daily PM-exposure and CV mortality (65-67).

In addition to the short-term exposure of PM particulates, the longer-term exposure may have more deleterious effects on healthy and cardiovascular mortality giving the more accumulated PM exposure during the extended periods of time. Miller *et al.* revealed that long-term exposure to fine particulate air pollution was associated with the incidence of cardiovascular disease and death among postmenopausal women based on the data from 36 USA metropolitan areas (33). Many large prospective cohort studies and fine meta-analysis have further provided us with clear answers on the correlation between longer-term PM-exposure and CV mortality (29,68,69). However, a most recent large cohort study performed by Beelen *et al.* (29) did not found any association between PM and cardiovascular mortality. The explanation for the difference between this study and those of previous studies may be because of the changes in cardiovascular risk profile (e.g., reduced smoking and increased medication and medical treatment). And the changed risk profile finally altered the relationship between air pollution and cardiovascular mortality. The extended reanalysis of the two large cohort studies—the Harvard Six Cities and ACS Studies further emphasized the notorious effects of PM2.5 on CV mortality (2,32,70). Furthermore, studies demonstrated that significantly reduction of PM2.5 level was associated with reduced mortality risk (70,71). However, unlike the results observed in short-term exposure studies, the reanalysis of ACS study demonstrated that the coarse particles (PM10) were generally not significantly related to CV mortality (32).

Ischemic heart disease (IHD) and particulate matter (PM) particulates exposure

An earlier hospital-based study (72) demonstrated that the incidence of myocardial infarction (MI) and angina was found to associate with atmospheric gases and/or black smoke. Another studies conducted in USA (4-year in 204 counties) and European (10-year in five major cities) indicated that hospital admission for IHD were positively associated with increased level of fine PM particulates (73,74). Furthermore, a very recent large prospective cohort study and meta-analysis in 11 European cohorts from the ESCAPE project confirmed that long term exposure to PM is associated with incidence of coronary events, and this association persists at levels of exposure even below the current European limit values (25 μg/m^3 for PM2.5, 40 μg/m^3 for PM10) (75). They concluded that with a 5 μg/m^3 increase in estimated annual mean PM2.5 was associated with a 13% increased risk of coronary events (HR 1.13, 95% confidence interval 0.98 to 1.30), and a 10 μg/m^3 increase in estimated annual mean PM10 was associated with a 12% increased risk of coronary events (1.12, 1.01 to 1.25). In California teachers cohort study (76), Lipsett *et al.* provided evidence linking long-term exposure to PM2.5 with increased risks of incident IHD mortality, particularly among postmenopausal women. Meanwhile, exposure to nitrogen oxides was also associated with elevated risks for IHD and all cardiovascular mortality. In addition to the long-term effects of PM on IHD, short-term elevated ambient fine PM concentrations has also been reported to increase the IHD hospital admission, which was further proved by numerous time-series, case-crossover and meta-analysis studies (69,77,78). Recently a large cohort study investigated the relationship between occupational particle exposure and the incidence of IHD in Swedish workers. They found that either exposure to a small job-exposure matrix (<1 μm) or large (>1 μm) was associated with an increased HR for acute MI, and the association was somewhat stronger for those exposed to small particles for more than 5 years (79).

Although few direct evidence for the induction of cardiac ischemia by exposure to ambient level of PM has been documented in real patient world, the experimental MI model provided more evidence linking PM exposure and increased infarct size and/or potential myocardial ischemia (80-82). The mechanisms for PM exposure induced myocardial ischemic injury can be attributed to increased systemic inflammation, altered endothelial function and enhanced thrombotic tendency (80,83). In addition, the PM exposure was found to be associated with a small but significant decrease in myocardial flow, especially in ischemic area in a conscious canine myocardial ischemic model (82). Moreover, traffic-related PM in patients with coronary artery disease was found to be strongly related to the incidence of ST-segment depression during 24-hour Holter monitoring.

Cardiac arrhythmias, out-of-hospital cardiac arrest (OHCA) and particulate matter (PM) particulates exposure

Several studies have observed a positive association between exposure to ambient PM and the incidence of ventricular arrhythmias in patients implanted with automatic defibrillators (84,85). A 5-year prospective study (86) in Taipei demonstrated that increased numbers of emergency room cardiac arrhythmia visits were significantly associated with PM2.5 on both warm days (>23 ℃) and cool days (<23 ℃), with an interquartile range rise associated with a 10% and 4% elevation in number of ER visits for cardiac arrhythmias, respectively. Very recently, another prospective follow-up study evaluated the association of air pollution with the onset of atrial fibrillation (AF) in 176 patients with dual chamber implantable cardioverter-defibrillators (ICDs). The authors revealed that PM2.5 is an acute trigger of AF, which was associated with increased odds of AF onset [26% (95% CI: 8-47%) increase for each 6.0 mg/m^3 increase in PM2.5 concentration] within hours following exposure in patients with known cardiac disease (87). Similarly, PM2.5 or fine PM-exposure has been reported to be associated with OHCA in Melbourne (88), Houston (89), New York (90), and many other cities or countries but not in Demark (91) and Seattle (92). These seemed inconsistent results may reflect different PM compositions due to different sources among the cities and countries. Furthermore, the lower exposure levels in Demark and Seattle than in New York and Houston should also be considered.

In general, the incidence of sudden cardiac death and cardiac arrhythmias is closely related to the activity of the autonomic nervous system, and its activity in susceptible patients can be evaluated by measuring the changes in heart rate variability (HRV). HRV is mediated by a balance between sympathetic and parasympathetic branches of autonomous nervous system (34), which is recognized as a marker for prognosis the incidence of ventricular arrhythmia. Reduced HRV often predict the likelihood of developing ventricular arrhythmias in post-MI and heart failure patients (93,94). The reductions in HRV were observed on exposure to ambient, household or occupational PMs in healthy volunteer, susceptible patients, housewives and workers (95-97). In the studies in Beijing, the authors demonstrated an increase in HRV in healthy volunteers and CHD patients when exposure to ambient PM particles. On the contrary, the protective effects were observed when the participants used the highly efficient facemask (98,99). Although the mechanisms for PMs induced HRV and other changes in ECG remain largely unknown, some studies demonstrated that PM-induced cardiac electrophysiological changes can be prevented by inhibiting the transient receptor potential vanilloid receptor 1 (TRPV1) in the lungs (100). In addition, there have been relatively few researchers studied on the gene-PM exposure interactions, and most have done on a small number of loci for genetic polymorphisms. Some authors indicated that the associations between PM2.5 and HRV can be modified by gene polymorphisms of apolipoprotein E (APOE), lipoprotein lipase (LPL), vascular endothelial growth factor (VEGF) and glutathione S-transferase (GST) in general population, and the biological metabolism for PM related HRV changes might be related to the action on autonomic function via the lipid/endothelial metabolism and oxidative stress pathways (101,102).

Vascular function, blood pressure (BP), atherosclerosis and particulate matter (PM) particulates exposure

Experiments demonstrated that PM particulates can cause excess ROS formation thus leading to impairment of nitric oxide-dependent vascular dilation and enhancing vasoconstrictor in ex vivo and *in vivo* studies (5,103). Furthermore, exposure to PM has found to be associated with an increase in plasma concentration of endothelin-1 (ET-1), which is a putative potent endogenous vasoconstrictor to cause vascular endothelial dysfunction (104,105). Although the PM-related vascular dysfunction is documented in many articles, the results for BP response to acute PM exposure is inconsistent. Some controlled studies reported that PM exposure cause no changes among healthy adults, while other recent findings suggested that actual period of exposure to concentrated ambient particulate (CAP) significantly increase the diastolic BP (106), whereas no changes was observed with longer time of exposure (24 h) to PM (107). In that, those results suggested that this CAP induced BP changes might be more related to the PM-induced ANS imbalance which favored sympathetic over parasympathetic cardiovascular tone.

Although a recent meta-analysis from four European cohort studies in the ESCAPE study only find a positive but not significant associations between CIMT and long-term exposure to the PM2.5 (108), many epidemiological and animal evidences still documented that exposure to PMs plays a role in the development of atherosclerosis. Sun and his colleague demonstrated that exposure to environmentally relevant PM2.5 (regional northeastern of US) in conjunction with a high-fat chow diet in ApoE$^{-/-}$ mice for 6 months can cause endothelial dysfunction, increase the vascular plaque burden and accelerate the progression of atherosclerosis (109). The same results were reported in Beijing, Los Angeles and many other places when the ApoE$^{-/-}$ mice were exposure to the local ambient particle (110,111). To investigate the relation between individual-level estimates of long-term air pollution exposure and the progression of subclinical atherosclerosis, a large prospective, multicenter study named Multi-Ethnic Study of Atherosclerosis and Air Pollution (MESA Air) was initiated in 2004. That study demonstrated that long-term PM2.5 exposure was significantly associated with decreased endothelial function with increased IMT progression even over a relatively short follow-up period, which add to the literature on air pollution and the progression of atherosclerotic processes in humans (112,113). Even more, the authors observed that the slower IMT progression was related to greater reductions in PM2.5. A very recent study recalled the data [2000-2003] from the German Heinz Nixdorf Recall Study, which included a population-based cohort of 4,814 randomly selected participants. The study used a reliable indice, the thoracic aortic calcification (TAC), to evaluate the subclinical atherosclerosis. Their results demonstrated that long-term exposure to fine PM is independently associated with subclinical atherosclerosis (114). Taken together, these findings may elucidate important pathways linking air pollution to the development of atherosclerosis.

Thrombus formation, blood coagulation and particulate matter (PM) particulate exposure

In vivo as well as *in vitro* studies demonstrated that PM particulates can induce pro-thrombotic effects by producing inflammatory mediators in the lungs and releasing into the blood circulation or directly translocation of small particulates from lung to the circulation. Nemmar *et al.* revealed that exposure of hamster to the diesel exhaust particles after photochemical injury resulted in platelet function abnormalities and thrombus formation both in arteries and veins (115). Mutlu GM and his colleague using IL-6 knockout (KO) mouse model demonstrated that IL-6 and its downstream signaling pathway plays a pivotal role in PM-induced prothrombotic state by increasing the expression of fibrinogen, factor VIII and tissue factor (TF), thus increasing the risk of both venous and arterial thrombosis (34,116). Furthermore, they also found that the prothrombotic effect of PM was further mitigated in macrophage-depleted mice (116). Those results may suggest that IL-6, macrophage and pulmonary inflammation are the necessary initial steps for PM-induced prothrombotic changes. Kilinç *et al.* documented the possible mechanisms for early and chronic exposure of PM (UFPs)-driven procoagulant activity in genetically modified mice [FXII($^{-/-}$)]. They revealed that PM promotes its early procoagulant actions mostly through the TF-driven extrinsic pathway of coagulation, whereas PM-driven long lasting thrombogenic effects are predominantly mediated via formation of activated FXII. Hence, they concluded that FXII-driven thrombin formation may be relevant to an enhanced thrombotic susceptibility upon chronic exposure to PM in humans (40). In addition to increasing the inflammatory mediators and prothrombotic proteins, particulate nanoparticles and other UFPs themselves could reach the circulation and directly enhance thrombus formation as analyzed by scanning electron microscopes (117). In real-world studies, the MONICA survey indicated that plasma viscosity was increased in both men and women when exposure to air pollutions (118). Recently, researchers studied the effects of short-term changes in exposure to UFPs on stroke, separately for ischaemic and hemorrhagic strokes, and ischaemic strokes with (likely embolic) and without (likely thrombotic) AF. Their results demonstrated that exposure to UFPs lead to a 21% increase in hospital admissions (per interquartile range of 5-day averages; 95% CI: 4-41%) for mild ischaemic stroke of without AF (likely thrombotic origin), which may further indicate the thrombotic and procoagulant actions of PM particles (119).

Conclusions

In summary, a wide array of experimental and epidemiological studies have unequivocally provided persuasive evidences on the negative impact of PMs on cardiovascular events and outcomes. In addition, numerous findings indicate that even a few hours to weeks of short-term exposure to PM particulates can trigger CVD-related mortality and events, especially among the susceptible individuals at great risk including the elderly or the patients with preexisting coronary artery disease. The underlying mechanisms for PM-caused cardiovascular disease include directly insults by UFPs translocating to the circulations and remote localization to the heart or indirectly injury by inducing systemic inflammation and oxidative stress in circulation, thus leading to cardiovascular damage. However, even the epidemiology and the biomedical studies will possibly help us better understand the underlying mechanisms and increase the effectiveness of our efforts to reduce the risk of air pollution—related cardiovascular disease, the major strategy in decreasing the harmful effects of air pollution is to reduce the air pollutants themselves. As the air pollution is becoming an ecological and social dilemma in the world, especially in developing countries like China, the social movements backed up by medical doctors, medias and government, therefore, might be great needed to combat with the deteriorating air pollution problem and finally to lower the associated cardiovascular risk.

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Footnote

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Association between Local Traffic-Generated Air Pollution and Preeclampsia and Preterm Delivery in the South Coast Air Basin of California

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Background: Preeclampsia is a major complication of pregnancy that can lead to substantial maternal and perinatal morbidity, mortality, and preterm birth. Increasing evidence suggests that air pollution adversely affects pregnancy outcomes. Yet few studies have examined how local traffic-generated emissions affect preeclampsia in addition to preterm birth.

Objectives: We examined effects of residential exposure to local traffic-generated air pollution on preeclampsia and preterm delivery (PTD).

Methods: We identified 81,186 singleton birth records from four hospitals (1997–2006) in Los Angeles and Orange Counties, California (USA). We used a line-source dispersion model (CALINE4) to estimate individual exposure to local traffic-generated nitrogen oxides (NO_x) and particulate matter < 2.5 µm in aerodynamic diameter ($PM_{2.5}$) across the entire pregnancy. We used logistic regression to estimate effects of air pollution exposures on preeclampsia, PTD (gestational age < 37 weeks), moderate PTD (MPTD; gestational age < 35 weeks), and very PTD (VPTD; gestational age < 30 weeks).

Results: We observed elevated risks for preeclampsia and preterm birth from maternal exposure to local traffic-generated NO_x and $PM_{2.5}$. The risk of preeclampsia increased 33% [odds ratio (OR) = 1.33; 95% confidence interval (CI), 1.18–1.49] and 42% (OR = 1.42; 95% CI, 1.26–1.59) for the highest NO_x and $PM_{2.5}$ exposure quartiles, respectively. The risk of VPTD increased 128% (OR = 2.28; 95% CI, 2.15–2.42) and 81% (OR = 1.81; 95% CI, 1.71–1.92) for women in the highest NO_x and $PM_{2.5}$ exposure quartiles, respectively.

Conclusion: Exposure to local traffic-generated air pollution during pregnancy increases the risk of preeclampsia and preterm birth in Southern California women. These results provide further evidence that air pollution is associated with adverse reproductive outcomes.

Key words: air pollution, nitrogen oxides, particulate matter, preeclampsia, pregnancy outcome, preterm birth, vehicle emission. *Environ Health Perspect* 117:1773–1779 (2009). doi:10.1289/ehp.0800334 available via *http://dx.doi.org/* [Online 23 June 2009]

Preeclampsia is a multisystem disorder in pregnant women, which is characterized by elevated blood pressure, edema, and protein in the urine. Preeclampsia complicates an estimated 2–8% of pregnancies and is a major cause of maternal mortality and morbidities, perinatal deaths, preterm birth, and intrauterine growth restriction (Duley 1992; Sibai et al. 2005). Because the only cure is delivery of the baby and placenta, preeclampsia is the most frequent primary reason for elective nonspontaneous preterm birth, accounting for 30–35% of total preterm deliveries (PTD) (Goldenberg et al. 2008; Meis et al. 1998). Preeclampsia does not necessarily lead to spontaneous PTD, and the association between preeclampsia and spontaneous PTD depends on PTD subtypes defined by gestational age (e.g., very or moderately preterm) and pathway (e.g., membrane rupture or spontaneous onset of labor before membrane rupture) (Ananth et al. 1997).

More than half a million infants are born prematurely each year in theUnited States (Hamilton et al. 2006). Preterm birth is associated with 70% of neonatal deaths and up to 75% of neonatal morbidity (Challis et al. 2001). Extremely preterm infants who survive the neonatal period face an elevated risk of serious life-long health problems, including learning disabilities and other chronic conditions (Doyle 1995, 2008). A growing body of research has linked elevated air pollutant exposures to PTD at pollution levels typical of many U.S. cities (Maroziene and Grazuleviciene 2002; Perera et al. 2003; Ritz et al. 2000, 2007; Šrám et al. 2005; Wilhelm and Ritz 2005). So far, preeclampsia has been associated with air pollution in only two recent U.S. studies (Rudra and Williams 2006; Woodruff et al. 2008).

There is also a growing body of evidence linking pollutants found in traffic exhaust specifically to respiratory and cardiovascular diseases (Adar and Kaufman 2007; Delfino 2002; Heinrich and Wichmann 2004; Sarnat and Holguin 2007). Although data are limited to date (de Kok et al. 2006), evidence is emerging that fresh vehicle emissions contain more toxic compounds per unit of particle mass than do aged aerosols, in part because of the contribution of ultrafine particles (UFPs; < 0.1 µm in aerodynamic diameter), which are found in higher concentration closer to emission sources (Zhu et al. 2002). Fresh traffic emissions' toxicity may originate from a high concentration of organic components because particle number concentrations are orders of magnitude higher, increasing the surface area to which volatile and semivolatile pollutants such as polycyclic aromatic hydrocarbons (PAHs) and carbonyl compounds can adhere.

There is indirect evidence for adverse impacts of traffic-generated PAHs on birth outcomes from studies in the United States (Choi et al. 2006, 2008; Perera et al. 2003, 2004), Poland (Choi et al. 2006), and the Czech Republic (Dejmek et al. 2000). However, most previous birth outcome studies relied solely on data from air monitors operated by government agencies, which are usually sited to assess regional ambient pollution and are thus unlikely to adequately capture the high spatial heterogeneity of air pollutants directly emitted from traffic (Hitchins et al. 2000; Zhu et al. 2002). Two studies examined the impact of local traffic emissions specifically on PTD (Wilhelm and Ritz 2003; Yang et al. 2003), but both assigned exposures based on the distance to and/or level of traffic on major roadways near residences, a relatively crude measure of traffic exhaust that does not consider vehicle emission rates or meteorology (Jerrett et al. 2005). Two recent birth outcome studies (Brauer et al. 2008; Slama et al. 2007), however, employed more sophisticated techniques to model traffic-related air pollution based on land use regression (LUR) that yielded quantitative estimates for specific pollutants.

Because of population and economic growth and the lack of effective public transportation in the Los Angeles area, the amount of passenger traffic and of goods being moved

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through this region is projected to increase substantially in the next decade (California Environmental Protection Agency 2006). Such rapid growth in traffic-related fossil fuel use is expected to occur worldwide (Energy Information Administration 2008), adding urgency to research evaluating the impact of increased vehicle emissions on reproductive health outcomes. To address this issue, in the present study we investigated the effects of local traffic-generated air pollution on preterm birth and preeclampsia based on the CALINE4 line-source dispersion model (Benson 1989), which is specifically designed for the assessment of traffic emissions from roads. We obtained health outcomes data from a perinatal database with detailed clinical data from a four-hospital network in southern Los Angeles County and Orange County, California, from 1997 to 2006.

Materials and Methods

Study population. Our racially and socioeconomically diverse study population resided in two areas of the South Coast Air Basin of California [see Supplemental Material, Figure 1 (doi:10.1289/ehp.0800334.S1 via http://dx.doi.org)] that exhibit a wide range of air pollution concentrations from mobile sources. One is located in southern Los Angeles County, north of the Ports of Los Angeles and Long Beach. The communities adjacent to the port are affected by major commuter freeways and main trucking routes for goods leading out of the port (Interstate 710); 15% of all containers arriving in the United States travel on this freeway (Beverly 2005). The other area is located in Orange County, southeast of the ports. Four major commuter and truck transport freeways traverse these neighborhoods. The study region also covers some suburban, low-traffic neighborhoods.

Birth data. We acquired all birth-related variables and antenatal information for pregnant women delivering during 1997–2006 within the Memorial Health Care System (MHCS), a four-hospital network (Chung et al. 2006). Poverty (percentage of population living below the poverty level) information by census block groups was obtained from U.S. Census 2000 data (U.S. Census Bureau 2004). No birth certificate data were used. The MHCS database included residential address at delivery, birth hospital, prenatal care insurance, maternal age and race/ethnicity, maternal medical history (heart disease, chronic hypertension, previous PTD), preeclampsia and other maternal complications during pregnancy (diabetes, pyelonephritis), parity (first birth vs. second or subsequent birth), gestational age, and the neonate's sex and birth weight. Gestational age was calculated according to delivery date and estimated date of conception (based on last menstrual period and ultrasound dating). We did not have diagnosis dates for preeclampsia; therefore, we could not determine when the disease first occurred.

A total of 105,092 neonatal records were extracted from the birth database. We successfully geocoded 92.8% of nonmissing residential addresses with exact matches to house number using the TeleAtlas Geocoding Service (http://www.geocode.com). A total of 81,186 singleton birth records remained in the data set for final analyses (77%) after excluding multiple gestations (*n* = 5,261; 5%), incomplete records including those without full residential address and those missing any covariate information (*n* = 12,666; 12%), and unsuccessfully geocoded residential addresses and addresses outside the study region (*n* = 5,979; 6%). Excluded births were similar to included births by study region (Los Angeles County and Orange County), demographics (age and race/ethnicity), and the prevalence of preeclampsia.

Air pollution exposure assessment. Background air pollutant concentrations may be high in the study region due to port activities and relatively heavy traffic regionwide. However, in this study we focused solely on local traffic-generated pollution to assess the potentially high toxicity of hypothesized causative agents (e.g., UFPs and PAHs) in traffic emissions. Our estimated pollutant exposures should be regarded as indicators of primary emissions from local vehicular traffic on top of background ambient levels [see Supplemental Material (doi:10.1289/ehp.0800334.S1)]. We modeled local traffic pollution using a modified CALINE4 dispersion model for two surrogate pollutants [nitrogen oxides (NO_x) and particulate matter ≤ 2.5 µm in aerodynamic diameter ($PM_{2.5}$)] originating from traffic emissions within 3 km of each residence (Benson 1989; Wu et al. 2005, 2009), assuming that at this distance we would capture most local traffic emissions but little regional pollution transported from upwind areas. CALINE4 is a Gaussian dispersion model that employs a mixing zone concept to characterize pollutant dispersion over the roadway. Major inputs to CALINE4 include meteorology (atmospheric stability, mixing height, wind, and temperature), roadway geometry and traffic activities, and vehicle emission factors. The performance of CALINE4 has been evaluated in a number of studies (Benson 1989, 1992; Broderick et al. 2005; Gramotnev et al. 2003; Levitin et al. 2005; Marmur and Mamane 2003). Previous studies have found moderate to high correlations (*R* = 0.55–0.95) of CALINE4-modeled estimates with measured variability of traffic-related air pollutants [e.g., NO_x and nitrogen dioxide] in urban communities (Gauderman et al. 2005; Jerrett 2006). Our recent study showed a high correlation (*R* = 0.87) of CALINE4-modeled monthly NO_x concentrations with measurements at nine monitoring sites in the Long Beach study area in December 2007 and April 2008 (Wu J, Lurmann F, Avol E, unpublished data).

A comprehensive traffic database with annual average daily traffic counts and gasoline and diesel vehicle fractions was constructed for the entire study region. Vehicle emission factors were obtained from the California Air Resources Board's EMFAC2007 vehicle emissions model (California Air Resources Board 2008). Paved road-dust emissions for $PM_{2.5}$ were based on in-roadway measurements (Fitz and Bufalino 2002). Hourly wind speed, direction, and temperature were obtained from the National Weather Service (National Climatic Data Center 2008). Summarized mixing heights by season and hour were obtained from the 1997 Southern California Ozone Study (Croes and Fujita 2003) and assigned to each modeled day based on season and hour.

Statistical analyses. PTD was defined as a birth at < 37 completed gestational weeks, moderate preterm deliveries (MPTD) as births at < 35 gestational weeks, and very preterm deliveries (VPTD) as births at < 30 gestational weeks. We defined preeclampsia as the occurrence of mild preeclampsia (blood pressure > 140/90 mmHg and proteinuria), severe preeclampsia (e.g., blood pressure > 160/110 mmHg and proteinuria with or without signs of end-organ involvement, including oliguria, liver function abnormalities, thrombocytopenia, headache), or hemolysis, elevated liver enzyme levels, and low platelet count (HELLP) syndrome at any time during pregnancy. Because hemolysis/HELLP is on the continuum of mild/severe preeclampsia and is relatively uncommon, we chose to combine this diagnosis with severe preeclampsia. Pregnancy trimesters were defined as gestational weeks 1–13, 14–26, and 27 weeks to birth.

We performed multiple logistic regression using the statistical package R (version 2.6.1; R Foundation for Statistical Computing, Vienna, Austria). Confounders were selected based on *a priori* knowledge and included maternal age, maternal race/ethnicity, parity, prenatal care insurance type [private, public (government-sponsored or self-pay), and unknown], poverty, season of conception, pyelonephritis (preterm analyses only), and diabetes (preeclampsia analyses only). We adjusted for maternal age as a continuous variable using a quadratic polynomial function. For the preeclampsia analyses, we excluded women who had preexisting chronic conditions such as hypertension and heart disease before pregnancy. We separately calculated odds ratios (ORs) and 95% confidence intervals (CIs) for increases in the interquartile range (IQR) for each pollutant exposure metric. ORs and 95% CIs were scaled to IQR increases in air pollutant variables to standardize and compare associations regardless of pollutant concentration range or units of measurement (Lipfert and Wyzga 1999). In addition to using continuous exposure variables, we performed categorical analyses in which we compared subjects in each exposure quartile with those in the lowest quartile and tested for dose response. We also examined the outcomes both collectively and separately by subcategories, including study region, race, poverty, insurance type, infant sex, maternal age, parity, delivery type and method, and health conditions (diabetes for preeclampsia and preeclampsia for preterm birth).

Results

Descriptive statistics. Most mothers were non-Hispanic white or Hispanic (Table 1). The prevalence of preeclampsia was higher among PTD women compared with non-PTD women (12% vs. 2%) and among African-American women compared with other races (4% vs. 3%). Mild, severe, and HELLP syndrome accounted for 75%, 18%, and 7% of the preeclampsia cases, respectively. The prevalence of PTD was higher among male infants than among female infants (9% vs. 8%) and in African-American women than in other races (13% vs. 7–9%). Spontaneous delivery accounted for 79% of all births and occurred in 87% of preterm births and 78% of term births. The poverty rate in our study region was higher than the national average (14% vs. 11% based on 2000 Census data) (U.S. Census Bureau 2004).

Average air pollution exposures derived from the CALINE4 model for each pregnancy period and during the entire pregnancy were similar and moderately to strongly correlated (Table 2). CALINE4-estimated average monthly (over all subjects in each calendar month) NO_x exposures showed a clear seasonal trend, with higher exposures in the cool season (average of 10.8 ppb in December) and lower exposures in the warm season (average of 5.8 ppb in June), and we observed a very similar monthly trend for $PM_{2.5}$. The estimated concentrations were much lower than those measured at three ambient monitoring stations in the area (e.g., annual mean of 57.0 ppb NO_x), likely because our model estimates were for local traffic-generated emissions only. As expected, the modeled NO_x and $PM_{2.5}$ exposures were highly correlated (correlation coefficient $r = 0.91$) in every pregnancy trimester, because the two pollutants are emitted by the same source: local traffic.

Regression analyses. Because of only slight variations in exposures and effect estimates in different pregnancy periods [see Supplemental Material, Tables 1 and 2 (doi:10.1289/ehp.0800334.S1)], we present all regression results based on exposure during the entire pregnancy period. We found positive associations of preeclampsia and preterm birth with entire-pregnancy exposure to traffic-related air pollution (Table 3). An 11% increase was observed in adjusted risk of preeclampsia per IQR increase of entire-pregnancy NO_x. Preeclampsia results were the same for modeled $PM_{2.5}$ exposures. Overall, we observed somewhat stronger increases in risk of preterm birth with increases in modeled NO_x than with modeled $PM_{2.5}$. The effect of exposure tended to be stronger for VPTD (25% increase in risk per IQR increase in NO_x) than for PTD considered as a whole (6% increase in risk per IQR increase in NO_x).

Stratified analyses for preeclampsia and preterm birth were conducted [see Supplemental Material, Tables 3–6 (doi:10.1289/ehp.0800334.S1)]. We found greater impacts of traffic-related air pollution on preeclampsia and VPTD for women ≥ 40 years of age and in women < 20 years of age when giving birth, although 95% CIs overlapped to a large degree. We observed a higher risk of preeclampsia from local traffic-generated air pollution exposure among privately insured women than among women on public or government-sponsored insurance [for entire-pregnancy NO_x: interquartile OR (IOR) = 1.12; 95% CI, 1.06–1.18, vs. IOR = 1.04; 95% CI, 0.96–1.13]. Closer inspection, however, showed that this was mostly driven by the high percentage (83%) of older women (> 40 years of age) using private insurance (for > 40 age group: IOR = 1.44; 95% CI, 1.22–1.69; ≤ 40 age group:

Table 1. Descriptive statistics of infants and mothers in our study in south Los Angeles County and Orange County, California, from 1997 to 2006 (*n* = 81,186).

Variable	Measure
Mother's age (mean ± SD)	30.0 ± 6.2
Mother's race (%)	
African American	8.8
Asian	9.9
Hispanic	32.1
White	40.3
Other	8.9
Male infant (%)	51.6
Gestational age [weeks (mean ± SD)]	38.7 ± 2.1
Preeclampsia (%)	3.0
Mild preeclampsia	74.9
Severe preeclampsia	18.2
HELLP syndrome	6.9
Term birth [≥ 37 weeks (%)]	91.7
Spontaneous	78.3
PTD [< 37 weeks (%)]	8.3
Spontaneous	87.2
MPTD [< 35 weeks (%)]	3.4
VPTD [< 30 weeks (%)]	1.0
Pyelonephritis (%)	0.2
Diabetes (%)	5.4
First child (%)	81.5
Delivery mode (%)	
Vaginal	73.1
Cesarean	26.9
Previous preterm infant (%)	1.1
Prenatal care insurance (%)	
Private	67.6
Government-sponsored or self-pay	28.4
Unknown	4.0
Poverty (%)[a]	14.2

[a] The percentage of the population living below the poverty level based on U.S. Census block group data for the year 2000.

Table 2. Pollutant averages and Pearson's correlation coefficients for pollutants by pregnancy period.

					Pearson correlation coefficient							
					Entire pregnancy		First trimester		Second trimester		Third trimester	
Trimester	Pollutant	Mean[a]	IQR	SD	NO_x	$PM_{2.5}$	NO_x	$PM_{2.5}$	NO_x	$PM_{2.5}$	NO_x	$PM_{2.5}$
Entire pregnancy	NO_x	7.23	5.65	5.22	1.00							
	$PM_{2.5}$	1.82	1.35	1.33	0.90	1.00						
First trimester	NO_x	7.45	6.17	5.68	0.91	0.83	1.00					
	$PM_{2.5}$	1.83	1.44	1.37	0.84	0.94	0.91	1.00				
Second trimester	NO_x	7.29	6.02	5.57	0.97	0.87	0.85	0.79	1.00			
	$PM_{2.5}$	1.83	1.42	1.36	0.89	0.98	0.80	0.91	0.91	1.00		
Third trimester	NO_x	7.14	5.88	5.54	0.91	0.83	0.71	0.68	0.85	0.79	1.00	
	$PM_{2.5}$	1.84	1.43	1.39	0.85	0.95	0.70	0.82	0.79	0.90	0.91	1.00

[a] Units are parts per billion for NO_x and micrograms per cubic meter for $PM_{2.5}$.

Table 3. Crude and adjusted ORs per IQR increase[a] in traffic-related air pollutions for preeclampsia and preterm, moderate preterm, and very preterm birth.

Condition	No. of cases	Pollutant	Crude IOR (95% CI)	Adjusted[b] IOR (95% CI)
Preeclampsia	2,442	NO_x	1.15 (1.10–1.19)	1.11 (1.06–1.16)
		$PM_{2.5}$	1.13 (1.09–1.17)	1.11 (1.06–1.15)
PTD (< 37 weeks)	6,712	NO_x	1.12 (1.09–1.15)	1.06 (1.03–1.09)
		$PM_{2.5}$	1.09 (1.06–1.11)	1.03 (1.01–1.06)
MPTD (< 35 weeks)	2,749	NO_x	1.22 (1.18–1.26)	1.13 (1.09–1.18)
		$PM_{2.5}$	1.15 (1.11–1.19)	1.07 (1.03–1.12)
VPTD (< 30 weeks)	775	NO_x	1.32 (1.25–1.41)	1.25 (1.17–1.33)
		$PM_{2.5}$	1.23 (1.16–1.31)	1.18 (1.10–1.26)

[a] Based on entire-pregnancy exposure. IQR was 5.65 ppb for NO_x and 1.35 μg/m³ for $PM_{2.5}$. [b] Adjusted for maternal age, maternal race/ethnicity, parity, prenatal care insurance type, poverty, and season of conception in all models. Additionally adjusted for pyelonephritis in PTD, MPTD, and VPTD models, and for diabetes in preeclampsia models.

IOR = 1.09; 95% CI, 1.03–1.16; based on entire-pregnancy NO_x) versus public or government-sponsored insurance (for > 40 age group: IOR = 0.93; 95% CI, 0.56–1.54; for ≤ 40 age group: IOR = 1.05; 95% CI, 0.97–1.14; based on entire-pregnancy NO_x). We observed no significant differences in effect estimates by study region, race/ethnicity, poverty, infant sex, parity, delivery type (spontaneous vs. nonspontaneous), delivery method (vaginal vs. cesarean section), diabetes status (for preeclampsia), and preeclampsia (for preterm birth).

Preeclampsia risk increased with quartiles of modeled NO_x and $PM_{2.5}$ exposures, and the increase was consistent with a linear dose response for NO_x (Figure 1). We observed a 33% (OR = 1.33; 95% CI, 1.18–1.49) and 42% (OR = 1.42; 95% CI, 1.26–1.59) increase in risk of preeclampsia for women in the highest NO_x and $PM_{2.5}$ entire-pregnancy exposure quartiles, respectively. We observed increasing risks with increasing quartiles of exposure to modeled NO_x and $PM_{2.5}$ and all preterm birth outcomes, yet the pattern was not always linear with dose (Figure 2). We observed a 128% (OR = 2.28; 95% CI, 2.15–2.42) and 81% (OR = 1.81; 95% CI, 1.71–1.92) increase in risk of VPTD for women in the highest NO_x and $PM_{2.5}$ entire-pregnancy exposure quartiles, respectively. The dose–response relationships from the quartile categorical analyses were consistent with what we observed from smoothing curves of dose response [see Supplemental Material, Figure 2 (doi:10.1289/ehp.0800334.S1)].

Discussion

There is growing interest in exploring the possible effects of ambient air pollution on fetal and perinatal development because the growing fetus may be particularly susceptible to the toxic effects of air pollutants (Maisonet et al. 2004; Mone et al. 2004; Pinkerton and Joad 2006). Our study contributes new results based on exposure data from a dispersion model for local traffic-generated air pollutants and preeclampsia. To our knowledge, this is the first study to show a positive association between exposure to local traffic-generated pollutants at the birth residence and the development of preeclampsia during pregnancy. We also found that the risk of premature birth increases with exposure to local traffic-generated pollutants, and this risk was strongest for VPTD followed by MPTD and PTD. This is important because postnatal health impairments are greatest for the children born most premature (Doyle 1995, 2008).

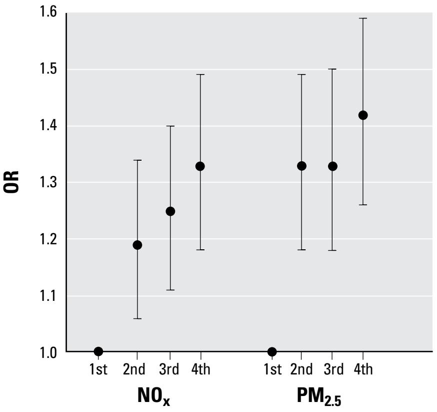

Figure 1. Adjusted ORs (95% CIs) for preeclampsia by entire-pregnancy exposure quartile (adjusted for maternal age, maternal race/ethnicity, parity, prenatal care insurance type, poverty, diabetes, and season of conception).

The present study had two major advantages over previous studies examining traffic air pollution and birth outcomes. First, we modeled air pollution exposures from local traffic sources (within 3 km) using a comprehensive traffic database and a well-established dispersion model that better characterizes spatiotemporal variability in exposure than that used in most previous studies. Two exceptions are recent studies from Munich, Germany (Slama et al. 2007), and Vancouver, Canada (Brauer et al. 2008), that employed temporally adjusted LUR models. However, because the LUR models were based on ambient air measurement data, they estimated total ambient air pollutant concentrations with contributions from many sources other than local traffic emissions. Thus, these exposure estimates only partially represent local traffic-generated air pollutants. The amount of total estimated ambient pollution that is contributed from traffic may vary according to location in LUR models. In addition, LUR models may not perform well in predicting temporal variations of exposures because they are mostly built relying on one to four purpose-designed monitoring windows of 7 to 14 days, with or without further temporal adjustment using ambient monitoring station data (Hoek et al. 2008).

The second major advantage is that the present study used detailed individual-level clinical data (e.g., chronic hypertension, pyelonephritis, diabetes, heart disease), allowing us to evaluate the impact of these clinical parameters on air pollution effect estimates. But more important, we were able to employ more accurate gestational age information to classify preterm birth than most previous air pollution studies that relied on birth certificates. Gestational ages on birth certificates are usually based on first day of last menstrual period, which leads to misclassification of gestational age due to poor recall, postconception bleeding, or menstrual irregularities (Dietz et al. 2007; Kline 1989; Lynch and Zhang 2007). One the other hand, gestational age estimated by ultrasound measurements alone may induce systematic errors and inflate the risk of PTD (Olsen and Basso 2005). More than 99% of our subjects obtained prenatal care early in pregnancy, which ensured that their estimated conception date was based on a combination of last menstrual period and early ultrasound dating. Moreover, our preeclampsia data were based on hospital records of clinical diagnoses, probably more accurate than the preeclampsia data reported on birth certificates that may only record extreme or severe preeclampsia cases.

We estimated only local traffic-generated air pollution exposure in this study, whereas

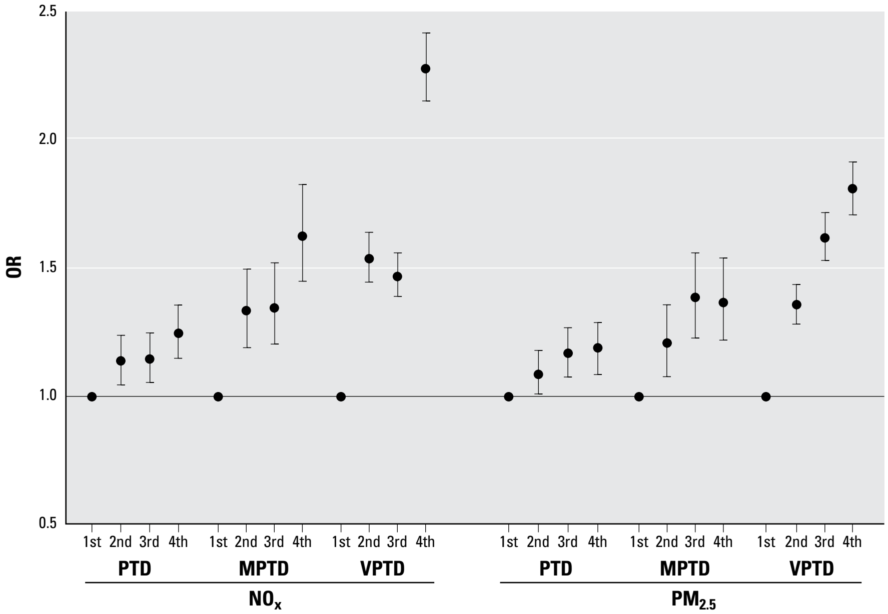

Figure 2. Adjusted ORs (95% CIs) for PTD, MPTD, and VPTD by entire-pregnancy exposure quartile (adjusted for maternal age, maternal race/ethnicity, parity, prenatal care insurance type, poverty, pyelonephritis, and season of conception).

most previous studies based on ambient or modeled total concentration data (e.g., carbon monoxide and NO_x) examined contributions from not only local traffic but also pollutants transported from upwind regions and from other sources. Local traffic emissions may differ from aged pollutants from long-range transport in terms of chemical composition and particle size distribution. Therefore, our estimated effect sizes for different outcomes may not be directly comparable to those from other air pollution studies.

The only results ever reported for air pollution and preeclampsia relied on CO concentrations measured at the nearest ambient air monitor to residence (Woodruff et al. 2008) or CO and $PM_{2.5}$ concentrations estimated using linear regression models at each residence (Rudra and Williams 2006). Rudra and Williams (2006) observed a 49% increase in preeclampsia risk (95% CI, 0.76–2.90) for third- versus first-tertile average CO exposures during the month of conception and the following 3 months among women in Seattle, Washington, and Woodruff et al. (2008) reported an 8% increase in preeclampsia risk (95% CI, 1.02–1.14) for the highest versus the lowest entire-pregnancy CO exposure quartile in Californian women. In our study, women exposed at the highest quartile of modeled entire-pregnancy $PM_{2.5}$ experienced approximately 40% higher risk of developing preeclampsia compared with women in the lowest quartile of exposure. We also noted a slightly higher risk of preeclampsia from local traffic-generated air pollution exposure among privately insured women. This might have been attributable to the high percentage (83%) of older women (> 40 years of age) using private insurance, as mentioned above, or may result from more accurate diagnosis of preeclampsia in privately compared with publicly insured women. Also, older pregnant women might be especially vulnerable to the effects of toxins such as air pollutants.

Our preterm birth results are consistent with results from previous birth outcome studies in the literature. In addition, the preterm birth results were similar using separate models for the three nonexclusive preterm outcomes compared with multilogit models that captured the relatedness of the three outcomes [see Supplemental Material, Table 7 (doi:10.1289/ehp.0800334.S1)]. We estimated a 6% increase in risk of PTD per IQR in modeled entire-pregnancy NO_x exposure and a 25% increased risk of PTD for mothers in the highest NO_x exposure quartile. Wilhelm and Ritz (2003) previously reported a 10–20% increase in the risk of PTD in mothers exposed to high levels of local traffic-generated air pollution in Southern California, based solely on residential distance-weighted traffic density. Following up on this first study, they conducted a nested case–control study within another birth cohort in Los Angeles County, California, and found PTD to be approximately 20% higher in mothers with first trimester CO exposure > 1.25 ppm (Ritz et al. 2007). A study from Taiwan estimated a 30% increased risk of PTD for mothers living within 500 m of a major freeway (Yang et al. 2003). A more recent study from Vancouver, Canada, reported no consistent association of PTD (< 37 weeks) with any of the pregnancy air pollution exposure metrics (including LUR measures) except inverse distance–weighted $PM_{2.5}$ concentration during the entire pregnancy (OR = 1.06; 95% CI, 1.01–1.11; per 1-$\mu g/m^3$ increase in $PM_{2.5}$) (Brauer et al. 2008). Similar to our findings, risk increased when they further restricted PTD to < 30 weeks of gestation (for $PM_{2.5}$ exposure: OR = 1.13; 95% CI, 0.92–1.39; for NO_x exposure: OR = 1.26; 95% CI, 1.08–1.47).

We found the risk of preeclampsia and VPTD due to modeled NO_x and $PM_{2.5}$ exposure from traffic to be greater in the youngest (< 20 years of age) and the oldest (≥ 40 years of age) age groups, consistent with the preterm birth results of a study in Los Angeles County, California (Ponce et al. 2005). Two U.S. studies, one conducted in Arizona and North Dakota (Ahluwalia et al. 1997) and the other in California (Windham et al. 2000), have also reported a stronger impact of environmental tobacco smoke (ETS) on preterm births among older (≥ 30 years of age) compared with younger (< 30 years of age) mothers, further suggesting possible differences in vulnerability by maternal age.

There were several limitations in the present study. We likely reduced exposure measurement error for primary traffic pollutants by using a dispersion model and a sophisticated traffic database versus relying on ambient measurements. However, the exposure estimates were based solely on the maternal address at time of birth. Mobility rates among pregnant women reported in the literature range from 12% (Fell et al. 2004) to 35% (Brauer et al. 2008). Ritz et al. (2007) found that associations between air pollution exposures (estimated via nearest air monitor) during pregnancy and preterm birth did not change or slightly strengthened when restricting analyses to women who did not move during pregnancy. The estimates of exposures in the present study, however, may have been affected more strongly by residential mobility because they are more spatially resolved than in previous studies. Second, our exposure estimates were based only on residential addresses, ignoring other microenvironments (e.g., workplace, commuting) that might be important for personal exposures. Ritz et al. (2007) reported associations between monitor-based estimates of air pollution exposure during pregnancy and PTD to be greater for women who did not work (and for whom a residence-based measure of exposure presumably is more accurate) than for women who worked outside their homes.

Another potential source of bias is residual confounding due to risk factors we were unable to account for in our analyses (e.g., maternal smoking, ETS, stress, and nutrition). Ritz et al. (2007) collected detailed survey data postnatally on risk factors not reported on birth certificates and assessed the influence of these potential confounding factors on air pollution effect estimates for preterm birth. Adjustment for covariates on birth certificates exhibited the strongest influence on the pollutant effect estimates, whereas additional adjustment for a large number of survey covariates (e.g., occupation, income, maternal smoking and ETS, alcohol drinking) changed the effect estimates by < 5%. This confirmed that for pollutants that change with season and are averaged over short time intervals (pregnancy months or trimesters), behavioral factors that do not change seasonally are unlikely to be confounders. Compared with ambient measurements of total pollutant concentrations, however, the major contrast in the CALINE4-modeled exposure was spatial rather than temporal. Therefore, residual confounding cannot be ruled out in these primarily spatially based exposure measures.

It is also uncertain to what degree the dispersion model we used represents pollutant species released only by traffic. Comparing modeled and measured concentrations, we observed reasonable agreement between CALINE4-modeled and measured 2-week average NO_2 concentrations at 260 residences in six communities participating in the Southern California Children's Health Study, with an R^2 ranging from 0.3 to 0.9 (Gauderman et al. 2005; Jerrett 2006). Relatively high correlations ($n = 14$; $R^2 = 0.76$) were found between CALINE4-modeled and measured monthly average concentrations of NO_x at nine monitoring stations in the Long Beach area in November 2007 and/or April 2008 (Wu J, Lurmann F, Avol E, unpublished data). The R^2 for daily estimates ranged from 0.19 to 0.81 (mean = 0.36) among the nine stations (Wu J, Lurmann F, Avol E, unpublished data). Thus, we expect that longer-term exposure estimates (monthly, trimester, and entire-pregnancy averages) derived from CALINE models closely reflect residential exposure to local traffic-generated pollutants because traffic counts and mixing heights are based on long-term, annual, or seasonal average observations.

Both modeled $PM_{2.5}$ and NO_x were associated with PTD and preeclampsia, but this should not be interpreted to mean that these pollutants are necessarily causative for these adverse outcomes; rather, they could be acting as surrogates of traffic exhaust, which is a complex mixture of hundreds of toxic components (Kim et al. 2008; Singer et al. 2004). There is evidence that UFP number concentrations may be a more appropriate metric than gas or particle mass concentrations when evaluating health risk from traffic-related air pollution (Oberdörster et al. 2005). UFPs may be causal agents for the observed health effects due to their high pulmonary deposition efficiency, and their orders of magnitude higher number concentration and surface area that allows them to carry larger concentrations of adsorbed or condensed toxic air pollutants (e.g., oxidant gases, PAHs, and transition metals) to the fetus and the placenta (Oberdörster et al. 2005). UFPs contain a significant amount of PAHs, which have been linked to various measures of intrauterine growth retardation in studies in New York State (Choi et al. 2006, 2008; Perera et al. 2003, 2004), Krakow, Poland (Choi et al. 2006), and industrial areas of the Czech Republic (Dejmek et al. 2000). Yet, little is known to date about the etiologic role that UFPs and PAHs may play for preterm birth and preeclampsia.

Several hypotheses have been postulated to explain how air pollution may trigger PTD. Toxic compounds in traffic-generated air pollutants may interfere with placental development and subsequent nutrient and oxygen delivery to the fetus (Dejmek et al. 2000). Another potential mechanism of developmental toxicity is through the activation of the oxidative stress pathway. PTD may be triggered by an abnormal production or an early activation of cytokines favoring inflammation, even though increasing concentrations of inflammatory cytokines may be part of the body's preparation for normal parturition (Engel et al. 2005; Keelan et al. 2003).

The mechanisms that initiate preeclampsia in pregnant women have been elusive (Mutter and Karumanchi 2008; Shah 2007). Pathology studies show that an abnormal development of an ischemic placenta with a high-resistance vasculature contributes to the development of preeclampsia. Endothelial dysfunction plays a central role in the pathogenesis of the syndrome. Multiple interconnected pathways linked to endothelial dysfunction involve oxidative stress, cytokine release, and a generalized intravascular inflammatory response (Baumwell and Karumanchi 2007). Exposure to traffic-related pollutants, such as UFPs and PAHs, can cause oxidative stress (Li et al. 2003; Nel et al. 2001; Oberdörster et al. 2005) and endothelial dysfunction (Tornqvist et al. 2007). Such exposure could thus contribute to the cardiovascular complications of preeclampsia as well as PTD (Gitto et al. 2002).

Conclusions

Exposures to local traffic-generated air pollution modeled with CALINE4 for the entire pregnancy elevated the risk of preterm birth and preeclampsia in Southern California women. A 42% increased risk of preeclampsia was observed for the highest quartile of modeled traffic-related $PM_{2.5}$ exposure during the entire pregnancy. For preterm birth, the exposure–response relation was strongest for VPTD with potentially serious consequences for the newborn. These results provide further evidence that traffic-related air pollution is associated with adverse reproductive outcomes.

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Associations of Children's Lung Function with Ambient Air Pollution: Joint Effects of Regional and Near-roadway Pollutants

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Abstract

Background—Prior studies have reported adverse effects of either regional or near-roadway air pollution (NRAP) on lung function. However, there has been little study of the joint effects of these exposures.

Objectives—To assess the joint effects of NRAP and regional pollutants on childhood lung function in the Children's Health Study.

Methods—Lung function was measured on 1,811 children from eight Southern Californian communities. NRAP exposure was assessed based on (1) residential distance to the nearest freeway or major road and (2) estimated near-roadway contributions to residential nitrogen dioxide (NO_2), nitric oxide (NO), and total nitrogen oxides (NO_x). Exposure to regional ozone (O_3), NO_2, particulate matter with aerodynamic diameter less than 10 μm (PM_{10}) and 2.5 μm ($PM_{2.5}$) was measured continuously at community monitors.

Results—A 17.9 ppb (two standard deviation) increase in near-roadway NO_x was associated with deficits of 1.6% in FVC (p=0.005) and 1.1% in FEV_1 (p=0.048). Effects were observed in all communities and were similar for NO_2 and NO. Residential proximity to a freeway was associated with a reduction in FVC. Lung function deficits of 2–3% were associated with regional PM_{10} and $PM_{2.5}$ (FVC and FEV_1) and with O_3 (FEV_1), but not NO_2, across the range of exposure between communities. Associations with regional pollution and NRAP were independent in models adjusted for each. Effects of NRAP were not modified by regional pollutant concentrations.

Conclusions—Results indicate that NRAP and regional air pollution have independent adverse effects on childhood lung function.

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COMPETING INTERESTS

Frederick Lurmann is employed by Sonoma Technology, Inc (Petaluma, CA). Rob McConnell has received research support from an air quality violations settlement agreement between the South Coast Air Quality Management District, a California state regulatory agency, and BP. The other authors declare they have no actual or potential competing interests.

Keywords

traffic; lung function; air pollution; children; land-use regression

INTRODUCTION

Reduced lung function has been associated with subsequent increased risk of overall mortality, including coronary artery disease and respiratory disease in adults [1] and with asthma in children.[2] Therefore, identifying factors that reduce lung function but are modifiable could lead to interventions with large public benefits.

Regional air pollutants have been associated with reduced lung function in both adults and children.[3–4] Studies examining lung function in children exposed to local residential near-roadway air pollution (NRAP) have not found consistent associations,[5–11] although exposure metrics differed across studies. However, there has been little investigation of the joint effects of regional and NRAP exposures.

In this study, we assessed the joint effects of NRAP and regional exposures to ozone (O_3), particulate matter with aerodynamic diameter of less than 10 μm and 2.5 μm (PM_{10} and $PM_{2.5}$), and nitrogen dioxide (NO_2) on childhood lung function in the Children's Health Study (CHS). We examined associations with both traffic proximity measures and land-use regression modeled NRAP based on a prior dense air monitoring study of NO_x conducted within CHS communities.

METHODS

Study Subjects

The CHS has enrolled over 11,000 children in a series of cohorts investigating the health effects of air pollution. The current analysis includes a cohort established in 2002–2003 when participants were 5–7 years of age.[12] During the 2007–2008 school year, lung function was measured on 1,811 cohort participants (82% of the active cohort) from eight communities, as described in detail in the Online Supplement.

Questionnaires

Questionnaires completed by parents or guardians at study enrollment provided information on participants' health, socio-demographic and other exposures, which was updated yearly. A complete list of covariates is described in the Online Supplement.

Lung Function

Trained technicians measured lung function, weight, and height, and collected information about recent acute respiratory illness. Using pressure-transducer-based spirometers (Screenstar Spirometers, Morgan Scientific, Haverhill, MA), we identified the maximal forced expiratory volume during the first second (FEV_1) and forced vital capacity (FVC) from a series of seven efforts from each child, as described previously.[13]

Air Pollution Exposure

NRAP exposures at each child's residence and school were based on estimates of surrogates, including distance to freeways, highways, and large surface streets. Spatial land use regression models were developed based on an extensive monitoring campaign of nitrogen oxides (NO_x) and nitrogen dioxide (NO_2) and by subtraction nitrogen oxide (NO) at over 900 locations in CHS communities, as described previously.[14] Key predictors included distance to freeways and major roads, traffic volumes and their emissions-weighted dispersion estimates, with lesser contributions from population density and local variation in elevation. The resulting annual average predicted residential concentrations of near-roadway NO, NO_2, and NO_x, incrementally increased above regional background, was used in analyses, as described below.

The regional level of NO_2, $PM_{2.5}$, PM_{10}, and O_3 was computed as the mean of the six years of each pollutant measured continuously at a central monitoring location in each community from cohort recruitment (2002) to the recording of lung function tests (2007).

Additional details of NRAP and regional pollutant exposure assessment are provided in the Online Supplement.

Statistical Methods

We fitted linear regression models (with fixed effects for each study community) to investigate associations of FVC and FEV_1 with NRAP and a mixed model that included a random intercept for community to assess associations with regional pollutants and joint effects with NRAP. Each pulmonary function outcome was log transformed to satisfy the assumptions of the models. All models were adjusted for demographic and anthropomorphic characteristics (eg. height) and selected other potential confounders (eg. spirometry technician). In sensitivity analyses, other potential confounders and effect modifiers were examined using standard methods described in further detail in the Online Supplement.

The NRAP NO_x (and NO and NO_2) predicted residential exposures were deviated from a community-specific mean. Conceptually, this allowed examination of the effect of the complex NRAP mixture, for which the nitrogen oxides are only a surrogate, and to distinguish it from the regional NO_2 effect, which was assessed based on the continuous measurements at the community monitor so as to be comparable to other regional pollutant assessments. This procedure was also necessary to make the NRAP NOx approximately orthogonal (uncorrelated) to cross-community regional exposures in the mixed models. Health effect estimates were scaled to the range of long-term average regional pollution across all communities and to two standard deviations in the predicted NRAP nitrogen oxides.

Based on our final model, we also computed estimated lung function representative of different combinations of high and low regional and NRAP environments. Low regional pollution was based on the minimum value of regional $PM_{2.5}$ while low NRAP was defined as one standard deviation below the mean value for deviated NO_x. Conversely, high regional pollution was based on the maximum value of regional $PM_{2.5}$ and high NRAP was defined as one standard deviation above the mean value for deviated NO_x. We expressed the predicted lung function in these different environments as percentages relative to those in the cleanest environment (low regional and low NRAP).

RESULTS

The average age at lung function measurement was 11.2 years (SD=0.6). A plurality of participants was White (40%) and a majority was of Hispanic ethnicity (57%, Table 1). Household income less than $30,000 and parental education less than high school were common, and secondhand tobacco smoke exposure was uncommon.

Overall, 27% of children lived within 500 m of a freeway, while 20%, 15% and 38% lived 500–1,000 m, 1,000–1,500 m, or >1,500 m from a freeway, respectively (Supplemental Material, Table S-1). There was 14% of children who lived within 75 m of a major road (mostly non-freeway), 17% between 75 and 150 m, 28% between 150 and 300 m, and 40% at least 300 m. The distributions of residential proximity to freeways and major roads varied substantially from community to community. Predicted residential near-roadway NO_x, NO, and NO_2 showed wide variation within most study communities (Figure 1). Correlations among regional pollutant levels ranged from 0.06 (between PM_{10} and NO_2) to 0.80 (between PM_{10} and $PM_{2.5}$; Supplemental Material, Table S-2). O_3 had relatively strong positive correlations with $PM_{2.5}$ and PM_{10}. The correlation between predicted near-roadway NO, NO_2 and NO_x (within communities) exceeded 0.90 (Supplemental Material, Table S-3).

The means of FEV_1 and FVC for males were 2,474 ml and 2,902 ml, respectively, and the corresponding means for females were 2,442 ml and 2,783 ml. Living within 500 m of a freeway was associated with a nearly 2 percent deficit in FVC (−1.96%; 95% CI: −3.41%, −0.49%; p=0.009) compared to those living at least 1,500 m from a freeway (Table 2). Mean FEV_1 was also lower for children living within 500 m of a freeway but the association was not statistically significant. Although close proximity to a major road was negatively associated with each measure of lung function, these associations were not statistically significant.

Near-roadway residential NO_x, NO, and NO_2 had statistically significant negative associations with both FVC and FEV_1 (Table 2). For example, a two standard deviation increase in near-roadway NO_x exposure (17.9 ppb) was associated with a 1.56% deficit in FVC (−2.62, −0.49; p=0.005), and a 1.10% deficit in FEV_1 (−2.19, −0.01; p=0.048). Negative associations between near-roadway NO_x and lung function were observed within six of the eight study communities for FEV_1 (Figure 2A) and within all eight study communities for FVC (Figure 2B). There was not significant heterogeneity of near-roadway NO_x effects across the eight communities for either FEV_1 (p=0.61) or FVC (p=0.64).

Adjustment for potential confounding variables resulted in only small changes to the estimated effects of near-roadway residential NO_x on FEV_1 and FVC (Table 3). For example, across models that included various additional adjustments, the near-roadway NO_x-related deficits ranged from −0.96% to −1.12% (main model: −1.10%) for FEV_1, and from −1.40% to −1.60% (main model: −1.56%) for FVC. In an analysis restricted to children without asthma, the effect of near-roadway NO_x was similar to that in the entire study population (1.19% decline in FEV_1 and 1.51% decline in FVC). The difference in effects between children with and without asthma was not statistically significant. There was also no significant heterogeneity in near-roadway NO_x effects on lung function in girls compared to boys. Although we have observed associations of lung function with exposure at schools of participants in this study in conjunction with psychosocial stress,[15] we observed no main effects of exposure in schools in this analysis (results not shown).

Deficits in FEV_1 of approximately 3% were observed across the range of community O_3 and $PM_{2.5}$ levels (p=0.006 for O_3 and 0.001 for $PM_{2.5}$, Table 4 and Figure 3). A greater than 2% deficit was observed across the range of PM_{10} exposure. Deficits in FVC of over 2% were also observed across the range of both $PM_{2.5}$ and PM_{10} (Table 4 and Figure 4); however, a single community (Mira Loma) appears to have driven the association between FVC and PM_{10}.

In models assessing the joint effects of regional and NRAP, there was little change in the strength of the regional pollutant associations with either FVC or FEV_1, after adjusting for near-roadway NO_x (Table 5). For FEV_1, there was little change in the unadjusted association of near-roadway NO_x (1.10% deficit in Table 2) after adjusting for regional pollutants effects (1.04% to 1.14% deficits in Table 5). For FVC, the unadjusted association with near-roadway NO_x (1.56% deficit in Table 2) was somewhat attenuated after adjusting for regional pollutants (1.40% to 1.49% deficits in Table 5), although the associations remained significant. Similar patterns of lung function deficits in two-pollutant models were observed for near-roadway NO and NO_2 (results not shown). The patterns of effects of freeway proximity associations were also similar in models including a regional pollutant and in models unadjusted for regional pollution (results not shown). We examined the possibility that background pollutant exposures might up-regulate pulmonary response to near-roadway pollutants resulting in larger lung function deficits in communities with high regional pollutants. However, none of the regional pollutants significantly modified the association between near-roadway residential NO_x and each of the lung function endpoints (results not shown).

DISCUSSION

These results indicate that exposure to near-roadway air pollution adversely affects childhood lung function. Strengths of the study were the ability to demonstrate consistent effects of NRAP using both roadway proximity and validated predicted NO_x markers for the NRAP mixture in communities with differing regional air quality, roadway networks, and geographical characteristics. The study design offered an unusual opportunity to demonstrate that associations of lung function with NRAP pollutant variation were independent of associations also observed with regional air pollution.

NRAP is a complex mixture of particles and reactive gases with oxidant and pro-inflammatory properties that could plausibly cause the observed lung function deficits.[16–17] Oxides of nitrogen were selected to develop prediction models for likely near-roadway variation of the mixture because they are inexpensive to measure with the spatial density needed to develop valid models. NO_2 also has known oxidant and immune-modulatory properties and could contribute to the near-roadway lung functions effects,[18] although in our analysis it was not possible to distinguish NRAP NO_2 effects from other components of the mixture. The association of regional $PM_{2.5}$ and PM_{10} with both FEV_1 and FVC, and no effect of regional NO_2, suggests that there were independent effects of transported or secondary regional particulate matter and of the NRAP mixture (rather than NO_2). In addition, previous reports from the CHS (and other studies) showing associations of NRAP, but not regional pollutants, with prevalent and incident asthma [12 19–20] also are consistent with separate and independent effects of these diverse pollutant mixtures.

It is also possible that more complex combinations of regional and NRAP account for the observed associations, as toxicological and experimental studies indicate that interaction with other pollutants may enhance the effects of particle exposure.[21–22] Although the study design allowed us to examine the heterogeneity of NRAP health effects across multiple communities, we found little evidence for interaction between regional pollutants and NRAP. Rather, the adverse effects were relatively consistent in all eight study communities, although there was limited precision to each estimate because of limited community-specific sample size.

We have previously observed associations of regional PM [23] and traffic proximity [7] with growth of FVC, but accompanied by larger effects in FEV_1 in an older cohort of CHS participants. Other studies of traffic and lung function in elementary school and adolescent children have also found larger associations with flow rates than with FVC.[8–9 24] However, the current results are consistent with an observed effect of regional pollutants on FVC in a cross sectional analysis of prior CHS cohorts.[13] Additional follow up of this cohort is ongoing and may help elucidate these relationships.

Some previous studies that have looked at associations between residential traffic related pollution and lung function were performed in multiple geographical regions,[5 7–8 10–11] but many of these studies used only roadway proximity or traffic count/density metrics rather than validated exposure models. Other studies that have used land-use regression to estimate the relationship between NRAP and childhood lung function were performed in relatively limited geographical regions.[6 9] Results have not been consistent across studies.

These inconsistencies in the strength of association between near-roadway residential traffic exposure and respiratory health across several prior studies[5–11] may result in part from the use of different types of NRAP measures, with differing degrees of uncertainty as proxies for pollution exposure. A strength of this study was the use of quantitative residential NO_x exposure assignments derived from a spatial land-use regression model calibrated to measurements at well characterized locations in study communities.[14] Additionally, the association between lung function and predicted NO_x was consistent with the inverse relationship between residential distance to a freeway and lung function, which was also observed in an earlier CHS cohort,[7] as concentrations of NRAP decrease with increasing distance from a freeway.[25] Comparable, high quality, exposure assessment across studies would facilitate qualitative comparisons or pooled analyses and might lead to more consistent epidemiologic findings.

The adverse associations of lung function with O_3, $PM_{2.5}$, and PM_{10} are consistent with other studies.[3] In earlier CHS cohorts we reported associations of lung function with $PM_{2.5}$ and PM_{10}, as well as NO_2, but not with O_3.[7 13] However, O_3 and PM were correlated across communities of the current cohort, and it was therefore not possible to distinguish effects of each.

This study replicates the general design and general age range of a cross-sectional report from a previous CHS cohort [19] but expands the scope of that earlier work by examining both between and within-community pollutant effects. The amount of between-community regional variation in the present study is less than that found in previous CHS studies due to our focus on more-urban communities with larger gradients in NRAP. However, a nearly two-fold difference in the six-year averaged regional pollution concentrations (Figures 3 and 4) exists between the highest and lowest polluted communities, which allowed us to identify between and within-community effects. We have been collecting additional lung function data and will examine longitudinal pollutant effects separately.

We considered the possibility that bias explained our results. Participants and non-participants from the cohort were generally similar across a broad range of demographic, social and housing characteristics (Supplemental Material, Table S-4). The only significant difference was for boys, who were more likely than girls to be non-participants. However, adjusting for sex and for other characteristics had little impact on the NRAP effect estimate (Table 3). Furthermore, the effect of NOx on lung function in analyses restricted to girls was generally similar to the effect among all participants. Although selection bias and residual confounding by other factors cannot be excluded as an explanation for our results, these analyses provide little reason to believe that this occurred.

There are potentially large public health implications of these findings because NRAP exposure due to proximity of homes and other locations where children spend time is common [26–27] and lung function in childhood tracks into adult life.[28–30] Furthermore, the strong association between exposure and lung function in non-asthmatic children suggests that traffic-related pollution did not affect only a sensitive subgroup but rather has a potential impact on all children. Although direct comparison of the magnitude of effects of regional and near-roadway pollution is difficult, the deficits associated with near-roadway NOx across a (two-standard deviation) range of within-community variation encompassing most children in our study communities was only modestly less than the effects of regional pollutants across the range of community-average exposure. Compared with a child living in a low NRAP environment in a low regional $PM_{2.5}$ community, the results suggest that a child living in a high NRAP environment in a community with high PM in Southern California would experience a greater than 4% decrease in FEV_1 (Figure 5) For comparison with another common exposure, maternal secondhand smoking of 1 pack/day has been shown to be associated with a 0.4% deficit in childhood level of FEV_1.[31] Prevention of these large pollutant effects poses a challenge to the current air pollution regulatory framework, which historically has set standards using risk calculations that consider effects of regional air quality but not near-roadway traffic-related variation in exposure.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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What is the key question?

Do residential near-roadway and regional air pollution cause reduced lung function?

What is the bottom line?

This study found that increased near-roadway and regional air pollutants were independently associated with lower FEV_1 and FVC.

Why read on?

A design including multiple communities and predicted near-roadway residential air pollution exposure from well-validated models allowed this study to demonstrate associations of lung function deficits with regional ozone and particulate matter that were independent of associations with indicators of the near-roadway pollutant mixture in multiple communities.

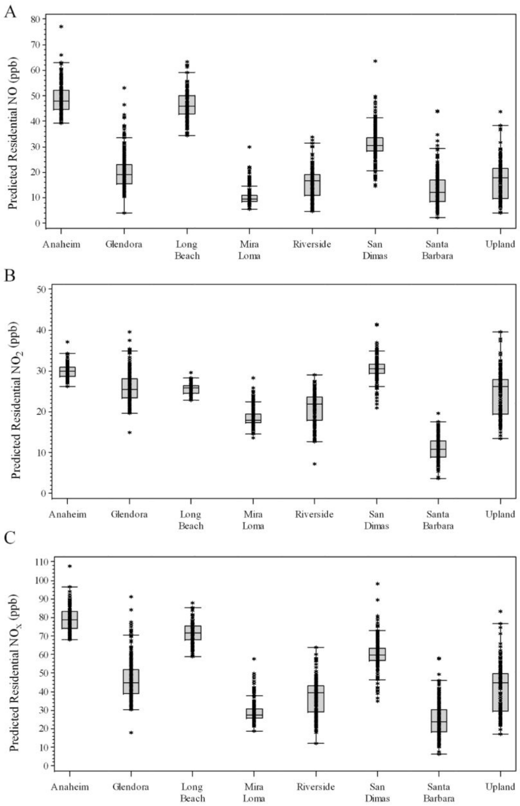

Figure 1.

Distribution of predicted local (A) NO, (B) NO_2, and (C) NO_x within each of the eight study communities based on a spatial land-use regression model.

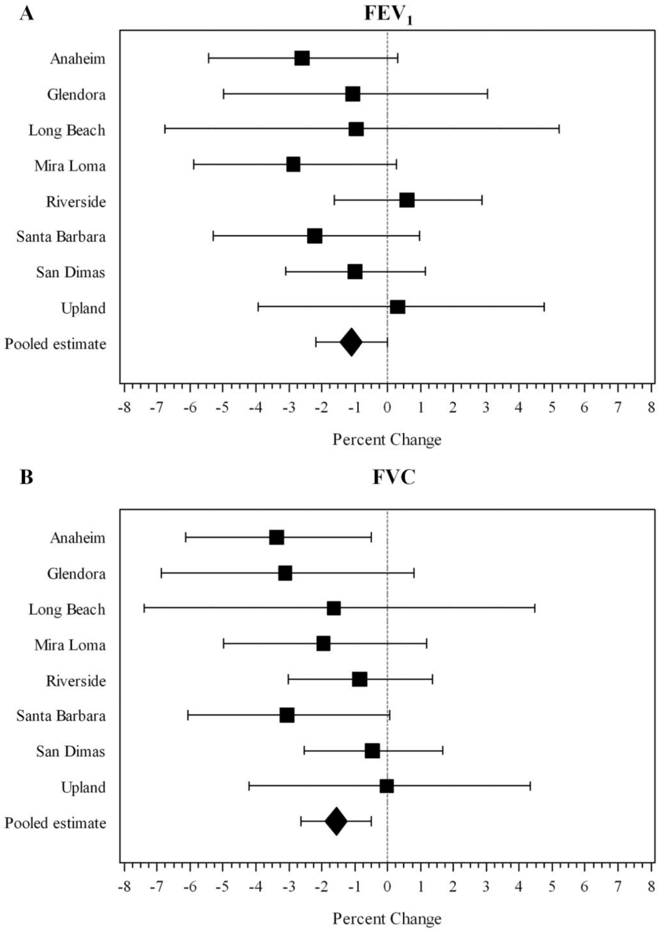

Figure 2.

Associations of local NO_x with (A) FEV_1 and (B) FVC within each study community.

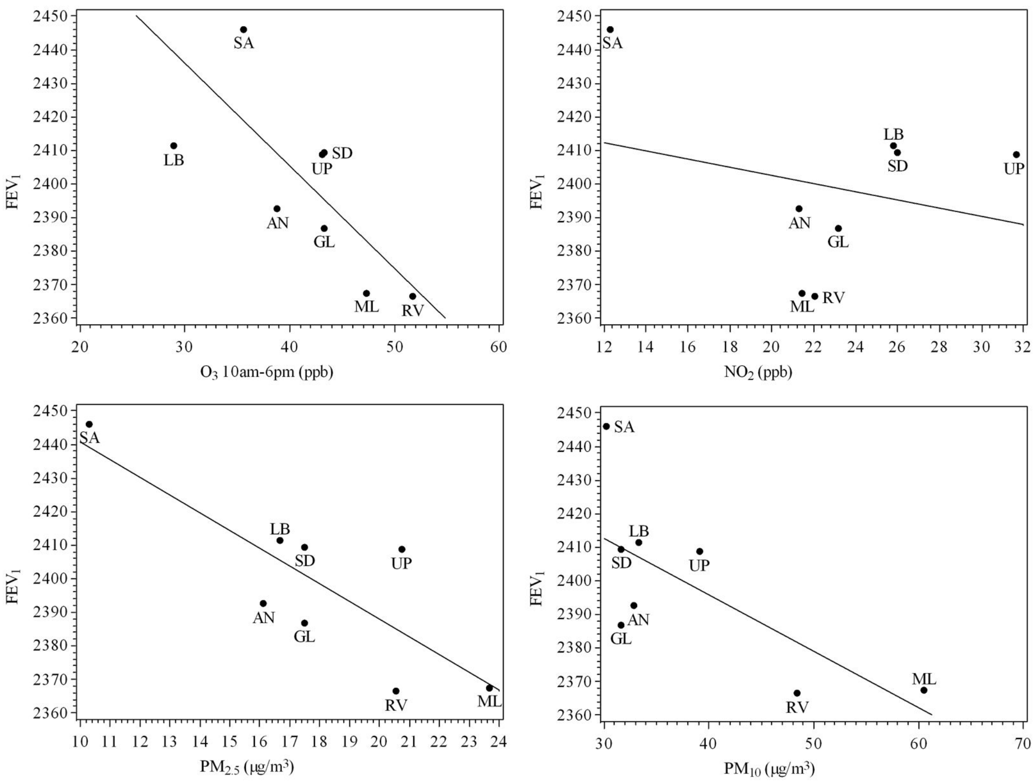

Figure 3.

Adjusted average FEV_1 versus 2002–2007 community-average pollutant levels.

Average FEV_1 values are referenced to a white, non-hispanic female of average height and BMI and without a respiratory infection on the day pulmonary function was examined.

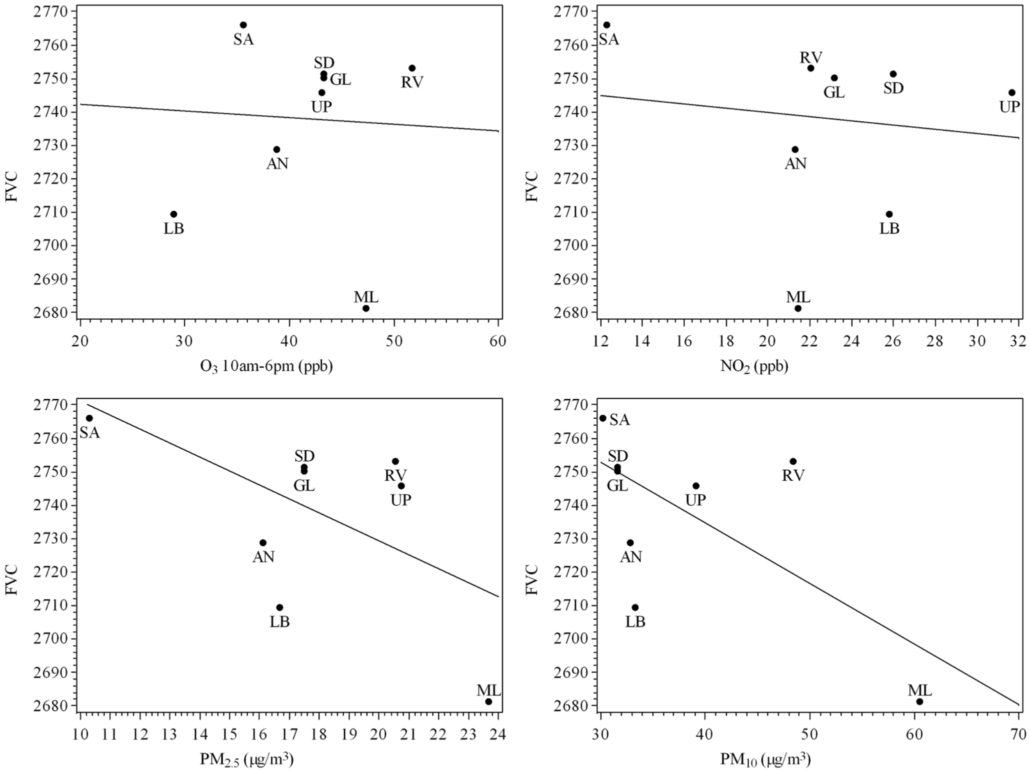

Figure 4.

Adjusted average FVC versus 2002–2007 community-average pollutant levels.

Average FVC values are referenced to a white, non-hispanic female of average height and BMI and without a respiratory infection on the day pulmonary function was examined.

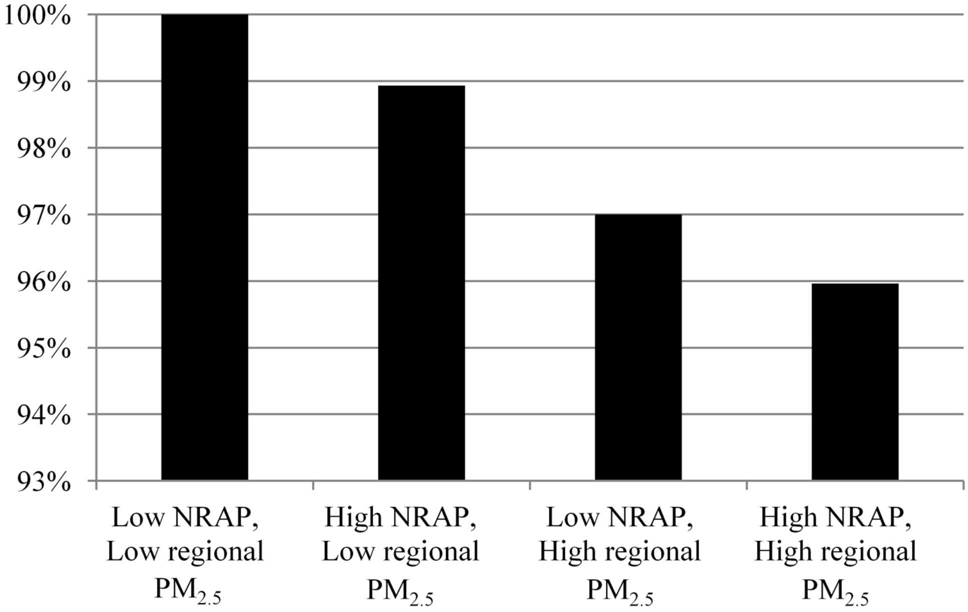

Figure 5.

Joint effect of regional $PM_{2.5}$ and NRAP on FEV_1.

Percentages in different exposure environments are relative to a low regional $PM_{2.5}$ and low NRAP environment as described in the Statistical Methods section.

Table 1

Characteristics of 1,811 CHS participants with lung function testing

	N (total=1811)	%[†]
Male	871	48.1
Race		
Asian	86	4.8
Black	39	2.2
Don’t Know	239	13.2
Mixed	229	12.6
Other	486	26.8
White	732	40.4
Hispanic ethnicity		
Don’t Know	92	5.1
Hispanic	1028	56.8
Not Hispanic	691	38.2
SES		
Household income		
<$30,000	402	27.1
$30,000 or more	1084	73.0
Parental education		
Did not finish high school	345	20.6
High school diploma or some college	854	51.0
College diploma or greater	477	28.5
Health insurance covers child	1508	89.3
Home characteristics/Potential exposures		
Gas stove	1462	86.5
Dog	599	35.8
Cat	312	18.8
Mold past 12 months	172	10.5
Secondhand smoke exposure	67	3.8
In-utero exposure to maternal smoking	99	5.8
Health conditions		
Acute respiratory illness	164	9.4
Medical diagnosis of asthma	334	19.5

[†] Due to missing values, denominators (n) for each percentage may differ.

Table 2

Effects of measures of near-roadway air pollution on lung function level.

	FEV$_1$[†]		FVC[†]	
	%Diff	**95% CI**	**%Diff**	**95% CI**
Freeway				
>1,500 m	Ref		Ref	
1,000–1,500 m	1.63	(−0.05, 3.34)	0.99	(−0.65, 2.66)
500–1,000 m	−0.50	(−2.05, 1.07)	−1.01	(−2.52, 0.53)
<500 m	−1.06	(−2.55, 0.45)	−1.96	(−3.41, −0.49)[**]
Trend (p-value)		0.09		0.004
Major Road				
>300 m	Ref		Ref	
150–300 m	−0.56	(−1.90, 0.79)	−0.69	(−2.00, 0.65)
75–150 m	−0.50	(−2.04, 1.06)	−0.82	(−2.32, 0.72)
<75 m	−1.58	(−3.21, 0.09)	−1.53	(−3.14, 0.11)
Trend (p-value)		0.09		0.06
Predicted Near-roadway Pollution[‡]				
NO$_2$	−1.00	(−2.08, 0.09)	−1.40	(−2.46, −0.33)[*]
NO	−1.19	(−2.27, −0.09)[*]	−1.68	(−2.74, −0.60)[***]
NO$_x$	−1.10	(−2.19, −0.01)[*]	−1.56	(−2.62, −0.49)[***]

[†] All models include adjustments for log of height and its squared value, BMI and BMI^2, sex, age, sex*age interaction, race, Hispanic ethnicity, respiratory illness at time of test, field technician, and study community.

[‡] Near-roadway residential pollutants were scaled to two standard deviations of their respective community-mean centered distributions (6.4 ppb for NO$_2$, 12.3 ppb for NO, and 17.9 ppb for NO$_x$).

[*] p<0.05,

[**] p<0.01,

[***] p<0.005

Table 3

Sensitivity analysis for lung function effects of near-roadway residential NO_x.

	FEV_1[†]	**FVC**[†]
	% diff (95% CI)	**% diff (95% CI)**
Main model	−1.10 (−2.19, −0.01)	−1.56 (−2.62, −0.49)
Additional covariates		
Main model + family income	−1.04 (−2.13, 0.07)	−1.51 (−2.58, −0.43)
Main model + parental level of education	−0.96 (−2.05, 0.14)	−1.44 (−2.51, −0.36)
Main model + diagnosis of asthma by medical doctor	−1.06 (−2.14, 0.03)	−1.55 (−2.61, −0.47)
Main model + dogs in home	−0.97 (−2.06, 0.13)	−1.40 (−2.47, −0.33)
Main model + cats in home	−1.09 (−2.18, 0.00)	−1.55 (−2.61, −0.47)
Main model + exposure to gas stove	−1.10 (−2.18, −0.01)	−1.56 (−2.62, −0.49)
Main model + in-utero exposure to maternal smoking	−1.09 (−2.17, 0.01)	−1.60 (−2.66, −0.53)
Main model + exposure to tobacco smoke at home	−1.12 (−2.20, −0.02)	−1.57 (−2.63, −0.50)
Main model + exposure to mold	−1.12 (−2.21, −0.03)	−1.57 (−2.64, −0.50)
Main model + insurance coverage	−1.10 (−2.18, −0.01)	−1.55 (−2.61, −0.48)
Subgroup analysis		
Non-asthmatics	−1.19 (−2.41, 0.05)	−1.51 (−2.72, −0.29)
Asthmatics	−0.65 (−3.35, 2.14)	−1.20 (−3.91, 1.58)
Boys	−0.96 (−2.48, 0.58)	−1.13 (−2.60, 0.36)
Girls	−1.10 (−2.65, 0.48)	−1.81 (−3.34, −0.25)

[†] See Table 2 for adjustment variables and scaling factor for pollutant effects.

Table 4

Effect of averaged regional pollutants on lung function level.

	Regional Pollutant	% Diff[†]	95% CI
FEV_1	O_3 (10am-6pm)	−3.10	(−5.24, −0.91)**
	$PM_{2.5}$	−2.94	(−4.65, −1.20)***
	PM_{10}	−2.19	(−3.98, −0.37)*
	NO_2	−1.19	(−4.14, 1.85)
FVC	O_3 (10am-6pm)	−0.31	(−3.11, 2.57)
	$PM_{2.5}$	−2.25	(−3.94, −0.52)*
	PM_{10}	−2.05	(−3.54, −0.54)**
	NO_2	−0.79	(−3.52, 2.02)

[†] See footnote to Table 2 for adjustment variables (community adjustment not included). Each pollutant was scaled to the range of the 24-hour average over the study period from 2002 until 2007 with the exception of O_3, which was scaled to the 8-hour average from 10am to 6pm (22.7 ppb for O_3 10-6, 13.3 μg/m^3 for $PM_{2.5}$, 30.3 μg/m^3 for PM_{10}, 19.4 μg/m^3 for NO_2).

*p<0.05,

**p<0.01,

***p<0.005

Table 5

Joint analysis of regional air pollution and near-roadway NO_X on lung function.

		Effect of Regional Pollutant†		Effect of Near-roadway NO_x†	
	Regional Pollutant	**% Diff**	**95% CI**	**% Diff**	**95% CI**
FEV_1	O_3 (10am-6pm)	−3.24	(−5.32, −1.11)***	−1.04	(−2.11, 0.05)
	$PM_{2.5}$	−3.00	(−4.76, −1.21)***	−1.07	(−2.14, 0.01)
	PM_{10}	−2.24	(−4.04, −0.41)*	−1.14	(−2.22, −0.06)*
	NO_2	−1.22	(−4.23, 1.88)	−1.07	(−2.15, 0.02)
FVC	O_3 (10am-6pm)	−0.34	(−3.21, 2.63)	−1.47	(−2.53, −0.41)**
	$PM_{2.5}$	−2.35	(−4.09, −0.57)**	−1.40	(−2.46, −0.34)**
	PM_{10}	−2.17	(−3.68, −0.63)**	−1.49	(−2.54, −0.43)**
	NO_2	−0.78	(−3.62, 2.15)	−1.46	(−2.52, −0.39)**

† See Table 2 for adjustment variables (community adjustment not included) and scaling factor for pollutant effects of near-roadway NO_X. See footnote to Table 4 for scaling factor for regional pollutants.

* $p<0.05$,

** $p<0.01$,

*** $p<0.005$

Concentration and Size Distribution of Ultrafine Particles Near a Major Highway

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Concentration and Size Distribution of Ultrafine Particles Near a Major Highway

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ABSTRACT

Motor vehicle emissions usually constitute the most significant source of ultrafine particles (diameter <0.1 µm) in an urban environment, yet little is known about the concentration and size distribution of ultrafine particles in the vicinity of major highways. In the present study, particle number concentration and size distribution in the size range from 6 to 220 nm were measured by a condensation particle counter (CPC) and a scanning mobility particle sizer (SMPS), respectively. Measurements were taken 30, 60, 90, 150, and 300 m downwind, and 300 m upwind, from Interstate 405 at the Los Angeles National Cemetery. At each sampling location, concentrations of CO, black carbon (BC), and particle mass were also measured by a Dasibi CO monitor, an aethalometer, and a DataRam, respectively. The range of average concentration of CO, BC, total particle number, and mass concentration at 30 m was 1.7–2.2 ppm, 3.4–10.0 µg/m^3, 1.3–2.0 × 10^5/cm^3, and 30.2–64.6 µg/m^3, respectively.

For the conditions of these measurements, relative concentrations of CO, BC, and particle number tracked each other well as distance from the freeway increased. Particle number concentration (6–220 nm) decreased exponentially with downwind distance from the freeway. Data showed that both atmospheric dispersion and coagulation contributed 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 13,900 vehicles/hr. Ninety-three percent of vehicles were gasoline-powered cars or light trucks. The measured number concentration tracked traffic flow well. Thirty meters downwind from the freeway, three distinct ultrafine modes were observed with geometric mean diameters of 13, 27, and 65 nm. The smallest mode, with a peak concentration of 1.6 × 10^5/cm^3, disappeared at distances greater than 90 m from the freeway. Ultrafine particle number concentration measured 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.

IMPLICATIONS

Although they constitute only 1–8% of the mass of particulate matter (PM) in ambient air, ultrafine particles have been suggested as a possible causative agent for increases in mortality and morbidity associated with increases in PM concentration. Motor vehicle emissions usually constitute the most significant source of ultrafine particles in an urban environment, yet little is known about their concentration and size distribution in the vicinity of major highways. The present study, conducted in the vicinity of Interstate 405, shows that particle number concentration near the freeway was ~25 times greater than that at background locations, and that the concentration of ultrafine particles drops to background levels within 300 m downwind of the freeway.

INTRODUCTION

Throughout the past decade, epidemiologic studies have reported a consistent relationship between increases in particulate matter (PM) exposure and contemporary increases in mortality and morbidity.[1-4] However, the underlying biological causes of the health effects of PM exposure and the correct measurement metric are unclear. For example, it is unclear whether the mass concentration[5] or the number concentration[6,7] is most important in causing these adverse PM health effects. The particle size of airborne PM controls where the inhaled particles deposit in the various regions of the human respiratory system by the complex mechanisms of aerosol deposition.[8] Recent toxicological studies have concluded that, at the same mass concentration, ultrafine particles (diameter <100 nm) are more toxic than larger particles with the same chemical composition.[9-15] Recent dosimetry studies have reported that the total deposition fraction of ultrafine particles increases as particle size decreases,[16,17] with the greatest fractional deposition in the deep lung occurring between 5 and 100 nm.[17] Currently, however, only the mass of PM less than 10 µm (PM_{10}) and less than 2.5 µm ($PM_{2.5}$) in aerodynamic diameter are regulated. Information about ultrafine particles is usually not available, even though ultrafine particles represent 80% of the particle number concentration in an urban environment.[18] The less numerous but much heavier supermicrometer particles dominate mass concentration measurements. Thus, both number concentration and the size distribution of ultrafine particles are needed to better understand ambient air quality and its potential health effects.

In an urban environment, motor vehicle emissions usually constitute the most significant source of ultrafine particles.[19,20] Although traffic-related air pollution in urban environments has been of increasing concern, most studies have focused on gaseous pollutants and the total mass concentration and chemical composition of particulate pollutants.[21-26] Because the majority of particles from vehicle exhaust are in the size range of 20–130 nm for diesel engines and 20–60 nm for gasoline engines,[27,28] 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. Previously, researchers have measured the horizontal and vertical profiles of submicrometer particulates (16–626 nm) near a major arterial route in the urban area of Brisbane, Australia.[29] They found that, with the exception of measurements in close proximity to the road (~15 m), the horizontal profile measurements did not show statistically significant differences in fine particle number concentration at ground-level distances up to 200 m away from the road.

Hitchins et al. examined 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.[19] They conducted measurements under different wind conditions and found that when the wind blew 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.[19] Shi et al. measured ultrafine particle number concentrations and size distributions at a busy roadside and at nearby urban background sites in Birmingham, England.[20] They observed a faster decline of particle number concentration than of mass concentration and concluded that dilution with background air is the main mechanism for the rapid decrease in particle number concentration and changes in particle size distribution with distance from traffic. Recently, it was reported that the fraction less than 10 nm constitutes more than ~40% of the total particle number concentrations at 4 and 25 m from the curb.[30]

While recent studies have examined ultrafine particles from traffic in other countries, no comparable work has been done in the Los Angeles basin, home to more than 15 million individuals and 10 million vehicles. Two studies characterizing Los Angeles freeway aerosols date to the 1970s.[31,32] More recently, ambient ultrafine particles in Pasadena, a city in the Los Angeles basin, have been studied.[33] Despite considerable improvements in air quality over the past two decades, the Los Angeles basin continues to exhibit the most severe particulate air quality problem in the United States. Laboratory studies have found that new engine technology and fuel reformulation have decreased particle mass concentrations emitted from vehicles, but ultrafine particle number concentrations have remained unchanged or have even increased.[27,28,34,35] With the advance of aerosol instrumentation, ultrafine particles now can be characterized much better than they could be 30 years ago. Thus, it is necessary and timely to conduct a comprehensive study of ultrafine particles in the vicinity of freeways in the Los Angeles area.

In view of the growing concern about ultrafine particle exposure, the need to assess exposure for epidemiology studies, and the high traffic density in the Los Angeles basin, the aim of this article was to systematically evaluate ultrafine particles in the vicinity of a freeway, particularly as they are transported downwind from the freeway. Particle number concentration and size distribution ranging in size from 6 to 220 nm were measured along with CO, black carbon (BC), and PM concentration as a function of distance from Interstate 405, one of the busiest freeways in the United States.

METHODS

Description of Sampling Site

This study was conducted in the Los Angeles National Cemetery adjacent to Interstate 405 between May 15 and July 18, 2001. Freeway 405 runs generally north and south (actual orientation 330°) along the western boundary of the cemetery, with a 1% upgrade going north. In the immediate vicinity of the sampling site, the terrain is flat-mowed lawn with scattered mature trees about 10 m high and 6 m apart. This flat region extends 0.7 km to the east of the freeway and 1.3 km along the freeway with no significant local sources of PM emissions other than the freeway. Measurements were made along Constitution Avenue, which runs perpendicular to the freeway. It passes through a tunnel under the freeway, thereby providing access to upwind and downwind sides of the freeway. At the sampling site, the freeway is elevated ~4.5 m above the surrounding terrain.

The site lies 6.4 km east of Santa Monica Bay and the Pacific Ocean. During the sampling period, a consistent sea breeze (eastward from the ocean) developed each day, beginning in the mid-morning, reaching its maximum in early to mid-afternoon, and dying out in the early evening. The region upwind of the freeway is a residential area with no industrial or other obvious PM sources. Background measurements were taken ~300 m upwind of the freeway.

The only other freeways or major roads nearby are Sepulveda Boulevard, which runs parallel and immediately adjacent to the freeway, and Wilshire Boulevard, which runs perpendicular to the freeway more than 0.8 km to the south. During the sampling periods, traffic on Sepulveda Boulevard was light, ~5% of that on the freeway. For the usual wind direction (from southwest to northeast), traffic on Wilshire Boulevard was more than 2 km away along the wind vector and had little influence on particle levels.

The freeway has nine lanes, five northbound and four southbound. It is ~30 m wide, including a 1-m-wide median strip. The location of each measurement site for this study was determined by measuring its distance from the center of the median strip. The distance from each of the five sampling locations to the nearest traffic lane was 15 m less than the indicated distance.

Sampling and Instrumentation

Wind speed and directions were measured 6 m above ground level 30 m downwind of the 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). Throughout each measurement, the traffic strength on the freeway, defined as the number of vehicles passing per minute, was continuously monitored by a video recorder (camcorder) located on top of a 10-m tower close to the main gate of the Los Angeles National Cemetery. The camcorder was high enough to capture all nine lanes on the freeway and on Sepulveda Boulevard. After each sampling session, the videotapes were replayed, and traffic density was counted manually. Three 1-min samples were randomly selected from every 10-min interval. The data then were averaged for cars, light trucks, and heavy-duty trucks to estimate the traffic strength 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.) and a scanning mobility particle sizer (SMPS 3936, TSI Inc.), respectively. The sampling flow rate of the SMPS was adjusted to 1.5 L/min to measure particles as small as 6 nm and to minimize the diffusion losses of ultrafine particles during sampling.[8] Flexible conductive tubing (Part 3001940, TSI Inc.) was used for sampling to avoid particle losses caused by electrostatic forces. The sizing accuracy of the SMPS was verified in the laboratory by means of monodisperse polystyrene latex spheres (PSL, Polysciences Inc.). Data reduction and analysis of the SMPS output were performed using Aerosol Instrument Manager software (version 4.0, TSI Inc.). Measurements were taken 30, 60, 90, 150, and 300 m downwind and 300 m upwind from the center of the freeway. The distances were chosen based on preliminary measurements and previously published literature.[19] At each location, three size distribution samples were taken in sequence with the SMPS. Scanning time for each was 180 sec.

In addition to size distribution and total number concentration, concentrations of BC, CO, and PM were monitored simultaneously at each sampling location. Before each measurement, all instruments were synchronized. Data were averaged later 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.) was used to measure BC concentrations every 5 min. CO concentrations were measured by a near-continuous CO monitor (Dasibi Model 3008, Environmental Corp.) every minute. The CO monitor was calibrated by means of standard CO gas (RAE Systems Inc.) in the laboratory and automatically zeroed each time the power was turned on. A DataRam photometer (RAM-1, MIE Inc.) was used as a continuous PM monitor. Because the PM concentrations measured by the DataRam were not actual gravimetric measurements, these values were used as indicators of general trends in PM concentrations and overall changes with distance from the freeway.

Electric power for the control site CPC and weather station was obtained by an extension cord to the cemetery office. Electric power for other sampling instruments at locations further downwind was supplied by a 1.2-kW gasoline-powered portable generator (Model EU 1000i, Honda Motor Co.). The generator was placed ~50 m downwind of each sampling location. Both total particle number and CO concentrations were measured at the control site while the generator was turned on and 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 the control CPC were placed at the 30-m downwind control site and sampled throughout the experiment. All other applicable instruments were moved together and sampled simultaneously at each sampling location. It took about 10 min to complete sampling at each location and 90 min to complete a set at all six locations. Three or four sets were performed on each sampling date.

RESULTS AND DISCUSSION

The measurements presented herein were conducted between May 15 and July 18, 2001. During the sampling

Table 1. Sampling dates and instruments used.

Date	Time	Weather Wizard III	Control CPC	SMPS	CO Monitor	Aethalometer	DataRam
05/15/01	10:30–15:30	×	×	×			
05/17/01	11:00–15:30	×	×	×			
05/30/01	11:00–16:00	×	×	×			
06/08/01	10:30–16:00	×	×	×			
06/20/01	10:30–15:30	×	×	×	×	×	×
06/21/01	11:00–16:00	×	×	×	×	×	×
06/22/01	10:30–16:00	×	×	×	×	×	×
07/17/01	10:30–15:30	×	×	×	×		×
07/18/01	10:30–16:00	×	×	×	×		×

period, traffic density ranged from 140 to 250 vehicles/min passing the sampling site in both directions. Average vehicle speed ranged from 2.5 to 30.0 m/sec (5–65 mph). Traffic primarily was dominated by gasoline-powered cars and light trucks, and less than 5% of vehicles observed were heavy-duty diesel trucks. The results presented in the next sections include measurements of total particle number concentrations by a control CPC and of wind velocity using a Weather Wizard III, both positioned at a fixed location 30 m downwind of the freeway; of CO, BC, and PM concentrations; and of ultrafine particle size distributions upwind and at five downwind distances from the freeway.

Wind Effects

Wind speed and direction were measured, averaged, and logged over every 1-min interval throughout each sampling period. Of more than 5000 observations from all the sampling dates, 100 wind data points were randomly selected and are plotted in Figure 1. The orientation of the freeway and the sampling road, Constitution Avenue, also are shown in the figure. Note that 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/sec intervals. In the figure, duplicate observations are 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 percentage of sampling time that the wind came from each 22.5° segment also is shown in Figure 1. As shown in the figure, for most of the sampling time, the wind came directly from the freeway toward the sampling road with a speed of 1–2 m/sec. The consistency of observed wind direction and speed is a result of a generally low synoptic wind velocity and a reliable sea breeze in the sampling area. For this study, the consistency of the wind is important, because it allowed data from different days to be averaged together. Hitchins et al. found a completely different characterization of changes in total particle number concentration with increasing distances from a major road when the wind was blowing directly from, parallel to, or away from the sampling location.[19] They observed no trend when the wind was blowing away from the sampling location.[19]

In this study, we found that both wind direction and wind speed played an important role in determining the characteristics of ultrafine particles near the freeway. Figure 2 shows total particle number concentrations as measured by the control CPC, located 30 m downwind of the freeway, versus wind speed. A linear regression line, equation, and R^2 value also are included in Figure 2. The CPC was programmed to archive averaged total particle number concentrations at 1-min intervals in synchronization with the averaging time of the meteorological data. Only wind data within 45° of normal to the freeway are used in this figure. This range accounts for more than 80% of the total observations. In addition, Figure 2 includes particle number concentrations ranging in size from 15 to 697 nm, at 30 m, given by Figures 3a–c of Hitchins et al.,[19] for comparison. It can be seen that total particle number concentration measurements near the freeway are in general 2–3 times greater than those observed by Hitchins et al. at Tingalpa, Australia.[19] This is mainly because of the much heavier traffic density on the freeway, as discussed in the next sections. In addition, vehicle type,

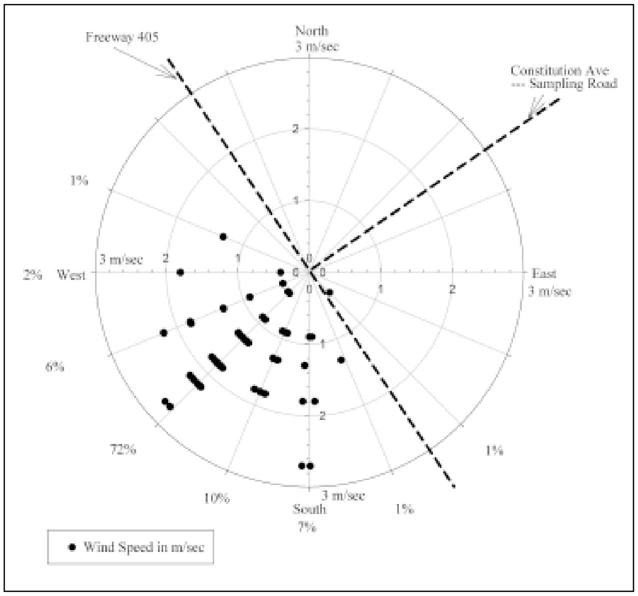

Figure 1. Wind direction and speed at the sampling site.

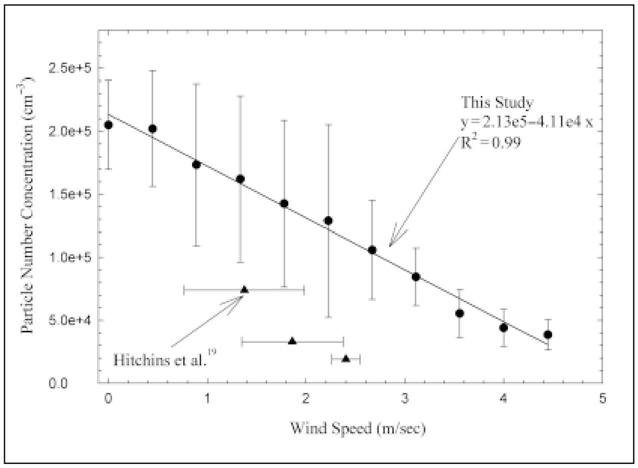

Figure 2. Total particle number concentration measured by a CPC located 30 m downwind from Freeway 405 vs. wind speeds. Bars indicate 1 standard deviation.

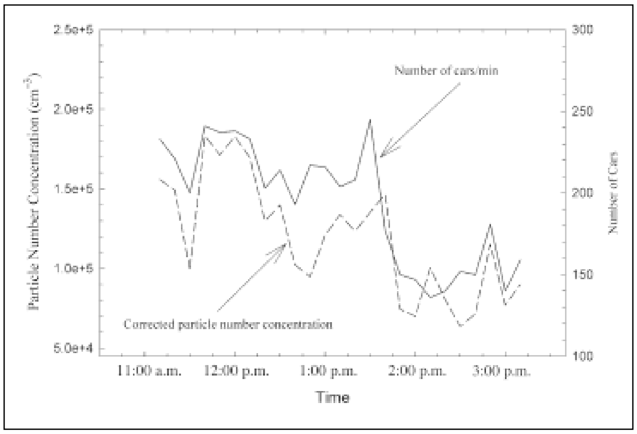

Figure 3. Correlation between traffic density and measured total particle number concentration, corrected for wind velocity, 30 m downwind from the freeway.

emission control equipment, and fuel type; utilization parameters such as age, accumulated mileage, inspection, and maintenance; operating modes such as average speed and fraction of cold/hot starts; and ambient parameters such as temperature and humidity also may contribute to the observed differences. Although the absolute particle number concentrations are quite different in these two studies, the relative particle number concentrations as a function of wind speed are quite similar. This indicates that atmospheric dilution of ultrafine particles by the wind is comparable for both cases.

Traffic Effects

Freeway 405 passing through west Los Angeles is considered one of the busiest freeways in the United States. The average traffic volume per hour during the measurement period was 13,000 cars, 350 light trucks, and 550 heavy trucks, totaling 13,900 vehicles. More than 93% of the vehicles passing by the measurement site on the freeway were gasoline-powered cars. This observed total traffic density was ~3 times higher than that reported by Hitchins et al. at Tingalpa, Australia,[19] and accounts for the higher observed total particle number concentrations.

Figure 3 shows the change in measured particle number concentration and the number of cars passing by the sampling site during those sampling periods when the wind was within 22.5° of normal to the freeway. Because wind speed played an important role in determining the total particle number concentrations, measured CPC readings were corrected to 1 m/sec by the following equation:

$$C_N{}^* = C_N \times \left(\frac{171{,}900}{213{,}000 - 41{,}100 \times V} \right) \qquad (1)$$

where $C_N{}^*$ is the corrected particle number concentration used in Figure 3, C_N is the CPC measured particle number concentration, 213,000 is the intercept of the regression line in Figure 2, 171,900 cm^{-3} is the particle number concentration at 1 m/sec velocity, –41,100 is the slope of the regression line, and V is the wind speed in m/sec as measured by the weather station. This correction will transform the measured particle number concentration to approximately a constant value at a relatively low wind speed (i.e., $V < 3$ m/sec). Because for most of the sampling time, average wind speed was in the range of 1–1.5 m/sec, this correction applies to more than 95% of the observations.

As shown in Figure 3, normalized particle number concentration tracked the traffic density very well, indicating that traffic is the major contributor to fine and ultrafine particles. A traffic slowdown on the northbound side of Freeway 405 usually developed on weekdays around 1:30 p.m., as indicated by the sharp drop of the solid curve in Figure 3. During this traffic slowdown, the average vehicle speed was usually less than 5 mph. The control CPC reading during that time period was observed to be much lower than normal, indicating that fewer ultrafine particles are produced during such traffic slowdowns. One possible explanation lies in the fact that nanoparticles produced by idling engines have longer residence times before they are exhausted from the tailpipe. Kittleson found that coagulation may reduce output number concentrations dramatically if engine exhaust is not diluted rapidly.[36,37]

Because both wind speed and traffic density affected the characteristics of ultrafine particles near the freeway and the control CPC reacted to these effects reasonably well, subsequent data for ultrafine particle analysis at increasing distances from the freeway were all normalized to the control CPC reading. An average CPC reading, $\overline{C_N}$, was obtained based on all the measurements. In Figures 4, 5, and 6, number concentration size distribution data were scaled to $\overline{C_N}$ by dividing each measurement by the ratio of the CPC reading for the period of measurement to $\overline{C_N}$.

Change in Ultrafine Particle Size Distribution with Increasing Distance

Figures 4a–f depict ultrafine particle size distribution at 30, 60, 90, 150, and 300 m downwind and at 300 m upwind of the freeway, respectively. The horizontal axis represents particle size on a logarithmic scale, while the vertical axis represents normalized particle number concentration. The normalized ultrafine particle size distributions, in the size range of 6–220 nm as measured by the SMPS, were averaged for all applicable sampling dates for each distance from the freeway. It is useful to describe the size characteristics of ultrafine particles near a vehicular source in terms of the parameters of a suitable distribution.[38-40] The number of modes for each ultrafine particle size distribution

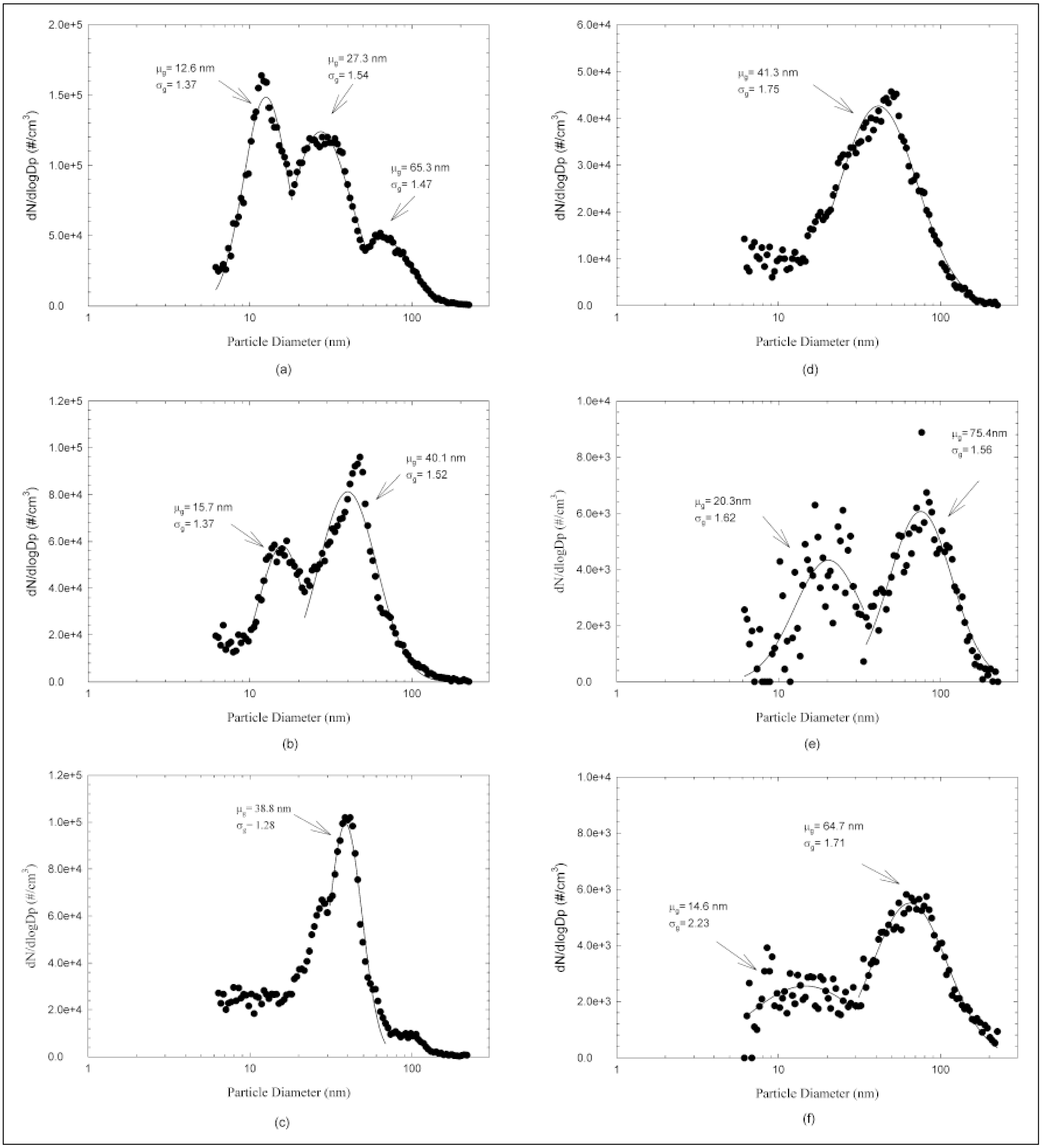

Figure 4. Fitted multimodel particle size distribution at different sampling distances from Freeway 405. (a) 30 m downwind, (b) 60 m downwind, (c) 90 m downwind, (d) 150 m downwind, (e) 300 m downwind, and (f) 300 m upwind. Size distributions were normalized to the control CPC's reading.

was determined by visual inspection of the size distribution graphs. Then, the full spectrum was subdivided into one, two, or three size-groups according to the number of modes. The data for each size-group then was fitted with a lognormal distribution using the SigmaPlot 2000 lognormal three-parameter fitting procedure.[41] The fitted distribution, the geometric mean diameter, μ_g, and the geometric standard deviation, σ_g, also are shown in Figures 4a–f for each observed mode.

As shown in Figure 4, ultrafine particle size distribution from the freeways changed markedly and its number concentration dropped dramatically with increasing distance. In Figure 4a, at the nearest sampling location, 30 m downwind from the freeway, three distinct modes were observed with geometric mean diameters of 13, 27, and 65 nm, respectively. The mode for the smallest particle sizes, with a peak concentration of 1.6×10^5/cm^3, was similar to that previously reported for direct laboratory measurement of vehicle emissions.[28] This mode shifted to a larger geometric mean diameter, 16 µm, and the modal number concentration dropped to one-third of the maximum concentration at 60 m downwind (see Figure 4b). This mode was not observed at greater downwind distances (see Figures 4c–e). The dramatic decrease in particle number concentration at ~10 nm likely was caused by several atmospheric aerosol particle mechanisms that enhanced small particle loss, diffusion to surfaces, evaporation, and coagulation. The smaller the particle, the greater its diffusion coefficient and its Brownian motion. Particles of 10 nm diffuse ~80 times faster than do particles of 100 nm. 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 because of their Brownian motion (coagulate), they form a bigger particle. Thus, coagulation reduces number concentrations and shifts the size distribution to larger sizes.[8,32] The coagulation effect will be discussed in detail in the following paragraphs.

Because of atmospheric dilution, the number concentration for all sizes dropped dramatically with increased distance from the freeway. Number concentration dropped to approximately half its original value at 30 m somewhere between 90 and 150 m, as shown in Figure 4d. This result is in good agreement with Hitchins et al., who found that particle number concentrations decreased by 50% at 100–150 m.[19] Ultrafine particle concentration measured at 300 m downwind of the freeway (see Figure 4e) was comparable to what was measured at the background location 300 m upwind of the freeway (see Figure 4f). The maximum number concentration that was observed near the freeway was ~25 times greater than that at the background location. This suggests that people who live, work, or travel within 100 m downwind of major traffic sources will have much higher ultrafine particle exposure than those will who live farther from such sources. This result can be used in epidemiologic studies to evaluate the health effects of ultrafine particles.

The trend of size distribution and number concentration with increasing distances is shown in Figure 5, in which fitted lognormal distributions are used for each mode of the size distributions and shown together with a common scale for the vertical axis. According to Figure 5, 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. This suggests that coagulation is more important than atmospheric dilution for ultrafine particles and the reverse is true for large particles. Researchers who have conducted experimental and theoretical studies on the transportation and transformation of vehicle particle emissions in the atmosphere often have concluded that the rapid dilution of the exhaust plume made coagulation insignificant.[20,42] However, in this study, the observed size distribution changes indicate that coagulation is not negligible.

Figures 6a–b show the decay of normalized total particle number and volume concentration, respectively, with distance along the wind direction from the freeway. Volume concentration was obtained from size-segregated SMPS data in the size range 6–220 nm. The horizontal axis represents the true distance as an air parcel travels from the freeway to the sampling locations. The total number and volume concentrations were normalized by dividing the averaged total number concentration by the control CPC concentration during each sampling period. Each data point in the figures represents an averaged value for all measurements with the same wind directions. The solid line is the best-fitting exponential decay curve, measured

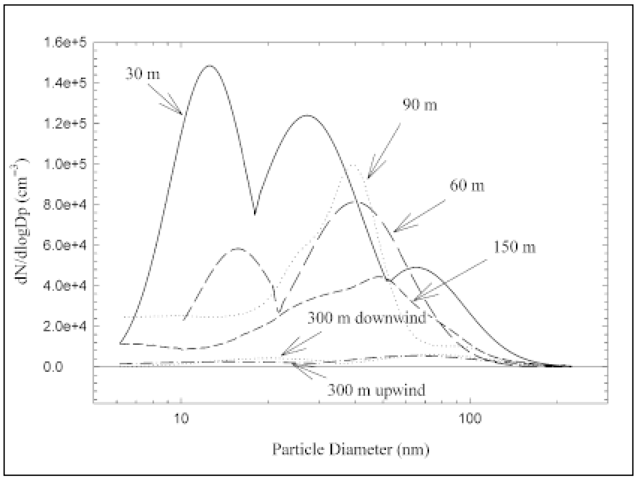

Figure 5. Ultrafine particle size distribution at different sampling locations near Freeway 405. Size distributions were normalized to the control CPC's reading.

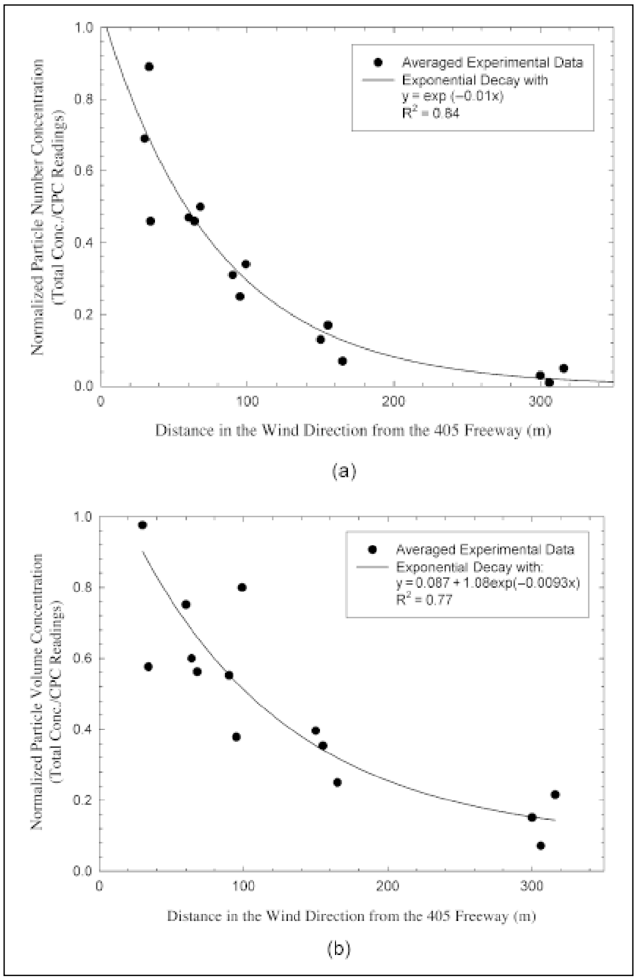

Figure 6. Normalized total particle (a) number and (b) volume concentration in the size range of 6–220 nm as a function of distance from Freeway 405.

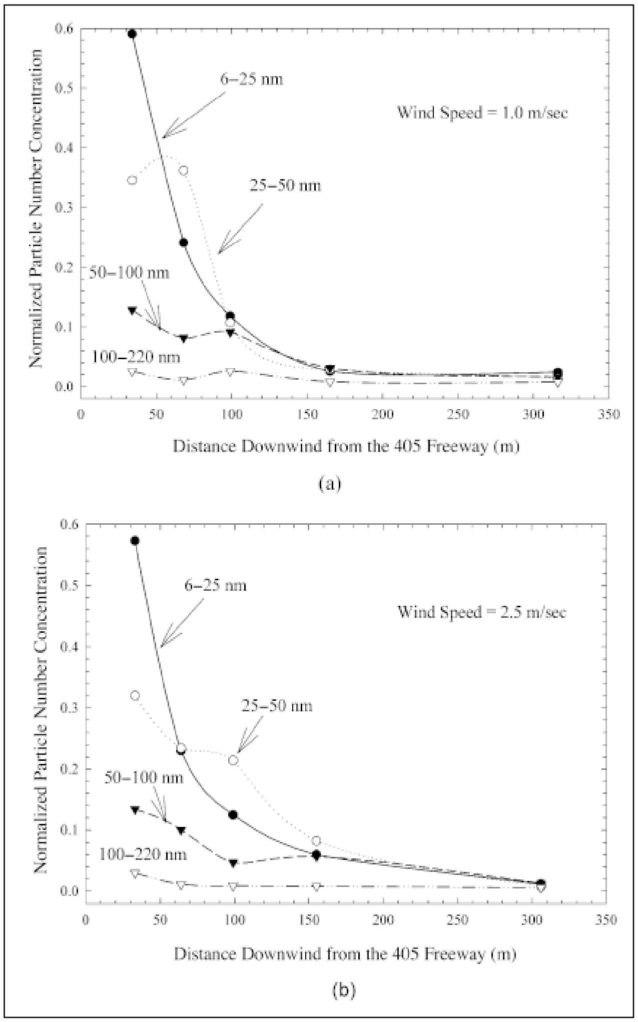

Figure 7. Normalized particle number concentration for different size ranges as a function of distance to the 405 freeway on (a) May 15, 2001, average wind velocity 1 m/sec, and (b) May 17, 2001, average wind velocity 2.5 m/sec.

using the SigmaPlot 2000 nonlinear curve-fitting procedure.[41] Exponential decay curves have been used previously to fit decreasing NO_2 concentrations with distance from a road[24] and were recently proposed by Hitchins et al. for ultrafine particle dispersion.[19] The best-fitting exponential decay equations and R^2 values also are given in the figures. Because coagulation will decrease only the total particle number concentration, not the volume, if coagulation is occurring, then total number concentration will decay faster than will total volume concentration, which is the case as shown in Figures 6a and 6b.

Based on Figures 4 and 5, it is clear that vehicle-emitted particles of different size ranges behave quite differently in the atmosphere. Thus, Figure 7 was prepared to illustrate the decay of particle number concentrations in four size ranges: 6–25 nm, 25–50 nm, 50–100 nm, and 100–220 nm. Two sampling days with different average wind speed were selected: May 15, at 1 m/sec, and May 17, at 2.5 m/sec. Particle number concentrations in each size group were obtained by adding the measured number concentrations in each SMPS size bin within the corresponding size range and normalizing to 1 and 2.5 m/sec, respectively. As shown in Figures 7a–b, the general trends of subgrouped ultrafine particle decay curves were quite comparable for the two dates. Total particle number concentration in the size range of 6–25 nm accounted for ~50% of the total ultrafine particle number concentration; it dropped sharply, ~80%, before 100 m, and leveled off after 150 m. Overall total particle number concentration decayed exponentially throughout the entire measured distance.

Number concentrations in the next two size ranges, 25–50 nm and 50–100 nm, all experienced a shoulder between 50 and 150 m. This can be explained by particles in smaller size ranges coagulating with these particles to increase their size and concentration, which partially compensates for the atmospheric dilution effects. Again, this result is consistent with the previous discussion, namely,

Table 2. Measured average concentrations at increasing distances from the freeway.

	Downwind Distance (m)				
Measurement	**30**	**60**	**90**	**150**	**300**
CO (ppm)	2.0 (1.7–2.2)	0.9 (0.7–1.0)	0.6 (0.5–0.7)	0.4 (0.3–0.5)	0.2 (0.1–0.3)
BC (μg/m^3)	5.4 (3.4–10.0)	3.2 (3.0–3.5)	2.5 (2.4–2.6)	1.6 (1.1–2.0)	1.3 (1.1–1.5)
Number Concentration (× 10^{-5}/cm^3)	1.5 (1.3–1.7)	0.88 (0.77–0.96)	0.70 (0.61–0.85)	0.50 (0.42–0.58)	0.37 (0.30–0.39)
Mass Concentration (μg/m^3)	49.0 (30.2–64.6)	48.0 (37.1–55.0)	47.5 (29.5–63.4)	46.9 (30.1–65.5)	46.5 (30.0–58.9)

Note: Range given in parentheses.

that coagulation played a significant role in vehicle-emitted ultrafine particle atmospheric transportation and transformation. This observed result differs from model predictions by Shi et al.[20] and Vignati et al.[42] One reason is that the present study accurately measured freshly emitted particles down to 6 nm, while the previous models usually assumed a much lower particle number concentration for particles smaller than 15 nm.[20,42] As shown in Figure 7, only particles in the smallest size range coagulated with larger particle sizes. The number concentration of particles bigger than 100 nm did not change significantly as distance from the freeway increased. Because the wind speed was considerably stronger on May 17 than on May 15, one would expect that the atmospheric dilution effect also would be stronger. Thus, it was not surprising to see that those shoulders in Figure 7b occurred farther from the freeway and were not as significant as those shown in Figure 7a.

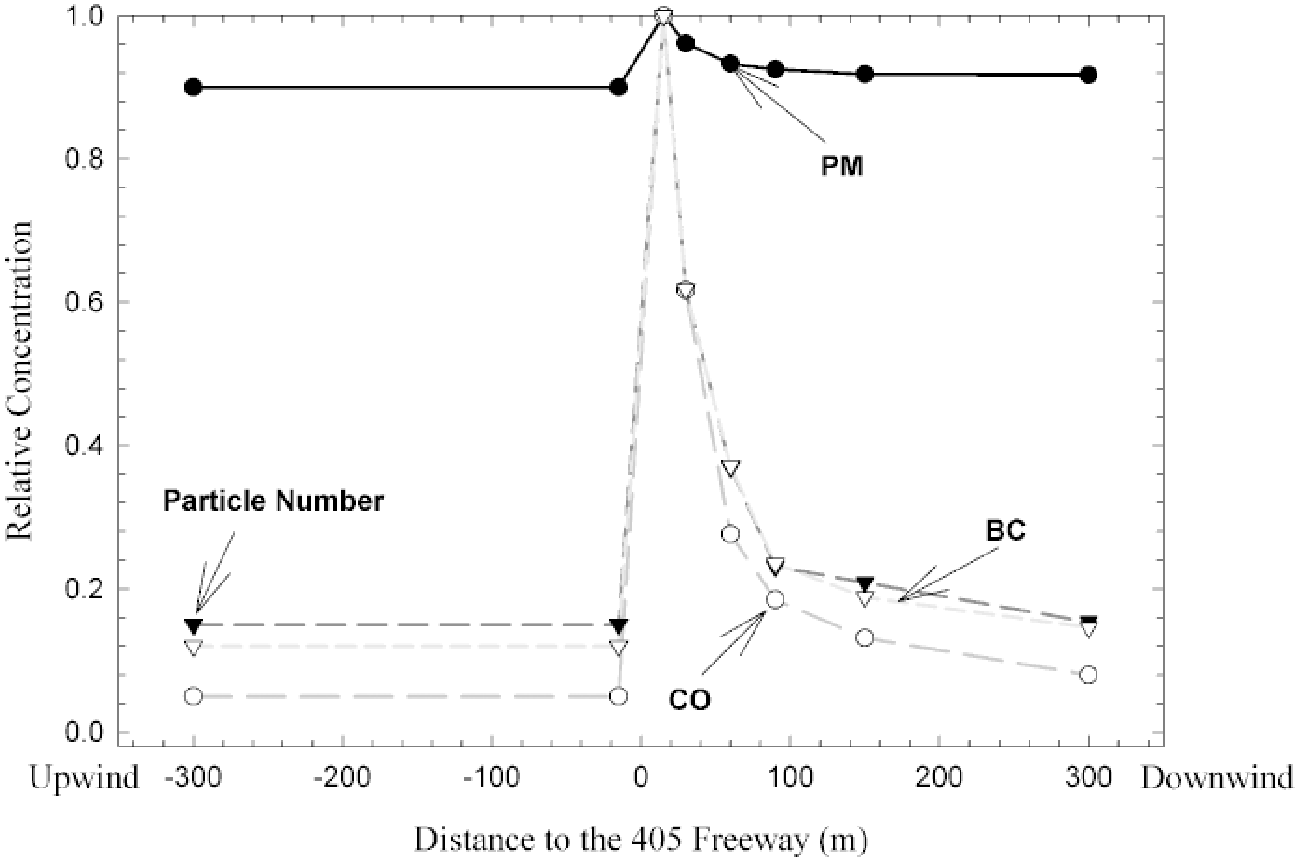

Figure 8. Relative mass, number, BC, and CO concentrations vs. downwind distance.

CO, BC, PM, and Particle Number

To make this freeway study more comprehensive, the concentrations of CO, BC, PM, and particle number also were measured at increasing distance from the freeway on certain days (see Table 1). CO and BC were intentionally selected because their ambient concentrations are related closely to vehicular emissions. Averaged concentration values at five distances from the freeway of each measured property are summarized in Table 2. Measured upper and lower limits also are given in Table 2. The CPC-measured total particle number concentration at the 30-m-downwind location was in good agreement with similar measurements by Shi et al. at 25 m downwind from the curb.[30] In general, the total particle number concentration found in this study is higher than that of urban ambient particles studied by Hitchins et al. in Tingalpa and Hughes et al. in Pasadena.[19,33] It can be seen in Table 2 that, except for the mass concentration measured by DataRam, all measured concentrations decreased noticeably when moving away from the traffic. The small change in PM concentration indicates that, although vehicular exhaust on one major freeway is the primary source of nearby ambient ultrafine particles, it contributes relatively little in terms of direct emissions to PM concentrations near freeways. Thus, regulation of vehicular emissions in terms of PM_{10} and $PM_{2.5}$ may have little effect on ambient particulate number concentrations.

Figure 8 shows the decay curves for CO, BC, total particle number, and mass concentration. The curves were normalized and extended to reach 1.0 at the downwind edge of the freeway. Background concentrations also are shown in the figure. The mass concentration measured by the DataRam decreased by only a few percent throughout the measured range, while CO, BC, and particle number concentration decreased ~60% in the first 100 m and then leveled off somewhat after 150 m. In fact, the CO, BC, and particle number concentrations tracked each other extremely well. This observed result confirmed the common assumption that vehicular exhaust is the major source of CO, BC, and ultrafine particles near a busy freeway. In addition, it suggests that, under the conditions of these measurements, the decreasing characteristics of any of these three pollutants can be used interchangeably to estimate the concentration of the other two pollutants near freeways.

CONCLUSIONS

Wind speed and direction are important in determining the characteristics of ultrafine particles near freeways. The stronger the wind, the lower the total particle number concentration. Total particle number concentration is related directly to traffic density and decreases significantly during a traffic slowdown. The average concentrations of CO, BC, particle number, and mass concentration at 30 m were in the range of 1.7–2.2 ppm, 3.4–10.0 μg/m^3, 1.3–2.0 × 10^5/cm^3, and 30.2–64.6 μg/m^3, respectively. CO, BC, and particle number concentrations tracked each other extremely well as distance from the freeway increased. Exponential decay was found to be a good estimator for the decrease in total particle number concentration with distance along the wind direction. Measurements showed that both atmospheric dilution and coagulation play important roles in the rapid decrease of particle number concentration and the change in particle size distribution as distance from the freeway increases.

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Correlation between co-exposures to noise and air pollution from traffic sources

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Correlation between co-exposures to noise and air pollution from traffic sources

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ABSTRACT

Background: Both air and noise pollution associated with motor vehicle traffic have been associated with cardiovascular disease. Similarities in pollution source and health outcome mean that there is potential for noise to confound studies of air pollution and cardiovascular disease, and vice versa, or for more complex interactions to occur.

Methods: The correlations between 2-week average roadside concentrations of nitrogen dioxide (NO_2) and nitrogen oxides (NO_X) and short term average noise levels ($L_{eq,5min}$) for 103 urban sites with varying traffic, environment and infrastructure characteristics were examined.

Results: The Pearson correlation coefficient for $L_{eq,5min}$ and NO_2 was 0.53, and for $L_{eq,5min}$ and NO_X , 0.64. Factors influencing the degree of correlation were number of lanes on the closest road, number of cars or trucks during noise sampling and presence of a major intersection.

Conclusions: We recommend measurement of both pollutants in future studies of traffic-related pollution and cardiovascular disease to allow for more sophisticated analysis of this relationship.

Recent studies have reported possible associations between cardiovascular disease and both road traffic noise[1] and road traffic air pollution.[2] Understanding of the adverse effects of each pollutant on the physiology of the cardiovascular system is incomplete; it is hypothesised that air pollution increases blood pressure, contributes to the instability of vascular plaques and may initiate cardiac arrhythmias,[3] while the cardiovascular effects of noise are hypothesised to be stress mediated via stimulation of the hypothalamo-pituary-adrenal and sympathetic-adrenal-medullary axes. Chronic or repeated stimulation of these axes leads to hypertension, accumulation of intra-abdominal fat and insulin resistance.[4] Because both exposures are strongly associated with road traffic, and because of the similarity in health endpoints, there is a possibility that the two pollutants act jointly, or that traffic noise may be a confounding factor in traffic-related air pollution studies and vice versa.

To date, there have been limited attempts to examine the combined effects of noise and air pollution and these have used a variety of approaches and outcomes. A recently published study of road traffic noise and hypertension investigated the joint effect by adjusting for PM_{10} levels in a noise–hypertension model. As this adjustment did not alter the effect estimate of noise on hypertension, the authors concluded that the noise effect was independent but noted study limitations including very small contrast between high and low PM_{10} levels.[5] An investigation of the association between traffic noise and all-cause cardiovascular and respiratory emergency hospital admissions adjusting for air pollution (O_3 and NO_x) found significant increases varying from 3.7% to 5.1% per decibel[6]; however, this study had limited noise exposure data from only six measurement stations across the city of Madrid. Ising *et al* reported that traffic noise was associated with aggravation of bronchitis in children, and that this effect was more important than that of exhaust fumes.[7] The two exposures were highly correlated in their study, which unfortunately had little power. A synergistic effect of traffic-related noise and air pollution on levels of annoyance was shown for a population in the city of Oslo.[8] Other studies have raised the possibility of confounding, but only data on traffic-related noise or on traffic-related air pollution, but not both, were available.[9 10]

Characterising the relationships between exposure to traffic-related noise and traffic-related air pollution would aid the interpretation of previous studies and contribute to the design of new studies. Here we report the correlation between noise and air pollution in a typical urban setting in Vancouver, British Columbia.

METHODS

We collected data on short term average noise levels (equivalent continuous sound level over 5 min, $L_{eq,5min}$) for 103 roadside sites in the Metro Vancouver region of British Columbia. At the same locations, data on 2-week concentration averages for nitrogen dioxide (NO_2) and nitrogen oxides (NO_X) were collected, as described elsewhere.[11] The noise samples were collected at the start of the air pollution sampling period during daytime hours (08:00–18:00). Sampling sites were selected using a location-allocation model that included land use, road networks, population density and regulatory air-quality monitoring to optimally place sampling locations with respect to air pollutants.[12] NO_2 and NO_X 14-day averages were collected with passive samplers equipped with a pre-coated pollutant collection pad (Ogawa USA, Pompano Beach, Florida), and analysis was by liquid chromatography. NO_2/NO_X samplers were positioned approximately 3 m from the ground. Noise levels were measured with an LDL 870 Environmental Noise Analyser (Larson Davis, Provo, Utah) and an LDL 2559 microphone, positioned 1.2 m from the ground at a 90° angle to the roadway. Calibration was

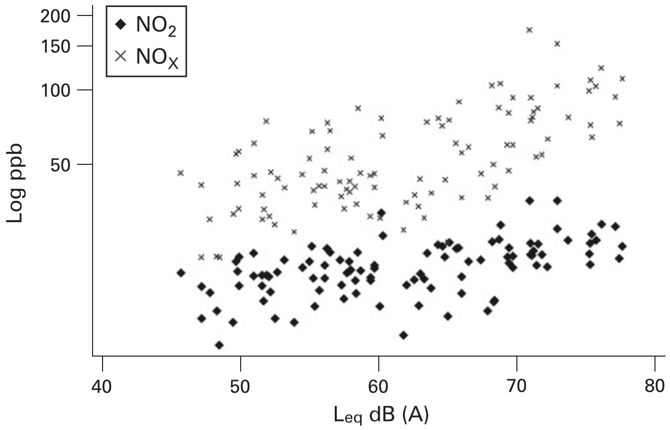

Figure 1 NO_2 and NO_X concentrations by noise level ($L_{eq,5min}$) at 103 measurement sites around Metro Vancouver, BC.

performed with a B&K 4231 calibrator (Bruel & Kjaer, Naerum, Denmark).

For each site information characterising the roadway and surrounding environment was collected, including the following variables that were tested in modelling: time of noise measurement (ie, rush hour), an ordinal subjective measure of car and truck traffic density on the closest roadway, car and truck density on all roads within a 500 m radius, number of lanes on the nearest road, hectares of open land within a 300 m radius, population density within a 750 m radius, and a binary indication of the presence of a four-way or five-way intersection. Input files for the road type, land use and population density measures were taken from the 2001 census prepared by DMTI Spatial (Markham, Ontario). The input file for variables in the vehicle density category was generated by the Metro Vancouver transit authority's EMME/2 model of morning rush-hour traffic volume. Meteorological data (wind speed, direction, rainfall) were collected from the air-quality monitoring network for Metro Vancouver. Distance from sampling site to roads, traffic density, land use and population density were calculated using a geographical information system (ArcGIS, ESRI, Redlands, CA).

Pearson correlation coefficients were calculated to describe the association between traffic-related noise and air pollution. To examine factors influencing the degree of correlation between noise and air pollution, forward stepwise multiple linear regression was performed with NO_2 and NO_X as dependent variables, and $L_{eq,5min}$ as an independent variable; then to examine their effect on reducing unexplained variability, covariates that represented various traffic intensity, infrastructure and environmental factors were added to the regression model. Covariates were retained if they contributed significantly to the regression model ($p<0.05$).

RESULTS

Noise, NO_2 and NO_X all showed fairly monotonic increasing levels of exposure with increasing car and truck traffic, as anticipated (table 1). The rates of increase vary by pollutant and source, however, suggesting that the vehicle fleet mix may result in heterogeneity between noise and air pollutants. The Pearson correlation coefficient for $L_{eq,\ 5\ min}$ and NO_2 was 0.53, and for $L_{eq,\ 5\ min}$ and NO_X, 0.64. Scatter plots in figs 1–3 show the relationship between pollutants, and between the pollutants and two major determinants traffic density and distance to a major road. The correlation between NO_2 and NO_X was 0.87. Simple linear models of NO_2 and NO_X levels with $L_{eq,\ 5\ min}$ as the only independent variable explained 28% and 41% of their variability, respectively, while final models for each explained 56% and 65%, respectively (table 2). Examination of normalised β coefficients suggested that the number of lanes of the nearest road, the presence of a major intersection and traffic density (either car or truck) were the major contributors to variability between noise and the two air pollutants. Other factors that were offered but not retained in either model included population density within a 750 m radius, distance to the nearest road, wind speed and rush hour measurement of noise (08:00–10:00, 16:00–18:00 h).

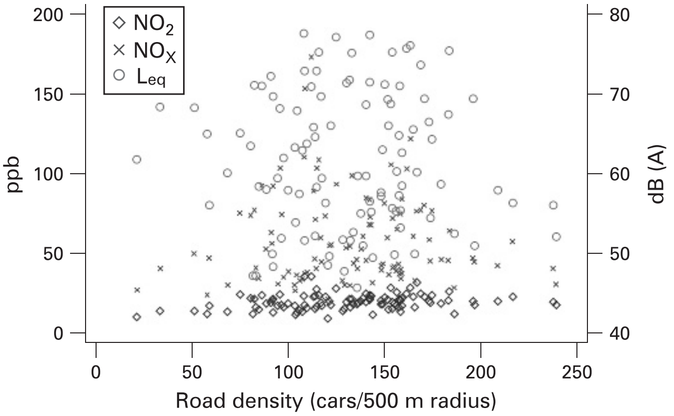

Figure 2 NO_2 and NO_X concentrations and noise level ($L_{eq,\ 5min}$) by traffic density (cars/500 m buffer).

DISCUSSION

The levels of noise, NO_2 and NO_X reported in this study were similar to levels reported in earlier literature. The correlation observed for noise and NO_2 (0.53) was lower than the finding of 0.84 by Ising *et al*, who also compared actual measurements.[7] It was similar to the results of Klaebo *et al* (0.46) who used modelled values for both noise and air pollution levels[8]; this is of interest as many epidemiological studies rely on modelled exposure estimates for both pollutants. However, the noise and NO_2 correlation was higher than that of Tobias *et al* (0.32) and a related study (0.14), but these had used the fairly crude 24 h averages of noise from six Madrid monitoring stations and NO_2

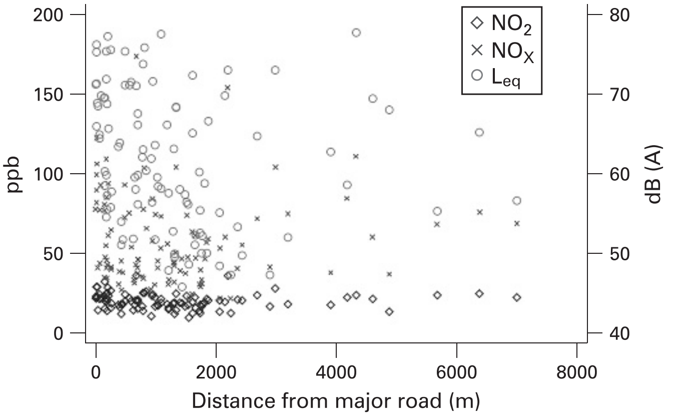

Figure 3 NO_2, NO_X concentrations and noise level ($L_{eq,\ 5min}$) by distance from a major road.

Table 1 Noise and air pollutant levels by car traffic density (row) and truck density (column)

	n	L_{eq} (dB(A)), mean (SD)	NO_2 (ppb), mean (SD)	NO_X (ppb), mean (SD)
Overall	103	61.7 (8.6)	19.6 (4.9)	57.6 (27.9)
Car traffic				
Very light	29	53.5 (5.0)	17.5 (3.9)	45.2 (17.5)
Light	35	59.2 (5.8)	18.6 (4.3)	45.5 (14.3)
Moderate	17	67.0 (4.3)	19.1 (4.0)	59.4 (23.0)
Heavy	19	72.3 (3.1)	24.4 (5.2)	91.9 (32.8)
Very heavy	3	73.1 (3.7)	23.2 (4.5)	92.1 (17.8)
Heavy truck traffic				
None	54	55.3 (5.1)	17.6 (3.6)	43.8 (14.8)
Very light	19	64.7 (6.0)	19.8 (5.0)	54.3 (21.5)
Light	12	69.8 (2.7)	21.7 (5.9)	74.8 (32.6)
Moderate	10	72.1 (3.3)	23.5 (2.5)	90.3 (18.4)
Heavy	5	73.9 (3.9)	26.2 (6.0)	104.6 (39.7)
Very heavy	3	70.8 (3.9)	20.7 (7.2)	72.8 (32.5)

$L_{eq,5min}$, equivalent continuous sound level over 5 min; NO_2, nitrogen dioxide; NO_X, nitrogen oxides.

Table 2 Multiple linear regression models

Variable	NO_2 model (ppb), β coefficient (SD)	NO_X model (ppb), β coefficient (SD)
R^2	0.56	0.65
Intercept	−0.37 (3.8)	−36.0 (0.039)
Noise (L_{eq}, dBA)	0.24 (0.06)	1.3 (0.31)
Light vehicles per hour per hectare within 500 m	0.01 (0.003)	–*
Heavy truck per hour per hectare within 500 m	–	3.0 (0.83)
Intersection	3.5 (0.87)	16.8 (4.4)
Number of lanes on the closest road		
1	Ref	Ref
2	−3.0 (1.0)	−10.6 (4.8)
4	1.5 (1.3)	17.4 (6.6)
6	−0.33 (1.9)	4.3 (9.6)
Distance to freeway (m)	0.006 (0.0003)	0.004 (0.001)
Kilometres of road network within 300 m radius	0.023 (0.009)	–
Hectares of open land within 300 m radius	–	−0.66 (0.34)

*Not retained in final model.
Coefficients (β's) show increase in air pollutant level (in ppb) per unit increase in the covariate (ie, per 1 dBA increase in noise). $L_{eq,5min}$, equivalent continuous sound level over 5 min; NO_2, nitrogen dioxide; NO_X, nitrogen oxides.

averages from 24 stations.[6 13] Comparison of our observed correlation between measured NO_X and noise (0.64) with previous studies showed a similar pattern to NO_2 (0.21, 0.35, 0.48 in Linares, Tobias and Klaebo, respectively).[6 8 13]

We noted several factors including road layout (eg, the presence of a major intersection), density of traffic (number of cars or trucks within a 500 m radius from EMME/2 models) and urban design (hectares of open land a within 750 m radius) that appeared to influence the variability between noise and the two air pollutants. This variability was not unexpected; while the primary sources of both air and noise pollution are motor vehicles, the generation mechanisms differ, as does the mode of their propagation. While gaseous pollutants result directly from the internal combustion engine, noise is emitted from the engine and tyres and by air displacement. Engine noise predominates below speeds of about 30 km/h for cars (50 km/h for trucks), but at greater speeds "rolling noise" produced by the tyre/road interface predominates.[14] Gaseous air pollutants diffuse and drift and have a wider impact, with a greater contribution of background levels to local effects than does noise. Noise is transmitted by pressure waves that can be reflected and refracted and are increased through superimposition, but otherwise have a short "half-life".

Not all the variability observed was related to these factors, however, and the study had a number of limitations. Principally, the 5 min measurement duration for noise was quite different from the measurement duration for the air pollutants (14 days). However, we examined how representative of longer exposure periods these 5 min samples were by analysing an associated dataset containing 24 h of consecutive 1 min average L_{eq}'s at 30 roadside sites in Vancouver (24 h L_{eq} range 47.5–73.4 dB(A), but without corresponding air pollution data). The 5 min samples taken during daytime over-estimated the 24 h L_{eq} by 1.7 dB(A) (SD 0.3 dB(A)). However, in a simulation study where we repeatedly (n = 10) extracted random daytime 5 min averages from the 30 sites and compared them to their 24 h averages, the mean correlation was 0.97 (SD 2.0). This suggested that the 5 min averages, although slightly biased, are reasonable surrogates of longer term measures, particularly for correlation studies. Many studies rely on such short term measures, and other work has also shown good repeatability of 5 min noise measurements between different seasons.[15] Rain on roads is known to substantially increase noise levels, but we did not obtain sufficient measurements to investigate this factor. In the future, repeated measurements at fewer sites with varying traffic intensity and over a variety of differing environmental conditions would provide more information on the true correlation between traffic noise and traffic-related air pollution. The authors are currently mapping traffic-related noise in the Metro Vancouver region; we will combine this with existing air pollution maps to then examine the joint effects of noise and air pollution exposure on cardiovascular disease in this area.

In summary, it is important to include accurate measurement of both exposures in future studies of traffic pollution and cardiovascular disease. While it may be difficult to separate the effects of traffic noise and traffic-related air pollution, the variability observed here and in other studies suggests it may be possible to disentangle the effects of the two pollutants, especially when those factors known to influence the correlation of the two types of pollutant are considered, and that more sophisticated analysis of potential confounding or effect modification could be undertaken.

Main message

Road traffic noise and air pollution exposures are moderately correlated (Pearson r = 0.5–0.6).

Policy implications

It is recommended that both road traffic noise and air pollution exposures be considered in all future studies of road traffic and cardiovascular disease outcomes.

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ARTICLE

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Disproportionate exposure to urban heat island intensity across major US cities

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Urban heat stress poses a major risk to public health. Case studies of individual cities suggest that heat exposure, like other environmental stressors, may be unequally distributed across income groups. There is little evidence, however, as to whether such disparities are pervasive. We combine surface urban heat island (SUHI) data, a proxy for isolating the urban contribution to additional heat exposure in built environments, with census tract-level demographic data to answer these questions for summer days, when heat exposure is likely to be at a maximum. We find that the average person of color lives in a census tract with higher SUHI intensity than non-Hispanic whites in all but 6 of the 175 largest urbanized areas in the continental United States. A similar pattern emerges for people living in households below the poverty line relative to those at more than two times the poverty line.

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Built environments are commonly hotter than their neighboring rural counterparts[1]. This phenomenon, commonly referred to as the urban heat island effect, contributes to a range of public health issues. Heat-related mortality in the USA, for example, causes more deaths (around 1500 per year) than other severe weather events[2–4]. Heat exposure is also associated with several non-fatal health outcomes, including heat strokes, dehydration, loss of labor productivity, and decreased learning[5–12]. Characteristics of the built environment (e.g., green space, urban form, city size, spectral reflectance) not only create temperature differentials between urban and surrounding rural areas[13–16] but also contribute to intracity temperature variation[17–20]. This variation has the potential to cause disparities in the distribution of the burden of adverse heat-related outcomes across sociodemographic groups.

Like other environmental stressors, such as air pollution[21], low-income or otherwise marginalized communities may experience disproportionately higher levels of heat intensity[22]. Small-scale case studies have found disparities in the distribution of urban heat island intensity within single cities[23] or differences in exposure among population groups within a few cities in different countries[24–26]. Although evidence suggests that extreme heat-related morbidity and mortality in cities disproportionately affect marginalized groups[27–30], there has been little research showing whether these groups have systematic disproportionately high exposure to the heat island effect.

Instead, research linking intracity differences in heat exposure to sociodemographic factors has typically been done in an ad hoc manner for a small number of individual cities[23,29–32]. Examining the relationship between the distribution of annual urban heat island exposure and income at the neighborhood level, ref. [25] find that the distribution tended to favor those with higher incomes in 18 out of 25 selected global cities. While illustrative, these results are difficult to generalize since the sociodemographic information comes from a variety of sources with distinct definitions and methods, and the sample of global cities was chosen in response to data constraints rather than random sampling. It also does not convey information about potential disparities for other US cities.

In 108 US cities, ref. [26] find that neighborhoods that were redlined in the 1930s have summer surface temperature profiles that are significantly higher than other coded residential areas ("redlining" refers to the historical practice of denying home loans or insurance based on an area's racial composition). In light of substantial demographic changes and urban growth patterns over the past 90 years, however, the extent to which this finding translates into current racial or income disparities remains unclear.

While these studies are suggestive, it is difficult to extrapolate their results to a widespread or national level for several reasons. Varying methodological approaches to quantifying urban heat island intensity may lead to different conclusions, or analyses may not be representative. One obstacle to a more uniform approach has been the lack of consistent multicity delineations of urban and rural areas that are also comparable with the administrative areas of aggregation for which socioeconomic data are collected. Case studies may also reflect selection bias. Prior beliefs regarding inequitable distributions of heat exposure may have motivated such scientific inquiry for particular locations, such that the chosen cities may not be representative of the nation as a whole.

Combining high-resolution satellite-based temperature data with sociodemographic data from the US Census, we find that the average person of color lives in a census tract with higher summer daytime surface urban heat island (SUHI) intensity than non-Hispanic whites in all but 6 of the 175 largest urbanized areas in the continental United States. A similar pattern emerges for people living in households below the poverty line relative to those at more than two times the poverty line. In nearly half the urbanized areas, the average person of color faces a higher summer daytime SUHI intensity than the average person living below poverty, despite the fact that, on average, only 10% of people of color live below the poverty line. This last finding suggests that widespread inequalities in heat exposure by race and ethnicity may not be well explained by differences in income alone. While we do not observe major differences in SUHI intensity for very young or elderly populations in most major cities, when compared to the total population, we find that the same racial and ethnic disparities in SUHI for specific populations of color compared to non-Hispanic whites are also consistent for these age demographics.

Results

Conceptually, an environmental risk analysis typically includes three components: hazard—measures of the spatial distribution of a potential harm; exposure—the intersection of the spatial distribution of human populations with the hazard; and vulnerability—the propensity to suffer damage when exposed to the hazard (see, for example, refs. [33,34]). We calculate harm on the basis of the census tract level database of SUHI intensity for the USA we developed in ref. [35]. During summer months, relatively large SUHI intensity is associated with increased local warming and extreme heat events in urban areas[13,36,37]. For exposure, we use census tract level demographic information from the 2017 5-year American Community Survey (ACS).

A comprehensive vulnerability assessment would require detailed information, not only about sociodemographic variables but also about other elements such as household resources, social capital, community resources, comorbidities, etc. that could be obtained at an individual or community level through localized fieldwork[38,39]. Although such an assessment is beyond the scope of this study, we consider one salient aspect, age, to evaluate whether differences in exposure by sensitive age groups affect conclusions drawn regarding exposure for the general population. In both very young and older populations, the body's ability to thermoregulate is compromised, and many older individuals have comorbidities or predispositions that increase the likelihood of heat-related illness and death[40,41]. Between 2004 and 2018, 39% of heat-related deaths in the USA occurred in ages 65 years or older[42]. Our framework is thus consistent with several studies using heat exposure to represent climate-related hazards and age to represent vulnerability to analyze the risk of heat stress in urban areas in Brazil, China, Finland, the Philippines, and the USA[34,43–46].

These combined data allow us to evaluate the relationship between race, income, age, and mean summer daytime SUHI intensity for all major urbanized areas in the USA (see "Methods" for the US Census definition of an urbanized area). These 175 largest US cities cover ~65% of the total population (see Supplementary Fig. 1) and are also where most US heat-related deaths have occurred in the last 15 years[42]. We narrow our analysis to the summer months of June, July, and August when the SUHI intensity is most pronounced during the day and when mean temperatures are generally higher than other periods through the year[47] (see Supplementary Fig. 2).

Recognizing that health impacts of summer heat exposure are likely to be nonlinear[48–51], i.e., incremental increases in environmental heat load may lead to disproportionately higher risk[47], we also consider environmental inequality metrics that evaluate the importance of within-group inequalities with respect to SUHI spatial distribution and exposure for different sociodemographic groups. We discuss our findings in three parts: first, comparing mean SUHI intensity across racial and income groups; second,

Table 1 Mean summer daytime surface urban heat island intensity (SUHI) by climate zone and sociodemographic group.

	Climate zone (number of urbanized areas)				
	Arid	**Snow**	**Temperate**	**Equatorial**	**Total**
	(19)	**(44)**	**(110)**	**(2)**	**(175)**
(a) Population-weighted means: Total	0.40	2.23	2.21	2.76	2.06
	(1.75)	(2.71)	(2.78)	(2.20)	(2.72)
By race/ethnicity[a]: People of color	0.65	3.44	2.93	3.19	2.77
	(1.61)	(2.57)	(2.74)	(2.15)	(2.70)
Hispanic	0.74	3.65	3.03	3.02	2.70
	(1.55)	(2.72)	(2.65)	(2.19)	(2.64)
Non-Hispanic Black	0.74	3.71	3.04	3.74	3.12
	(1.59)	(2.33)	(2.76)	(1.91)	(2.67)
Non-Hispanic White	0.11	1.67	1.54	1.93	1.47
	(1.86)	(2.58)	(2.65)	(2.06)	(2.60)
Non-Hispanic Other	0.22	2.68	2.60	2.34	2.41
	(1.78)	(2.60)	(2.84)	(2.13)	(2.80)
By income: Below poverty	0.74	3.32	2.92	3.42	2.77
	(1.61)	(2.67)	(2.78)	(2.02)	(2.73)
1–2 × poverty	0.69	2.87	2.64	3.32	2.50
	(1.62)	(2.69)	(2.72)	(2.03)	(2.67)
Above 2 × poverty	0.22	1.87	1.95	2.41	1.80
	(1.79)	(2.63)	(2.76)	(2.21)	(2.69)
(b) Difference in means: People of color – Non-Hispanic white	0.54***	1.77***	1.39***	1.26***	1.30***
	(0.059)	(0.100)	(0.206)	(0.020)	(0.171)
Below poverty – 2 × poverty	0.52***	1.45***	0.96***	1.01***	0.97***
	(0.070)	(0.142)	(0.094)	(0.001)	(0.071)
People of color – below poverty	−0.10**	0.13*	0.02	−0.23	−0.00
	(0.039)	(0.071)	(0.066)	(0.042)	(0.063)
Non-Hispanic white – below poverty	−0.63***	−1.65***	−1.38***	−1.50***	−1.30***
	(0.070)	(0.094)	(0.167)	(0.022)	(0.127)

Source: Author calculations, based on data from US Census Bureau and ref. [24]. Panel (a): Population-weighted means of urbanized area SUHI intensity in °C. Standard deviation is given in parentheses. Panel (b): Difference in group means. Standard errors clustered by urban area are given in parentheses.

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

[a] Hispanic is defined as all who report "Hispanic, Latino, or Spanish origin" as their ethnicity, regardless of race. People of color includes all Hispanic and all who do not identify as white alone. Black and white include all who identify as these races alone but not Hispanic. Other includes all other non-Hispanic races alone and more than one race.

using an inequality index to measure intragroup variation in SUHI intensity; and third, considering vulnerability according to age and race/ethnicity.

Mean SUHI intensity across sociodemographic groups. Table 1 (a) describes differences in exposure to SUHI by population groups defined by race/ethnicity and income (see "Methods" for demographic group definitions). We group urbanized areas by Köppen–Geiger[52] climate zones: arid, snow, warm temperate (henceforth referred to as temperate), and equatorial. For total population, summer day SUHI intensity is lowest (0.40 ± 1.75 °C) in arid zones, potentially due to the presence of more vegetation in urban areas compared to their rural references, which moderates the urban–rural temperature differentials[15,35]. Most cities are in snow and temperate zones, with a mean SUHI intensity of about 2.2 °C.

These population averages mask differences across population groups. With respect to race/ethnicity, in each climate zone, Black residents have the highest average SUHI exposure, for an overall average (±standard deviation) of 3.12 ± 2.67 °C, with Hispanics experiencing the second highest level (2.70 ± 2.64 °C). Non-Hispanic whites have the lowest exposure in each climate zone, with an overall average of 1.47 ± 2.60 °C. A similar pattern emerges across income groups: people living below the poverty line have the highest exposure in each zone (national average 2.70 ± 2.64 °C), while people living at above twice the poverty line have the lowest (1.80 ± 2.69 °C).

Figure 1 illustrates these sociodemographic differences in exposure, comparing kernel density plots of the distribution of mean SUHI across the 175 cities for different population groups. The starkest differences appear between race, Fig. 1a, and income, Fig. 1b. In only a few cities ($n = 17$) are white populations exposed to a mean SUHI intensity greater than 2 °C, while the corresponding number of cities for people of color is 83. A similar number of cities ($n = 82$) expose below-poverty populations to more than 2 °C SUHI. Figure 1c shows that distributions for those below poverty and for people of color are practically identical. As shown in Fig. 1d, e, there are not large differences in the distributions for the very young (less than 5) or the elderly (greater than 65) and the rest of the general population. Slightly more cities expose populations under 5 to higher SUHI intensity, while populations over 65 are exposed to lower mean SUHI intensity. Restricting attention to the most vulnerable age groups in Fig. 1g does not alter the conclusion drawn from Fig. 1a; for both age groups people of color appear to have a worse SUHI distribution than non-Hispanic whites.

Table 1(b) tests hypotheses that mean exposure is equal across selected groups. We reject ($p < 0.01$) both the null hypothesis of equal means for people of color and non-Hispanic whites in each climate zone, and the null hypothesis of equal means for people below and above two times the poverty line. Perhaps unsurprisingly, the average exposure of non-Hispanic whites is also significantly lower than the average exposure of people below poverty. Interestingly however, outside of arid climates, the

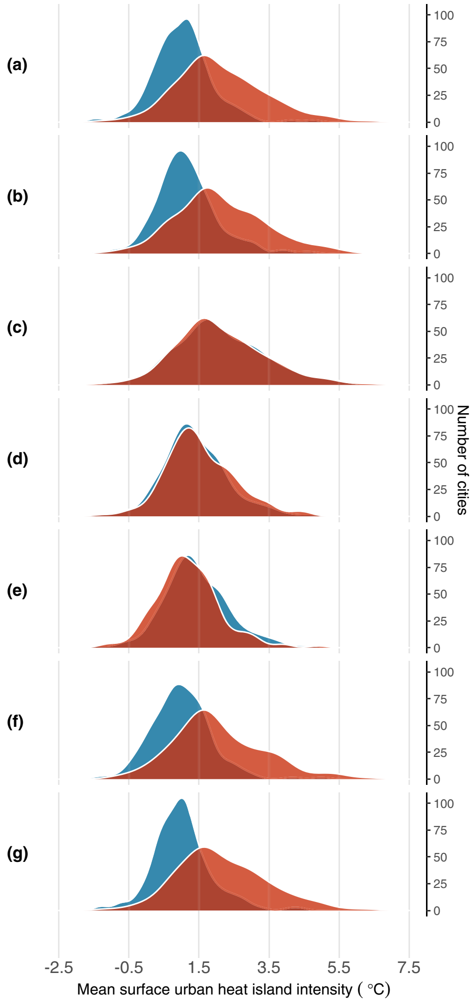


Fig. 1 Distribution across cities of mean summer daytime surface urban heat island (SUHI) intensity by sociodemographic group. Each panel compares kernel density estimates for two sociodemographic groups. Diagrams are normalized so that the area under each curve equals 175 cities. Hispanic is defined as all who report “Hispanic, Latino, or Spanish origin” as their ethnicity, regardless of race. People of color includes all Hispanic and all who do not identify as white alone. **a** Non-Hispanic white vs. all people of color. **b** 2× above poverty vs. below poverty. **c** Below poverty vs. all people of color. **d** Over 5 vs. under 5. **e** Under 65 vs. over 65. **f** Over 65: non-Hispanic white vs. all people of color. **g** Under 5: non-Hispanic white vs. all people of color. **a** illustrates that people of color have an average SUHI exposure greater than 2 °C in more cities than non-Hispanic whites.

average exposure of people of color is not significantly lower than the average exposure of people below poverty despite the fact that only 10% of people of color live below the poverty line.

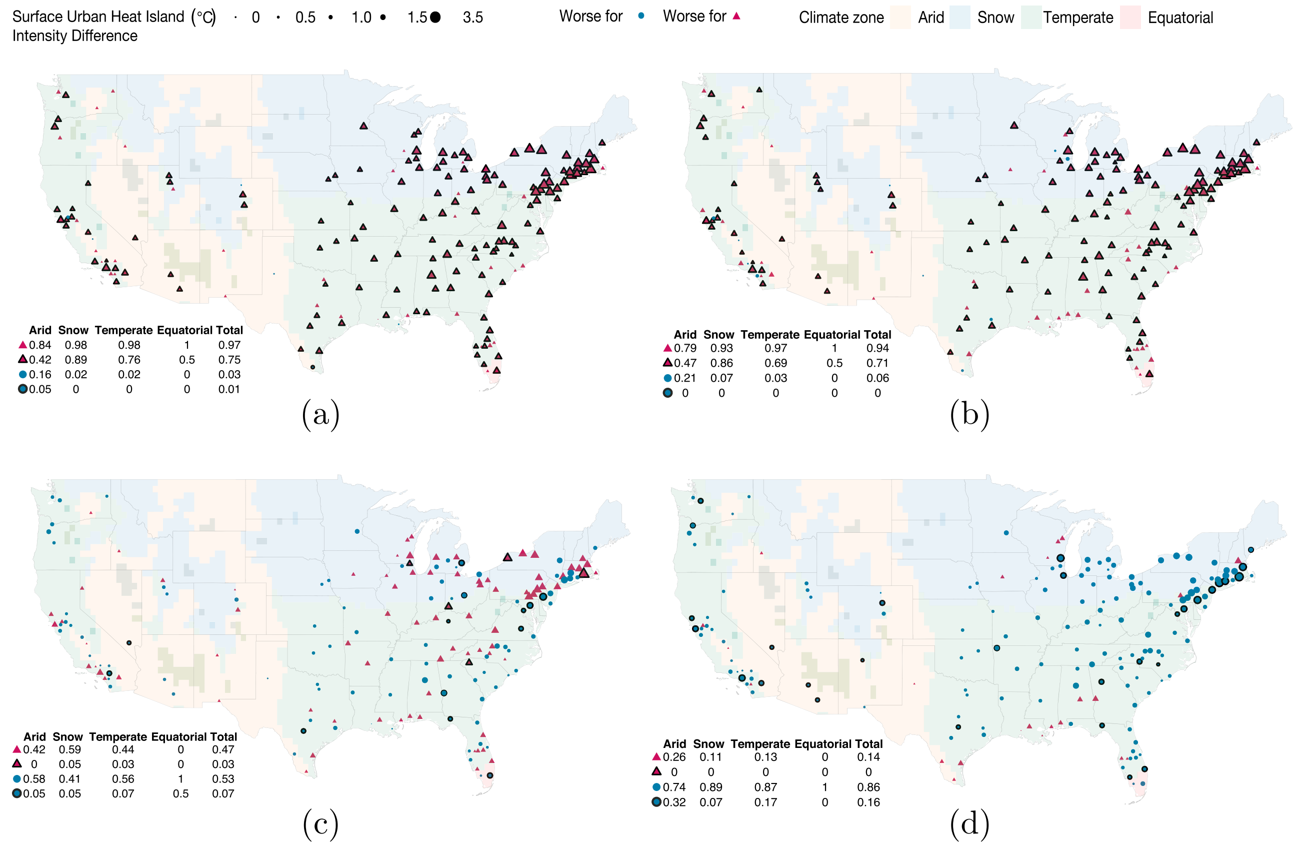
The values in Table 1 are weighted by population, thus raising the possibility that a few exceptionally large urbanized areas may be driving the results. By illustrating the spatial distribution of significant city-level racial and income disparities in SUHI exposure, the maps in Fig. 2 visualize the geographic scope of the phenomenon presented in the table. For each comparison, circles and triangles identify which group has the higher average SUHI exposure in each city. Symbols with black outlines indicate cities for which the differences in means are statistically significant ($p < 0.05$). (Supplementary Table 1 displays city-level results used to generate these maps). In Fig. 2a, map shows that people of color have higher SUHI exposure than non-Hispanic whites in 97% of cities nationally, and that this difference is significant in three quarters of cities. By zone, this proportion ranges from 42% in arid climates to almost 90% in snow. In contrast, non-Hispanic whites have a significantly higher exposure in only a single city, McAllen, TX. In Fig. 2b, the map shows a similar pattern for income. For over 70% of cities people below poverty have a significantly higher exposure than people above twice the poverty line (and in no city do they have a significantly lower exposure). In only 7% of cities nationwide does the average person of color have a lower exposure than the average person living below the poverty line (Fig. 2c).

Intragroup variation in SUHI intensity. A potential drawback to focusing on average exposures by demographic group is it can mask the existence of potential hotspots, geographic areas in which individuals are exposed to elevated levels of the hazard. Hotspots are particularly problematic when comparing exposures across groups if the additional damage caused by an incremental temperature increase grows as temperatures rise. In such cases, even if two groups were to hypothetically face the same average exposure, a group in which half of individuals were exposed to a temperature of, say, 38 °C and half were exposed to 32 °C, would suffer higher adverse effects than a group in which all individuals were exposed to 35 °C.

The Kolm–Pollak (KP) inequality index (see “Methods”) is a tool for ranking group distributions of exposures when there are potential differences in dispersion of outcomes within each group (e.g., hotspots). Table 2(a) summarizes the average KP inequality index values for each city by population group and climate zone. A higher value corresponds to a less equal distribution of SUHI exposures within each group, with zero indicating a perfectly equal exposure (i.e., no within-group variation).

In general, cities in arid climates tend to have the lowest intragroup variation, and cities in snow and temperate zones have the highest. Within a given zone, however, index values are remarkably similar across population groups. Table 2(b) evaluates the hypothesis that index values vary significantly by demographic groups. Differences, measured in °C, are small in magnitude and not generally significant. Taken together, results in Table 2 suggest that the group means presented in Table 1 do not mask significant differences in variation within demographic groups. That is, the presence of relative hotspots is not likely to be higher among people living below the poverty line, for example, than people living at more than twice the poverty line. Consequently, for the remainder of this analysis we focus on average exposure levels for each group.

Vulnerability. Analyzing vulnerability is a relevant factor in considering the implications of the difference in mean exposures presented in Table 1. Since SUHI intensity is more damaging to people over the age of 65 years, the fact that all people of color might be exposed to higher average SUHI than non-Hispanic whites may not be problematic, for example, if its vulnerable (over 65) subpopulations are not exposed in the same way. Map in Fig. 2d indicates that people over 65 have lower SUHI exposures than those under 65 in 86% of US cities. While this difference is significant for only 16% of cities, there are no cities in which they have a significantly higher exposure. Table 3(a) presents mean SUHI exposure levels by race and ethnicity, restricting attention to two particularly vulnerable subpopulations: those over 65 years old and those below the age of 5 years. Comparing the exposure levels of these ages in Table 3(a) with group-wide exposure in Table 1(a), we see that for people of color exposure levels are nationally the same or higher for these vulnerable groups: 2.76 ± 2.64 °C for those below 5 and 2.88 ± 2.77 °C for



(a)

	Arid	Snow	Temperate	Equatorial	Total
▲	0.84	0.98	0.98	1	0.97
△	0.42	0.89	0.76	0.5	0.75
●	0.16	0.02	0.02	0	0.03
◉	0.05	0	0	0	0.01

(b)

	Arid	Snow	Temperate	Equatorial	Total
▲	0.79	0.93	0.97	1	0.94
△	0.47	0.86	0.69	0.5	0.71
●	0.21	0.07	0.03	0	0.06
◉	0	0	0	0	0

(c)

	Arid	Snow	Temperate	Equatorial	Total
▲	0.42	0.59	0.44	0	0.47
△	0	0.05	0.03	0	0.03
●	0.58	0.41	0.56	1	0.53
◉	0.05	0.05	0.07	0.5	0.07

(d)

	Arid	Snow	Temperate	Equatorial	Total
▲	0.26	0.11	0.13	0	0.14
△	0	0	0	0	0
●	0.74	0.89	0.87	1	0.86
◉	0.32	0.07	0.17	0	0.16

Fig. 2 Sociodemographic differences in mean summer daytime surface urban heat island intensity by major urban area. Symbols outlined in black depict statistically significant differences in mean exposures ($p < 0.05$). Tables embedded in the lower left-hand corners indicate proportion of cities in each category (e.g., worse for △ or worse for ∘) by climate zone. Supplementary Table 1 provides detailed results for each city. Hispanic is defined as all who report "Hispanic, Latino, or Spanish origin" as their ethnicity, regardless of race. People of color includes all Hispanic and all who do not identify as white alone. **a** Non-Hispanic white (∘) and people of color (△). **b** Above 2 × poverty (∘) and below poverty (△). **c** Below poverty (∘) and people of color (△). **d** Below 65 (∘) and above 65 (△).

those above 65, compared to 2.77 ± 2.70 °C for all people of color. For non-Hispanic whites, however, these vulnerable populations have slightly lower exposures: 1.45 ± 2.53 °C for those below 5 and 1.44 ± 2.60 °C for those above 65, compared to 1.47 ± 2.60 °C for the entire white population. Table 3(b) compares mean exposures of these vulnerable ages across racial/ethnic groups. The patterns are almost identical to results in Table 1(b): people of color in each age group have significantly higher exposure levels than their white peers in each climate zone.

Discussion

Framework for understanding inequalities in SUHI. This analysis provides a framework for quantifying the intercity and intracity distribution of SUHI intensity by race, income, and age that considers both the intensity of the exposure as well as the inequality of distribution for different population subgroups. We find that the distributions of summer daytime SUHI intensity, taking into account both the mean and dispersion, is worse for both people of color and the poor, compared to white and wealthier populations in nearly all major US cities. As illustrated in Fig. 2, this pattern holds not only at the national level, but in almost all major urban areas regardless of geographical location or climate zones, with a particularly intense difference in the Northeast and upper Midwest of the continental United States. These findings provide comprehensive evidence supporting the narrative presented by earlier case studies that minority and low-income communities bear the brunt of the urban heat island effect[23,25,26,29–32,35], air temperature[23], and heat stress[31] in individual or multicity studies.

Although age presents a vulnerability to SUHI, and elderly individuals aged 65 and older comprise a substantial percentage (39%) of heat-related deaths in the USA[42], our finding that populations over 65 are on average slightly less exposed (1.84 °C versus 2.06 °C for those under 65) could have several explanations. Because SUHI intensity and greenness (as measured by normalized difference vegetation index) are negatively correlated[35], cooler areas tend to be greener. There is evidence that populations over the age of 65 tend to live in suburban areas in the USA. Approximately half live in rural areas or in urban areas with less than 1 housing unit per acre, and 28% live in suburban areas[53], which are typically greener than denser urban areas, except in arid climates[15,54,55]. Considering the intersection of race and age demographics, however, the same racial and ethnic disparities in SUHI intensity for specific populations of color compared to non-Hispanic whites are also consistent for both very young and elder populations[3], meaning non-white populations over the age of 65 or less than 5 are still exposed to higher levels of SUHI than their white counterparts. The fact that older people of color have a slightly higher SUHI exposure than all people of color suggests that they may be less able to escape the heat by changing location than their white counterparts.

The Intergovernmental Panel on Climate Change has identified the "increasing frequency and intensity of extreme heat, including

Table 2 Kolm–Pollak inequality index of summer daytime surface urban heat island intensity (SUHI) by climate zone and sociodemographic group.

	Climate zone				
	Arid	**Snow**	**Temperate**	**Equatorial**	**Total**
(a) Population-weighted index means: Total	0.12	0.29	0.27	0.20	0.26
	(0.09)	(0.11)	(0.12)	(0.03)	(0.13)
By race/ethnicity[a]: People of color	0.10	0.24	0.23	0.19	0.22
	(0.07)	(0.08)	(0.12)	(0.02)	(0.11)
Hispanic	0.09	0.25	0.21	0.20	0.19
	(0.06)	(0.08)	(0.11)	(0.02)	(0.11)
Non-Hispanic Black	0.09	0.19	0.22	0.15	0.21
	(0.05)	(0.07)	(0.08)	(0.01)	(0.08)
Non-Hispanic White	0.14	0.27	0.27	0.18	0.26
	(0.12)	(0.11)	(0.12)	(0.04)	(0.12)
Non-Hispanic Other	0.13	0.25	0.27	0.20	0.26
	(0.08)	(0.11)	(0.17)	(0.03)	(0.16)
By income: Below poverty	0.10	0.25	0.24	0.17	0.23
	(0.08)	(0.10)	(0.11)	(0.02)	(0.11)
1–2 × poverty	0.10	0.26	0.24	0.17	0.22
	(0.08)	(0.11)	(0.11)	(0.02)	(0.11)
Above 2 × poverty	0.13	0.28	0.27	0.21	0.26
	(0.10)	(0.11)	(0.13)	(0.04)	(0.13)
(b) Difference in mean index values: People of color – Non-Hispanic white	−0.04	−0.04	−0.04	0.01	−0.04*
	(0.055)	(0.031)	(0.030)	(0.018)	(0.023)
Below poverty – 2 × poverty	−0.03	−0.02	−0.03	−0.04	−0.03
	(0.048)	(0.032)	(0.029)	(0.014)	(0.023)
People of color – below poverty	0.00	−0.02	−0.01	0.02*	−0.01
	(0.038)	(0.027)	(0.026)	(0.007)	(0.020)

Source: Author calculations, based on data from US Census Bureau and[24]. Panel (a): Population-weighted mean of urban area Kolm–Pollak indexes in °C with moderate inequality aversion. Standard deviation is given in parentheses. Panel (b): Difference in group means. Robust standard errors are given in parentheses.

*$p < 0.10$.

[a]Hispanic is defined as all who report “Hispanic, Latino, or Spanish origin” as their ethnicity, regardless of race. People of color includes all Hispanic and all who do not identify as white alone. Black and white include all non-Hispanics identifying as these races alone. Other includes all other non-Hispanic races alone and more than one race.

the urban heat island effect” as a relevant hazard for certain age groups (i.e., elderly, the very young, people with chronic health problems), which creates a risk of increased morbidity or mortality during extreme heat periods[37]. Relating intercity SUHI disparities to health outcomes is challenging due to both prevalence of confounding factors in the populations groups, as well as the differences between land surface temperature (LST) and more comprehensive metrics of heat stress[56]. There is, however, evidence of disparities in heat-related health outcomes across the USA and for individual cities[42,57]. For example, ref. [57] finds positive correlations between heat-related mortality rates and poverty for neighborhoods in New York City. More recently, ref. [42] found higher heat-related mortality rates among non-Hispanic American Indians/Alaska Natives and Blacks than for non-Hispanic whites at the national level.

Locally-tailored SUHI mitigation strategies. In addition to evaluating the general scope of potential heat-related environmental inequality concerns, the metrics developed in our study can identify precisely in which cities specific sociodemographic groups are most adversely exposed to SUHI intensity and to potential heat-related health effects for vulnerable groups. These data can thereby assist policy makers in designing interventions to address this exposure differential, as well as facilitate analysis of different scenarios to select the most appropriate strategy to mitigate exposure in an equitable manner. According to ref. [47], many cities do not take into consideration the spatial location of the most exposed populations in climate mitigation planning and whether areas that present increased sociodemographic vulnerabilities, such as age or high minority populations, are coincident with areas exposed to higher temperatures.

Consideration of background climate differences, which have been found to strongly modulate the thermodynamics of SUHI intensity[15,16], are critical for adapting city-specific intervention strategies to reduce both total exposure and disparities in its distribution[58]. Because we use a globally consistent dataset derived from satellite remote sensing[35], our data allow for comparison of SUHI given differences in background climates and sociodemographics. Decision-makers and urban planners can utilize this information as a starting point to identify best practices and strategies for mitigating the overall SUHI as well as inequalities in its distribution, although there are certainly localized, context-specific factors that must be considered when determining SUHI management strategies. Studies have demonstrated the importance of coproduction (i.e., involving citizens in the production of knowledge and planning decisions) in developing tailored urban environmental policies[59]. Manoli et al.[60], who used similar globally consistent satellite-derived data to evaluate drivers of SUHI in 30,000 cities around the world, acknowledge that these data can provide a first-order analysis to understand base-level SUHI exposures and differences to complement more fine-grained data on local factors that influence the SUHI (see “Study limitations” section for more discussion on data issues).

For example, the presence (or absence) of urban vegetation is often proposed as a strategy to reduce the urban heat island effect[13,16,20,61], climate change more generally[62], and for their other cobenefits[63–66]. Access to green space has been found to be inversely correlated with median income[67]. Actions such as planting trees in low-income and minority neighborhoods, which has been shown to reduce summertime afternoon temperatures by as much 1.5 °C[68], can increase property values and housing

Table 3 Mean summer daytime surface urban heat island intensity (SUHI) by climate zone and age.

	Climate zone				
	Arid	Snow	Temperate	Equatorial	Total
(a) Population-weighted means—Below 5 years old: Total	0.55	2.38	2.37	2.94	2.20
	(1.67)	(2.66)	(2.73)	(2.16)	(2.68)
People of color[a]	0.73	3.41	2.94	3.24	2.76
	(1.57)	(2.53)	(2.68)	(2.06)	(2.64)
Black[b]	0.85	3.81	3.13	3.82	3.21
	(1.54)	(2.26)	(2.72)	(1.82)	(2.62)
Hispanic[c]	0.81	3.58	3.01	3.01	2.69
	(1.53)	(2.66)	(2.62)	(2.11)	(2.60)
Non-Hispanic white[d]	0.16	1.59	1.53	1.88	1.45
	(1.80)	(2.49)	(2.59)	(2.16)	(2.53)
Above 65 years old: Total	0.16	2.03	1.96	2.58	1.84
	(1.82)	(2.66)	(2.79)	(2.19)	(2.72)
People of color[a]	0.55	3.58	3.01	3.38	2.88
	(1.62)	(2.54)	(2.82)	(2.13)	(2.77)
Black[b]	0.69	3.82	3.22	3.77	3.28
	(1.63)	(2.33)	(2.83)	(1.92)	(2.72)
Hispanic[c]	0.65	3.85	3.16	3.32	2.80
	(1.53)	(2.79)	(2.70)	(2.16)	(2.68)
Non-Hispanic white[d]	−0.02	1.69	1.51	1.91	1.44
	(1.87)	(2.57)	(2.66)	(2.01)	(2.60)
(b) Difference in means—Below 5 years old: People of color[a] – Non-Hispanic white[d]	0.57***	1.82***	1.41***	1.36***	1.31***
	(0.078)	(0.106)	(0.159)	(0.018)	(0.138)
Above 65 years old: People of color[a] – Non-Hispanic white[d]	0.57***	1.88***	1.50***	1.47**	1.44***
	(0.086)	(0.111)	(0.258)	(0.080)	(0.209)

Source: Author calculations, based on data from US Census Bureau and ref. [35]. Sample includes all urbanized areas with 2017 population over 250,000. Panel (a): Population-weighted means of urbanized area SUHI intensity in °C. Standard deviation is given in parentheses. Panel (b): Difference in group means. Standard errors clustered by urban area are given in parentheses. alone.
**$p < 0.05$, ***$p < 0.01$.
[a] People of color includes all Hispanic and all who do not identify as white alone.
[b] Black alone, including Hispanic black.
[c] Defined as all who report "Hispanic, Latino, or Spanish origin" as their ethnicity, regardless of race.
[d] Non-Hispanic white alone.

costs. Previous work indicates that these housing price effects may displace minority residents the policies were designed to help[69,70]. Evidence suggests that homeowners value cooler temperatures and that local temperature differentials are capitalized into housing prices[71]. It is therefore unsurprising that people living below the poverty line have higher average temperature exposures than those at over two times above the poverty line in 94% of major urbanized areas in our study.

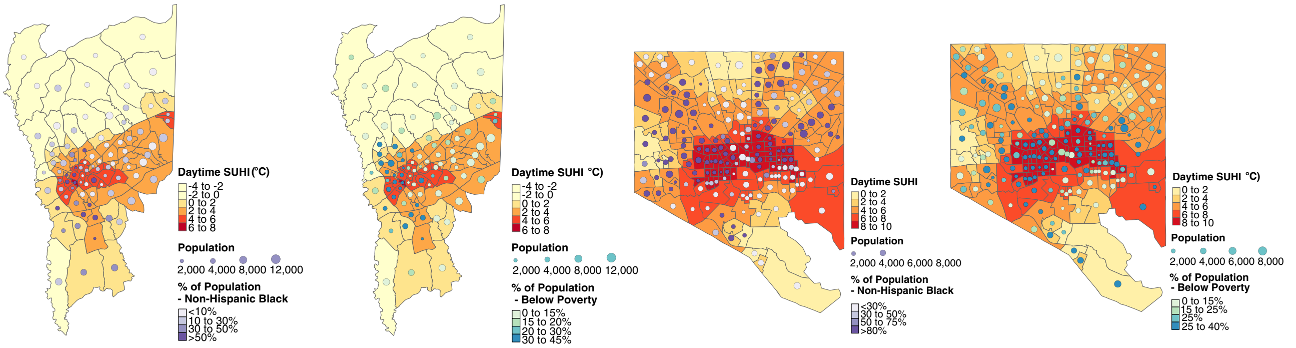
Complexity in disentangling race, income, and SUHI. The effect of historical practices of real estate, urban development, and planning policies that promoted spatial and racial segregation in US cities[26,72], as well as the fact that people of color tend to have lower income than white populations in the USA makes it difficult to disentangle purely economic reasons for the unequal distribution of SUHI intensity exposure to those based upon racial factors. We can, however, shed light on the complex relationships between race, poverty, and urban heat by comparing the SUHI distributions faced by people of color to those faced by people living below the poverty line.

While there is some overlap of individuals belonging to both groups, such individuals are a minority; according to the 2017 5-year ACS, only about 10% (ranging from 0.4 to 18.9%) of people of color live below the poverty line in these major urbanized areas. If income were to determine local summer daytime SUHI intensity exposure, one would expect that the typical person of color would have a lower exposure than the typical person living below poverty. Table 1 shows that this hypothesis is unsupported: across the entire sample the mean SUHI exposure of a person of color (2.77 ± 2.70 °C) is practically identical to that of a person living below poverty (2.77 ± 2.73 °C). The distribution of temperature differentials across cities is also similar for these two groups (Fig. 1). Nationally, we observe few cities (about 10%) with statistically significant differences between the mean SUHI intensities for these groups (Fig. 2c).

Illustrative examples. While the SUHI distributions for below poverty and people of color are nearly identical (Fig. 1), patterns of exposure by sociodemographic group are not all the same between cities. Figure 3 provides an illustrative example, contrasting the cases of Baltimore, MD, and Greenville, SC. In Baltimore, the temperature exposure of the average person of color is about 0.7° cooler than the average person in poverty, whereas the opposite is true for Greenville. Figure 3a, b shows that in Greenville, the Black population is highly concentrated in the warmest census tracts, while the poor population is more widely dispersed to cooler areas away from the city center. In Baltimore by contrast, Fig. 3c, d indicates that the poorest census tracts tend to be the warmest, while the Black population is much more evenly spread through the city.

As these illustrative examples of Greenville, SC, and Baltimore, MD, show, while many factors might explain our observed difference in below poverty and minority populations' SUHI exposure in these two cities, prior research on residential housing markets in the USA has shown that racial and ethnic segregation, among factors other than consumer preference alone, determine where certain groups live[73,74].

Future challenges. The patterns of systematically higher SUHI exposure for low-income populations and communities of color



(a) (b) (c) (d)

Fig. 3 Distribution of surface urban heat island intensity (SUHI) by race and income in Greenville, SC, and Baltimore, MD. The correlation between SUHI intensity (dark orange and red) and census tracts that are predominantly non-Hispanic Black (in dark purple) and low-income areas (in dark teal) differs across cities. Hispanic is defined as all who report "Hispanic, Latino, or Spanish origin" as their ethnicity, regardless of race. **a** Greenville, SC: SUHI and race. **b** Greenville, SC: SUHI and income. **c** Baltimore, MD: SUHI and race. **d** Baltimore, MD: SUHI and income.

in nearly all major US cities may lead to further inequality if these disparities persist or worsen. Currently disadvantaged groups suffer more from greater heat exposure that can further exacerbate existing inequities in health outcomes and associated economic burdens, leaving them with fewer resources to adapt to increasing temperature[75]. Increasing trends of urbanization, demographic shifts with aging populations, and the projected rise in extreme heat-related events due to climate change[37], may compound certain groups' vulnerability to extreme heat in the future[29,38]. From an environmental equity and justice perspective, understanding where these disparities in heat exposure exist today can inform future efforts to design policy interventions to ameliorate them.

Study limitations. While the SUHI database used in this study has been validated against other published estimates[35], we recognize limitations of its use as a metric to identify which groups may be more vulnerable to heat stress within cities. Our environmental equity analysis assumes that SUHI intensity is harmful. While this assumption is likely to be justified in the summer periods evaluated in this study, the effect may be beneficial in cities exposed to extreme winter cold[76]. Although in theory the association between SUHI intensity and income and race could imply less extreme cold-related stress in poorer and predominantly non-white neighborhoods, other research suggests that these winter benefits may not materialize[35]. Nonetheless, intracity variation should be taken into account while planning strategies both to reduce mean SUHI and to address environmental disparities in its exposure within cities.

Heat stress also depends on factors other than LST and air temperature, including humidity, wind speed, and radiation[77]. SUHI intensity, however, is still a useful proxy for the urban contribution to local heat stress[35]. Our analysis relies on satellite-based estimates, which could overestimate UHI magnitude compared to in situ weather stations, particularly during daytime[78], when shade from tree canopies or buildings reduce air temperature in a way that is not captured from a satellite's vantage point. Our estimates, therefore, likely slightly overestimate the absolute measures of UHI (in °C), but in lieu of dense, widely accessible ground-based air temperature networks, satellite-derived estimates represent the best available data source.

We assume every individual residing in a census tract has the same temperature exposure. In reality, temperatures and demographic characteristics may vary within a tract, and exposures can depend on individual behavior or conditions (home air conditioning, time spent outdoors, etc.). Our analysis also assumes that people pass the entire day in their census tract, abstracting from the possibility that they spend work or leisure time in other locations with distinct SUHI profiles.

The choice to use census tract as the unit of analysis is a compromise based on the relative precision of demographic and satellite data. Precise demographic data are publicly available at the smaller census block group level, and aggregating to larger tracts implies a loss of information. In other contexts, the environmental justice literature suggests that such aggregation can underestimate racial disparities due to the "ecological fallacy"[79]. In contrast, although satellite data are available at a resolution of 1 km, this pixel-level data have a relatively high degree of uncertainty, particularly for urban areas[80]. Since census tracts, unlike block groups, typically contain more than one pixel, averaging the satellite data to this level of aggregation provides more reliable surface temperature estimates.

We also do not evaluate inequities in SUHI among demographic groups over time. Future research could evaluate whether disparities in SUHI exposure have improved or worsened in time. A recent study examining inequality in fine particulate air pollution ($PM_{2.5}$) found that between 1981 and 2016, absolute disparities between more and less polluted census tracts in the USA declined but that relative disparities have persisted, meaning the most exposed subpopulations in 1981 remained the most exposed in 2016[81]. Incorporating a time-series panel dataset on SUHI intensity and sociodemographic characteristics would allow for future understanding of the role climate change and increasing temperatures may have on worsening heat exposure disparities over time.

Methods

SUHI intensity database. Existing maps of SUHI intensity use physical boundaries (e.g., boundary based on built-up, impervious land cover usually measured through satellite remote sensing) as the units of calculations for delineating both urban areas and their corresponding rural references, making them unsuitable for use with socioeconomic data without significant uncertainties. To deal with this scale mismatch between administrative and physical boundaries, we use summertime (June, July, and August; Supplementary Fig. 1) values from our recently created SUHI database for the USA that is consistent with census tract delineations[35].

This dataset uses global LST products from NASA's MODIS sensor[82] and the land cover product from the European Space Agency[83]. It calculates SUHI intensity at the census tract level by combining the land cover data with the census tracts that intersect US urbanized areas, as defined by the US Census Bureau[84].

We use the simplified urban extent method[15] to define the SUHI intensity of an urban census tract *t* as the difference between the tract's mean LST and the mean temperature of the rural reference r, the nonurban, nonwater land cover pixels within the tract's urbanized area

$$\mathrm{SUHI}_t = \mathrm{LST}_t - \mathrm{LST}_r. \tag{1}$$

Urbanized area boundaries do not necessarily coincide with those of census tracts. In such cases, we adjust the approach to include only pixels within the urbanized area of a census tract to calculate LST_t. For more details, see ref. [35]. The distributional analysis thus implicitly assumes no one resides in the nonurbanized portions of those outlying tracts.

Since previous studies have demonstrated the importance of background climate in modulating the SUHI intensity[15,16], we also examine the relationship between disparities in SUHI exposure and the Köppen–Geiger climate zone[85]. The possible impact of background climate has policy implications, since it constrains what city planners can do to mitigate the city-specific SUHI and its distributional impacts.

Demographic data. We assign the same SUHI intensity to every individual living in a given census tract. Demographic group averages are calculated as weighted means across census tracts, in which the weights correspond to the number of people of a given group residing in a tract. Census tract level demographic data come from the 2017 ACS 5-year Data Profile[86,87]. We collect data on race, ethnicity, poverty status, age, and age by race for all 46,346 census tracts in the 175 census-defined urbanized areas that contain more than 250,000 residents (Supplementary Fig. 2). Our set of urbanized areas ranges from 43 to 4470 tracts, with a median of 582 (Supplementary Table 2). Responses to race include options for single race (e.g., Black only) as well as multiple races. Hispanic is an ethnicity reported in addition to race (e.g., Black only and Hispanic). Regardless of race, it is defined as any who respond "yes" to the Census question asking whether the person is "of Hispanic, Latino, or Spanish origin"[88]. For the total population, we generate categories for two non-Hispanic single race groups (Black, white), Hispanic of any race, and "Other". Other includes non-Hispanics of other single races, including Black or African American, Asian, American Indian and Alaska Native, Native Hawaiian and other Pacific Islander, and non-Hispanics reporting two or more races. We also create a People of Color category that includes all Hispanic and all who do not identify as white alone. For age categories, we use the same race and ethnicity groupings to develop under 5 and over age 65 categories. Since ACS age data do not differentiate Black by Hispanic ethnicity, however, Black Hispanics appear in both the Black and Hispanic categories in Table 3 only.

The ACS reports poverty status as household income relative to the poverty line. This income is not measured in dollars since the poverty line depends on the number of individuals in the household. We use these data to generate three income categories: at or below the poverty line, from one to two times the poverty line, and at or above two times the poverty line (the highest recorded category). While results for each of these income categories are provided in our tables, for the ease of exposition, we focus our discussion on the tails of the income distribution: the poor (those below poverty) and the relatively rich (above two times).

Inequality metrics. The goal of comparing exposure levels across population groups is to determine whether a distribution of SUHI intensities for a given group is preferable in some sense to that of another. In contrast to approaches identifying correlations between summer temperatures and neighborhood characteristics such as historical redlining[26] or percentage poor or low income, e.g., ref. [23], we place the unit of analysis on the individual to better understand human welfare implications of SUHI exposure.

There is no clear link between what individuals find desirable and the significance of statistical correlations between neighborhood attributes. It is theoretically possible, for example, for the average individual in a demographic group to be better off with a positive (versus negative) correlation between summer heat and their group's majority status in a neighborhood if most members of the group happen to live in neighborhoods in which they are a minority.

A simple individual-based metric such as mean exposure is potentially misleading due to nonlinear adverse health impacts of summer heat. Evidence suggests that above a moderate threshold damage is an increasing convex function of temperature, i.e., a 1° temperature increase causes more damage at higher temperatures[48–51]. In such cases, Jensen's inequality implies that, all else equal, the average health damage for a population in which everyone faces an identical summer heat exposure will be lower than that of a population with the same mean exposure but an unequal temperature distribution. It follows that for any unequal temperature distribution there exists a more desirable (from a health perspective) distribution characterized by a higher mean and no inequality. That is, a perfectly equal summer temperature distribution is generally preferable to an unequal distribution with the same mean.

Using this principle, we adapt an ethical framework commonly used to study income distributions to compare distributions of environmental harm[89]. Under this framework, a distribution is considered more desirable than another if it would be chosen by an impartial agent who knows only that she will receive an outcome from that distribution but is ignorant regarding what that outcome will be. Reframing the problem of ranking SUHI exposure distributions as one of rational choice made behind a "veil of ignorance"[90,91], provides an intuitive approach founded on explicitly specified individual preferences.

To implement this method, we transform distributions of SUHI intensity across individuals in a demographic group to "lotteries" in which the probability of receiving a given exposure corresponds to the proportion of people in the group receiving that exposure. The more desirable distribution is the lottery that would be chosen ex ante by an impartial representative agent who only knows that her ex post exposure will be randomly drawn from that lottery. This choice in turn depends on assumptions made about the agent's tastes regarding the harm caused by different levels of exposure.

The equally distributed equivalent (EDE)[92,93] is a construct for cardinally ranking all possible lotteries. It represents the value of the outcome (in our case, SUHI intensity) that, if experienced by everyone in the group, would make the impartial agent indifferent between the actual unequal distribution and the hypothetical equal distribution.

In summer, the EDE is generally higher than the mean of the actual distribution, i.e., the agent would be willing to bear a higher average intensity if she knew that she were guaranteed not to randomly draw a value higher than the mean[89]. The gap between the EDE and the mean is an index of inequality within a given group, indicating the maximum additional SUHI intensity per person that would make the representative agent indifferent between the actual distribution and the hypothetical equal distribution.

As described in ref. [89] and Supplementary Note 1, the KP inequality index has several desirable features relevant to characterizing distributions of environmental harm. For an N-dimensional vector of SUHI intensities $\mathbf{x}$, with each element corresponding to the exposure of individual n in a given urbanized area, the KP inequality index can be expressed

$$I(\mathbf{x}) = -\frac{1}{\kappa}\ln\frac{1}{N}\sum_{n=1}^{N} \mathrm{e}^{\kappa[\bar{x}-x_n]}, \text{ for } \kappa < 0. \tag{2}$$

Here, $\bar{x}$ is the mean outcome and κ is a parameter indicating the degree to which inequality in the distribution is undesirable due to increasing marginal damage. The KP EDE is simply $I(\mathbf{x}) + \bar{x}$. As is standard in the literature, we present results for a range of possible values for κ (see Supplementary Tables 3–5).

Software. All statistical analyses were conducted in Stata (Version 15) and R (Version 3.6.3). Figures were made using ggplot2[94] and tmap[95,96] packages in R. The SUHI dataset was created using the Google Earth Engine platform[97].

Reporting summary. Further information on research design is available in the Nature Research Reporting Summary linked to this article.

Data availability

SUHI intensity data are available for exploration on an interactive Google Earth Engine platform tool, available at https://datadrivenlab.users.earthengine.app/view/usuhiapp and also for download at https://data.mendeley.com/datasets/x9mv4krnm2/2. Sociodemographic data were collected from the US Census Bureau 2017 5-year ACS via the API at https://api.census.gov/data/2017/acs/acs5/variables.html.

Code availability

Code to reproduce the figures is available upon reasonable request.

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Author contributions

All authors contributed equally to the conceptualization and design of this work, analyzed data, and wrote the paper. T.C. led development of the SUHI dataset.

Competing interests

The authors declare no competing interests.

Additional information

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Original Contribution

Does Traffic-related Air Pollution Explain Associations of Aircraft and Road Traffic Noise Exposure on Children's Health and Cognition? A Secondary Analysis of the United Kingdom Sample From the RANCH Project

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The authors examined whether air pollution at school (nitrogen dioxide) is associated with poorer child cognition and health and whether adjustment for air pollution explains or moderates previously observed associations between aircraft and road traffic noise at school and children's cognition in the 2001–2003 Road Traffic and Aircraft Noise Exposure and Children's Cognition and Health (RANCH) project. This secondary analysis of a subsample of the United Kingdom RANCH sample examined 719 children who were 9–10 years of age from 22 schools around London's Heathrow airport for whom air pollution data were available. Data were analyzed using multilevel modeling. Air pollution exposure levels at school were moderate, were not associated with a range of cognitive and health outcomes, and did not account for or moderate associations between noise exposure and cognition. Aircraft noise exposure at school was significantly associated with poorer recognition memory and conceptual recall memory after adjustment for nitrogen dioxide levels. Aircraft noise exposure was also associated with poorer reading comprehension and information recall memory after adjustment for nitrogen dioxide levels. Road traffic noise was not associated with cognition or health before or after adjustment for air pollution. Moderate levels of air pollution do not appear to confound associations of noise on cognition and health, but further studies of higher air pollution levels are needed.

air pollution; child psychology; cognition; environmental pollution; epidemiology; noise; public health; transportation

Abbreviation: RANCH, Road Traffic and Aircraft Noise Exposure and Children's Cognition and Health.

To date, over 20 studies have shown a negative association between environmental noise, such as aircraft or road traffic noise, and children's reading abilities and memories (1–6). Cognitive tasks affected by environmental noise tend to be those involving language and central processing skills, such as reading and memory. Several pathways for associations between chronic noise exposure and children's cognition have been suggested, including teacher and pupil frustration (7), learned helplessness (8), impaired attention (7, 9), increased arousal (10), indiscriminate filtering out of noise (11), and noise annoyance (12).

Road traffic and aircraft noise have also been shown to influence cardiovascular health in adults, and there is some evidence that environmental noise may also influence children's blood pressure levels (13, 14). Studies have also found associations between environmental noise exposure and children's psychological health (5, 15, 16). However, there has been little examination of the influence of air pollution on the associations observed between environmental noise exposure and children's health and cognition. Children attending schools exposed to high levels of environmental noise may also experience traffic-related air pollution. Although evidence for associations of air pollution with children's respiratory health is robust (17, 18), evidence for associations with children's cognition is equivocal. A study in Boston found that higher levels of black carbon, a marker for traffic particles, were associated with decreased cognitive function in 202 children aged

8–11 years, with associations being found across a range of verbal and nonverbal intelligence and memory assessments (19). However, noise exposure was not measured in that study. A study of Chinese children aged 8–10 years found some significant associations between traffic-related air pollution and neurobehavioral function (20). Conversely, a recent study of 210 Spanish children who were 5 years of age found few significant associations between nitrogen dioxide levels and a range of cognitive and motor abilities (21). Prenatal exposure to air pollution may also be associated with impaired infant mental development (22). Proposed mechanisms for the impact of chronic air pollution on cognition are inflammation or oxidative stress caused by air particles, which influence the central nervous system and lead to neurotoxicity in the brain, potentially influencing brain connectivity (23, 24). Ultrafine particulates may also directly influence the brain by being absorbed in the lungs or via the olfactory nerves (23).

Few studies have examined the impact of coexisting environmental noise and air pollution exposure on children's cognition and health (25). Studies examining the association between the 2 pollutants in general population samples indicated that there were correlations of approximately 0.5–0.6 between nitrogen dioxide and traffic-related noise levels, although local factors, such as traffic and building density, urbanicity, and road layout, influenced the association (26, 27). These studies concluded that there was enough variability between the 2 pollutants to warrant studying the influence of both pollutants using separate measures (26, 27). Little is known about how the 2 pollutants may interact to influence health and cognition (25).

The present article is a secondary analysis of the United Kingdom sample from the Road Traffic and Aircraft Noise Exposure and Children's Cognition and Health (RANCH) project, a cross-sectional epidemiologic study of the associations between aircraft and road traffic noise exposure at school and the health and cognition of 9–10-year-old children in the Netherlands, Spain, and the United Kingdom (2). That study, which to our knowledge is the largest to date, found exposure-effect associations between aircraft noise exposure at school and reading comprehension (3) and recognition memory (2) in the cross-national data. No associations were observed between road traffic noise exposure at school and cognition, with the exception of conceptual recall and information recall, which surprisingly were higher in areas with high road traffic noise in the cross-national data (2). Neither aircraft noise nor road traffic noise affected working memory (2), and there were no significant associations between aircraft noise at school and psychological distress or self-reported health (2). Aircraft noise at school was not associated with systolic and diastolic blood pressure levels in the cross-national data (13); associations were observed for the Dutch sample but not the United Kingdom sample.

The present study had 4 aims. The first was to examine the correlations of aircraft noise exposure and road traffic noise exposure at school with air pollution measured at school for the United Kingdom RANCH sample. The second was to examine whether air pollution at school (nitrogen dioxide) was associated with poorer child cognition and health outcomes in the United Kingdom RANCH sample. We postulated that air pollution would not be associated with impaired cognitive function and health. The third and fourth aims were to examine whether adjustment for air pollution at school would explain or moderate the previously observed associations of aircraft and road traffic noise exposure at school with children's health and cognition. We postulated that air pollution would not explain or moderate these associations.

MATERIALS AND METHODS

Sampling and design

Children who were 9–10 years of age were selected to participate in this field study based on their noise exposure in schools around London Heathrow airport (2, 3). We conducted a secondary analysis of a subsample of these children for whom air pollution data were available (hereafter referred to as the air pollution subsample). Ethical approval was provided by the East London and the City Local Research Ethics Committee, East Berkshire Local Research Ethics Committee, Hillingdon Local Research Ethics Committee, and the Hounslow District Research Ethics Committee in the United Kingdom; by the Medical Ethics Committee of the Netherlands Organization for Applied Scientific Research, Leiden, the Netherlands; and by the Consejo Superior De Investigaciones Cientificas Bioethical Commission, Madrid, Spain.

Noise exposure assessment

Aircraft noise estimates for the schools were based on 16-hour outdoor L_{Aeq} contours (L_{Aeq} is the "equivalent" average sound level A-weighted to approximate the typical sensitivity of the human ear) provided and validated by the United Kingdom Civil Aviation Authority, which gave the average continuous equivalent sound levels of aircraft noise in an area from 7 AM to 11 PM in July through September of 2000. Estimates of outdoor road traffic noise at the school were based on a combination of proximity to motorways, A roads, and B roads and traffic flow data (28) and were confirmed using noise measurements taken at the facade of the school building (2). In all analyses, aircraft and road traffic noise were entered as continuous variables in dB(A); dB(A) is a measure of sound level in decibels A-weighted to approximate the typical sensitivity of the human ear. See references 2 and 3 for further information about the noise exposure assessment.

Air pollution assessment

Concentrations of nitrogen dioxide (μg/m^3) representing traffic-related air pollution for each school were derived using a combined emission-dispersion and regression modeling approach using the King's College London Emissions Toolkit, which has been validated against known measurements (29). The Emissions Toolkit provides detailed road traffic emissions for over 6,000 major and minor roads in London using hourly link-by-link traffic flow and speed data to calculate annual average emissions for pollutants from different types of vehicles. Emission estimates were for 2001 at a 20 × 20-m grid-point resolution.

The emission estimates were then inputted to the King's College London Air Pollution Toolkit (30) to model and predict the annual mean ambient concentrations of nitrogen dioxide (in μg/m^3). Model inputs included meteorological data from Heathrow airport and detailed data on traffic flow, speeds, and vehicle types from the London Atmospheric Emissions Inventory (31). Air pollution values were linked to schools using the schools' postal codes. Procedures were carried out with the use of ArcGIS system (Environmental Systems Research Institute, Inc., Redlands, California). Air pollution could only be modeled for schools within the greater London area, so it was not possible to derive air pollution data for 7 of the 29 schools in the original RANCH United Kingdom cohort.

Outcome and confounding factors assessment

Cognition. Reading comprehension was measured using the Suffolk Reading Scale 2 (32). Episodic memory was measured using a task adapted from the Child Memory Scale (33) that assessed time-delayed conceptual recall, information recall, and recognition of 2 stories presented on compact disc. A modified version of "The Search and Memory Task" (34) was used to assess working memory. See Clark et al. (3) for further details.

Health. Parents completed a self-report questionnaire that included questions on sociodemographic factors, as well as questions on the perceived health of their children (very good/good versus fair/poor/very poor) and psychological distress measured using the parental version of the Strengths and Difficulties Questionnaire (35). We used a continuous Strengths and Difficulties Questionnaire score in our analyses. Blood pressure was assessed in half of the United Kingdom sample following a standard protocol (13) using automatic blood pressure meters (OMRON 711, OMNILABO International BV, Breda, the Netherlands). We used the mean of 3 blood pressure measurements in our analyses.

Confounding factors. Data on a number of potential confounders were available (2), including socioeconomic position (employment status, housing tenure, home crowding (>1.5 people per room at home)), maternal educational level, ethnicity, and main language spoken at home (Table 1). Blood pressure analyses were adjusted for premature birth (before gestational week 36), self-reported parental high blood pressure, birth weight (<2,500 g vs. ≥2,500 g), cuff size of blood pressure monitor, temperature during testing (°C), and body mass index (weight (kg)/height (m)^2) (13).

Procedure

Group testing was carried out in the classroom in the spring of 2002 and the cognitive tests and child questionnaire were administered as part of a 2-hour testing session conducted in the morning. Written consent was obtained from parents and children. Each child took home a questionnaire for his or her parent.

Analysis

Data were analyzed using the STATA xtmixed command for multilevel modeling (StataCorp LP, College Station, Texas), which enabled variables at the school level (e.g., air pollution) and the individual level (e.g. home ownership) to be fitted in the same model. Beta values, 95% confidence intervals, and P values for each variable were obtained. Spearman's rho bivariate correlations were calculated to assess the strength of association between nitrogen dioxide and the noise exposure at school measures, as nitrogen dioxide was not normally distributed.

As air pollution data were available for 22 of the original 29 schools sampled in the United Kingdom RANCH cohort, descriptive statistics were run to compare characteristics of the air pollution subsample data with the original RANCH United Kingdom sample. We fitted multilevel regression models to examine the associations between aircraft and road traffic noise exposure and child cognition and health and adjusted those models for sociodemographic factors to see if the original findings (2, 3, 13) could be replicated in the United Kingdom sample and the United Kingdom air pollution subsample.

Multilevel linear and logistic regression models were used to examine the associations between air pollution and the child cognition and health outcomes. Model 1 included nitrogen dioxide levels and was adjusted for age, gender, mother's educational level, parental employment status, crowding in the home, home ownership, long-standing illness, main language spoken at home, parental support for school work, and classroom window glazing. Model 2 was additionally adjusted for aircraft and road traffic noise exposure at school. We then examined multiplicative interactions between noise exposure and air pollution. For the blood pressure analyses, model 1 was additionally adjusted for body mass index, blood pressure cuff size, room temperature, birth weight, parental high blood pressure, and prematurity. To maximize power in the analyses, complete case analyses were conducted, resulting in a different number of participants for each outcome.

RESULTS

Correlations between noise exposure and air pollution at school

The correlation between nitrogen dioxide levels with aircraft noise exposure was moderate ($r = 0.41$, $P < 0.01$). Similarly, the correlation between road traffic noise exposure at school and nitrogen dioxide was also modest ($r = 0.46$, $P < 0.01$).

Comparison of the sample with and without air pollution data at school

Data on air pollution at school were available for 75% ($n = 719$) of the original United Kingdom sample ($n = 960$). Descriptive analyses revealed few differences between the samples with and without air pollution data (Table 1). Aircraft noise exposure and road traffic noise exposure in

Table 1. Comparison of the Exposure, Cognitive, and Health Outcome Scores and the Sociodemographic Background Variables, United Kingdom RANCH Project, 2001–2003

Characteristic	Subsample With Air Pollution Data ($n = 719$)			Sample Without Air Pollution Data ($n = 241$)			Difference Between the Samples With and Without Air Pollution Data[a]		
	Range	Mean (SD)	%	Range	Mean (SD)	%	t	χ^2	P Value
Exposure data									
Aircraft noise exposure at school, dBA	34–68	54 (10.6)		46–59	52 (3.83)		3.60		<0.01
Road traffic noise exposure at school, dBA	37–67	50 (7.7)		47–63	52 (5.04)		−4.78		<0.01
Nitrogen dioxide at school, μg/m^3	29.41–79.88	42.73 (10.60)		N/A					N/A
Cognitive outcomes									
Reading comprehension	−1.49–2.51	0.20 (1.13)		−1.49–2.51	0.23 (1.11)		−0.36		0.72
Recognition memory	15–30	25.10 (2.63)		14–30	24.78 (2.75)		1.54		0.12
Information recall	0–30.5	19.02 (5.31)		0–29	18.06 (5.86)		2.30		0.02
Conceptual recall	0–7.5	5.25 (1.37)		0–7.5	5.04 (1.53)		1.93		0.06
Working memory	−11–32	15.02 (7.37)		−13–32	14.50 (7.85)		0.84		0.40
Health outcomes									
Overall Strengths and Difficulties Questionnaire score	0–34	10.16 (6.02)		0–29	9.79 (5.63)		0.81		0.42
Very good/good self-rated health			82.7			80.8		4.43	0.51
Fair/poor/very poor self-rated health			17.3			19.2			
Systolic blood pressure[b]	85–141	108.4 (10.1)		91–135	110.5 (8.0)		−1.89		0.06
Diastolic blood pressure[b]	49–106	67.1 (8.1)		46–82	66.9 (7.5)		0.16		0.87
Sociodemographic factors									
Age	8 years, 10 months–11 years, 11 months	10 years, 3 months		8 years, 10 months–11 years, 11 months	10 years, 3 months		−0.78		0.43
Male			45.6			43.6		0.30	0.58
Female			54.4			56.4			
Parent(s) not employed			22.7			22.9		0.004	0.95
Parent(s) employed			77.3			77.1			
Home overcrowded			21.7			25.7		1.53	0.22

Table continues

Table 1. Continued

Characteristic	Subsample With Air Pollution Data ($n = 719$)			Sample Without Air Pollution Data ($n = 241$)			Difference Between the Samples With and Without Air Pollution Data[a]		
	Range	Mean (SD)	%	Range	Mean (SD)	%	t	χ^2	P Value
Home not owned/ mortgaged			42.5			41.0		0.16	0.67
Child has long-standing illness			26.6			25.7		0.07	0.79
Child speaks other language at home			20.3			27.0		4.67	0.03
Classroom has single window glazing			57.3			74.7		73.23	<0.01
Mother's educational level[b]	0.004–0.853	0.48 (0.28)		0.004–0.853	0.56 (0.28)		−4.28		<0.01
Parental support scale	4–12	10.2 (2.0)		5–12	10.2 (1.9)		−0.40		0.69
Small blood pressure cuff size[c]			5.8			1.3		2.55	0.11
Low birth weight (<2,500 g)[c]			9.4			8.0		0.14	0.71
Premature birth (before gestational week 36)[c]			12.0			14.7		0.40	0.53
Parent(s) with high blood pressure[b]			20.3			25.3		0.89	0.35
Body mass index[c,d]	9–23	13.3 (2.32)		10–18	13.0 (1.71)		1.31		0.19
Temperature during blood pressure measurement, °C[c]	20–27	22.9 (1.63)		21–26	23.8 (1.35)		−4.47		<0.01

Abbreviations: dB(A), sound level in decibels A-weighted to approximate the typical sensitivity of the human ear; N/A, not applicable; RANCH, Road Traffic and Aircraft Noise Exposure and Children's Cognition and Health; SD, standard deviation.

[a] χ^2 tests were used for categorical variables and *t* tests were used for continuous variables to detect differences between the samples with and without air pollution data.

[b] Measured using a relative inequality index based on a ranked index of standard qualifications in each country resulting in a standardized score ranging from 0.01 to 1.00.

[c] These factors were only included as confounders/covariates in the blood pressure regression models and the numbers were reduced. There were 276 for whom we had air pollution data and 75 for whom we did not.

[d] Weight (kg)/height (m)^2.

the air pollution subsample were slightly higher: Schools with lower noise exposure levels were also schools for which emission data were not available. There were no differences in cognitive or health outcomes or in sociodemographic factors between the samples except for the fact that the air pollution subsample had slightly lower information recall test scores, were more likely to speak English at home, and had mothers with lower educational levels.

Table 2 shows a comparison of the multilevel regression models for aircraft and road traffic noise associations with cognition and health in the original United Kingdom RANCH sample ($n = 960$) and the air pollution subsample ($n = 719$). We observed associations of similar magnitudes between aircraft and road traffic noise and cognition and health. In the air pollution subsample, aircraft noise exposure at school was significantly associated with children's recognition memory and conceptual recall. Associations with reading comprehension and information recall were borderline significant, and there were no associations with health (Table 2). No associations between road traffic noise and children's cognition or health were observed (Table 2).

The association that we found between aircraft noise exposure and recognition memory replicates that from analyses of the cross-national data (2). The borderline association for reading comprehension replicates and is of a magnitude similar to that from previous analyses of the United Kingdom RANCH data (3). We did not replicate the cross-national findings of an association between road traffic noise and conceptual or information recall (2) in either sample. Neither the cross-national nor the United Kingdom sample data set showed a significant association between aircraft noise and conceptual recall; however, the air pollution subsample did show such an association. There were no associations between aircraft noise or road traffic noise at school and psychological distress, self-rated health, or blood pressure (Table 2) in either sample, replicating the findings of previous analyses (2, 13).

Associations between air pollution, aircraft noise, and road traffic noise at school and children's cognition

After adjusting for sociodemographic factors, we found that nitrogen dioxide levels at school were not significantly associated with children's reading comprehension, recognition memory, information recall, conceptual recall, or working memory, either before or after adjustment for aircraft and road traffic noise exposure at school (Table 3). Overall, adjustment for air pollution at school had little influence on the associations previously observed between aircraft noise exposure at school and children's cognition (Table 3). Aircraft noise exposure at school remained significantly associated with poorer recognition memory, reading comprehension, information recall, and conceptual recall. There were no significant associations between road traffic noise exposure and cognition either before or after adjustment for air pollution at school.

Associations between air pollution, aircraft noise, and road traffic noise at school and children's health

There were no significant associations of nitrogen dioxide at school with children's psychological distress, systolic blood pressure, diastolic blood pressure, or self-rated health either before or after adjustment for aircraft noise and road traffic noise at school (Table 4).

Does air pollution moderate associations of aircraft noise and road traffic noise at school with children's health and cognition?

Air pollution did not moderate the associations between noise exposure and children's cognition or health. One exception was that road traffic noise exposure was associated with poorer recognition memory for children with lower nitrogen dioxide exposure ($\beta = -0.07$, $P < 0.05$, $n = 314$) compared with children higher nitrogen dioxide exposure ($\beta = 0.03$, $P = 0.13$, $n = 327$).

DISCUSSION

In the present article, we explored the associations between air pollution at school and children's cognition and health in a sample of 9–10-year-old children attending schools near London Heathrow airport. There were 4 main findings. First, there were moderate correlations of both aircraft and road traffic noise exposure at school with air pollution measured at the school. Second, there was no evidence of a relation between air pollution (nitrogen dioxide) and a range of children's cognitive and health outcomes. Third, associations between aircraft noise exposure and children's cognition could not be fully explained by air pollution. No associations between road traffic noise exposure and children's cognition were observed, either before or after adjustment for air pollution. Finally, there was little evidence that air pollution moderated the association of noise exposure on children's cognition. These results raise concerns regarding the influence of chronic aircraft noise on children's cognitive abilities.

To our knowledge, this is one of the first studies to examine the impact of both environmental noise exposure and air pollution on children's cognition and health. Air pollution was not significantly associated with a range of cognitive outcomes, either before or after adjustment for environmental noise exposure. These findings contrast with some previous studies, which found associations between air pollution and a range of cognitive abilities, including verbal and nonverbal intelligence, vocabulary, attention, and memory after adjustment for socioeconomic factors (19–21). There are several explanations for the difference in our findings compared with previous studies. Despite adjusting for socioeconomic factors, residual unmeasured confounding remains possible in all the studies. There may be differences in air pollution exposure and cognitive

Table 2. Multilevel Model Parameter Estimates for the Impact of Aircraft and Road Traffic Noise at School on Children's Cognitive Performance and Health Outcomes, United Kingdom RANCH Project, 2001–2003

Variable	Aircraft and Road Traffic Noise at School Adjusted for Sociodemographic Factors[a]							
	Original Sample ($n = 960$)				Air Pollution Subsample ($n = 719$)			
	No. of Participants	β^b	95% CI	*P* Value	No. of Participants	β^b	95% CI	*P* Value
Cognitive outcomes								
Reading comprehension	864				651			
Road traffic noise		−0.001	−0.014, 0.011	0.80		−0.002	−0.017, 0.013	0.77
Aircraft noise		−0.010	−0.020, 0.0005	0.06		−0.011	−0.022, 0.00021	0.05
Recognition memory	844				641			
Road traffic noise		−0.012	−0.046, 0.021	0.47		−0.012	−0.048, 0.023	0.50
Aircraft noise		−0.035*	−0.061, −0.009	0.01		−0.042*	−0.069, −0.016	<0.01
Information recall	837				638			
Road traffic noise		0.039	−0.030, 0.108	0.27		0.040	−0.014, 0.094	0.14
Aircraft noise		−0.025	−0.080, 0.028	0.35		−0.040	−0.082, 0.001	0.06
Conceptual recall	834				636			
Road traffic noise		−0.007	−0.008, 0.022	0.37		0.007	−0.007, 0.021	0.31
Aircraft noise		−0.011	−0.023, 0.001	<0.01		−0.015*	−0.025, −0.004	<0.01
Working memory	785				580			
Road traffic noise		0.038	−0.063, 0.142	0.45		0.036	−0.096, 0.167	0.60
Aircraft noise		−0.004	−0.063, 0.142	0.92		0.00077	−0.096, 0.097	0.99
Health outcomes								
Psychological distress	842				634			
Road traffic noise		−0.025	−0.084, 0.032	0.38		−0.030	−0.093, 0.033	0.35
Aircraft noise		−0.017	−0.064, 0.029	0.46		−0.023	−0.073, 0.026	0.36
Self-rated health	868				655			
Road traffic noise		0.0006	−0.024, 0.025	0.96		0.003	−0.024, 0.030	0.82
Aircraft noise		0.002	−0.018, 0.022	0.83		0.007	−0.015, 0.028	0.54
Systolic blood pressure	351				276			
Road traffic noise		−0.09	−0.25, 0.08	0.22		-0.092	−0.303, 0.118	0.39
Aircraft noise		0.02	−0.12, 0.15	0.77		0.024	−0.131, 0.179	0.76
Diastolic blood pressure	351				276			
Road traffic noise		0.02	−0.11, 0.15	0.76		0.042	−0.125, 0.211	0.61
Aircraft noise		0.01	−0.09, 0.12	0.83		0.019	−0.104, 0.144	0.75

Abbreviations: CI, confidence interval; RANCH, Road Traffic and Aircraft Noise Exposure and Children's Cognition and Health.

* $P \leq 0.05$.

[a] All models were adjusted for age, gender, employment status, crowding, home ownership, mother's educational level, long-standing illness, main language spoken at home, parental support for schoolwork, and classroom window glazing type.

[b] Per 1-dB increase in road traffic noise or aircraft noise.

assessment between studies. Associations may be found at higher exposure levels: In our sample, the range of exposure to air pollution was low to moderate. Associations may also differ by city. Studies have assessed air pollution in the school environment (20) or the home environment (19, 21), which could also influence the findings. There may be error associated with school exposure, as children spend more time at home, which could account for our null findings. Further cross-national large studies examining exposure-effect relations between air pollution exposure and a range of cognitive abilities would further inform the field.

Overall, our findings confirm those of studies that have demonstrated associations between environmental noise and children's cognition (1, 4, 5) after taking air pollution

Table 3. Multilevel Model Parameter Estimates for Nitrogen Dioxide Levels at School on Children's Cognitive Performance, With Further Adjustment for Aircraft and Road Traffic Noise Exposure at School, in the United Kingdom Air Pollution Subsample of the RANCH Project, 2001–2003 ($n = 719$)

Variable	No. of Participants	Air Pollution at School Adjusted for Sociodemographic Factors[a]			Air Pollution, Aircraft Noise, and Road Traffic Noise at School Adjusted for Sociodemographic Factors[a]		
		β[b]	95% CI	*P* Value	β[b]	95% CI	*P* Value
Reading comprehension	651						
Nitrogen dioxide		0.00041	−0.013, 0.014	0.95	0.004	−0.009, 0.018	0.53
Road traffic noise					−0.004	−0.019, 0.012	0.65
Aircraft noise					−0.012*	−0.023, −0.000063	0.05
Recognition memory	641						
nitrogen dioxide		−0.005	−0.041, 0.031	0.78	0.012	−0.021, 0.044	0.48
Road traffic noise					−0.016	−0.054, 0.022	0.40
Aircraft noise					−0.045*	−0.073, −0.017	<0.01
Information recall	638						
Nitrogen dioxide		0.012	−0.036, 0.061	0.62	0.015	−0.033, 0.062	0.54
Road traffic noise					0.036	−0.020, 0.092	0.21
Aircraft noise					−0.043*	−0.086, −0.000036	0.05
Conceptual recall	636						
Nitrogen dioxide		−0.002	−0.015, 0.011	0.79	0.00023	−0.012, 0.013	0.97
Road traffic noise					0.007	−0.008, 0.022	0.34
Aircraft noise					−0.015*	−0.026, −0.003	0.01
Working memory	580						
Nitrogen dioxide		0.036	−0.174, 0.246	0.74	0.003	−0.295, 0.301	0.98
Road traffic noise					0.034	−0.141, 0.209	0.70
Aircraft noise					0.00086	−0.109, 0.111	0.99

Abbreviations: CI, confidence interval; RANCH, Road Traffic and Aircraft Noise Exposure and Children's Cognition and Health.

* $P \leq 0.05$.

[a] All models were adjusted for age, gender, employment status, crowding, home ownership, mother's educational level, long-standing illness, main language spoken at home, parental support for schoolwork, and classroom window glazing type.

[b] Per 1-dB increase in road traffic noise or aircraft noise or a 1-point increase in nitrogen dioxide (μg/m^3).

into account. Aircraft noise exposure at school remained significantly associated with poorer recognition memory, reading comprehension, information recall, and conceptual recall after adjustment for nitrogen dioxide levels. Taken as a whole, these findings suggest studies that have found associations between environmental noise and children's health and cognition seem unlikely to have been seriously confounded by air pollution, although this conclusion may differ for samples with greater air pollution exposure.

However, conclusions in terms of whether air pollution confounds associations between road traffic noise exposure and children's cognition are less clear, as we failed to replicate the original cross-national RANCH finding of associations between road traffic noise exposure and improved conceptual and information recall (2) in either the original United Kingdom RANCH sample or the air pollution subsample and subsequently found no associations after adjustment for air pollution. Comparison of the original United Kingdom RANCH sample with the air pollution subsample suggests that the subsample had slightly higher noise exposures and lower maternal educational levels, were more likely to speak English at home, and had slightly higher scores on the information recall test. Overall, these differences seem unlikely to explain the lack of replication of the original RANCH road traffic noise findings for conceptual and information recall, findings that were themselves unexpected (2) and have yet to be replicated in another sample.

The finding of a significant association between aircraft noise exposure and conceptual and information recall was unexpected, as analyses of the larger cross-national (2) and United Kingdom sample did not show a significant association. It seems counterintuitive that a significant association would be found in a slightly smaller subsample, but the coefficients observed were only slightly larger in magnitude than those in the cross-national and United Kingdom samples. Given the lack of association in the better-powered cross-national data for these cognitive outcomes, these findings should be interpreted with caution.

To our knowledge, no studies have examined associations of air pollution with child health other than with respiratory health (17, 18). We found no associations between air pollution at school and a range of children's health outcomes, including psychological distress, self-rated health, and systolic and diastolic blood pressures.

Table 4. Multilevel Model Parameter Estimates for Aircraft and Road Traffic Noise at School and Nitrogen Dioxide Levels at School on Children's Health in the United Kingdom Air Pollution Subsample of the RANCH Project, 2001–2003 ($n = 719$)

Variable	No. of Participants	Air Pollution at School Adjusted for Sociodemographic Factors[a]			Air Pollution, Aircraft Noise, and Road Traffic Noise at School Adjusted for Sociodemographic Factors[a]		
		β[b]	95% CI	*P* Value	β[b]	95% CI	*P* Value
Psychological distress	634						
Nitrogen dioxide		0.012	−0.042, 0.067	0.67	0.025	−0.033, 0.083	0.40
Road traffic noise					−0.037	−0.104, 0.029	0.27
Aircraft noise					−0.028	−0.079, 0.023	0.28
Self-rated health	655						
Nitrogen dioxide		0.013	−0.006, 0.033	0.18	0.013	−0.008, 0.033	0.22
Road traffic noise					−0.00020	−0.027, 0.027	0.99
Aircraft noise					0.004	−0.018, 0.026	0.70
Systolic blood pressure	276						
Nitrogen dioxide		0.058	−0.092, 0.210	0.45	0.070	−0.120, 0.259	0.47
Road traffic noise					−0.102	−0.31, 0.11	0.35
Aircraft noise					0.017	−0.139, 0.174	0.83
Diastolic blood pressure	276						
Nitrogen dioxide		0.033	−0.084, 0.151	0.58	0.088	−0.059, 0.236	0.24
Road traffic noise					0.030	−0.136, 0.195	0.73
Aircraft noise					0.012	−0.110, 0.134	0.85

Abbreviations: CI, confidence interval; RANCH, Road Traffic and Aircraft Noise Exposure and Children's Cognition and Health.

[a] All models adjusted for age, gender, employment status, crowding, home ownership, mother's educational level, long-standing illness, main language spoken at home, parental support for schoolwork, and classroom window glazing type except the blood pressure models, which were additionally adjusted for body mass index, cuff-size, room temperature, birth weight, parental high blood pressure, and prematurity.

[b] Per 1-dB increase in road traffic noise or aircraft noise or a 1-point increase in nitrogen dioxide (μg/m^3).

Thus, although there is a consensus that air pollution is associated with hypertension and cardiovascular death in adults (36, 37), our findings suggest that no associations with blood pressure are observable for children. This probably reflects the length of exposure required for the cardiovascular effects of air pollution to develop but could also reflect a lack of power to detect associations in our smaller blood pressure subsample or the moderate levels of pollution examined.

Few studies have examined whether air pollution moderates associations between environmental noise exposure and children's cognition and health. Van Kempen et al. (25) found that children with high air pollution exposure experienced shorter reaction times with high road traffic noise exposure. We found no evidence that air pollution moderated associations, with the exception that road traffic noise exposure was associated with poorer recognition memory for children with lower nitrogen dioxide exposure at school compared with children with higher nitrogen dioxide exposure at school. It is unclear by what mechanism lower levels of air pollution might impact the association between road traffic noise and recognition memory. This could be a chance finding given the number of interactions examined, and it needs to be replicated in a study with a wider range of air pollution exposures.

There are several limitations to the study that may influence the generalizability of the findings regarding air pollution. The sample lacks schools with high levels of air pollution. Children were not selected for the study based on air pollution exposure at school, which may have biased the distribution of air pollution levels in our sample. Data from participants attending 7 of 29 schools were excluded from the analyses because no air pollution data were available. We were restricted to examining the associations for air pollution at school and lacked information about air pollution exposure at home, which may be important (25). We could not model particulate matter less than 2.5 μm in diameter or black carbon, which could influence cognitive outcomes (19, 23, 24). Exposure misclassification associated with modeling air pollution exposure is a possibility, and the accuracy of estimation may differ for noise and air pollution.

The present study is the largest to date that examined the impact of exposure to both environmental noise and air pollution at school on children's health and cognition. Other strengths include the assessment of a wide-range of cognitive and health outcomes, a sample drawn from a wide range of noise exposure levels, adjustment for a wide-range of individual confounding socioeconomic factors, and the use of multilevel modeling to take school- and individual-level variation into account.

The results of this project have implications for national and local authorities involved in public health, transport planning, and land-use planning. In terms of policy implications, the RANCH project findings indicate that a chronic environmental stressor—aircraft noise exposure at school—could impair cognitive development in children, specifically reading comprehension and memory. Schools exposed to high levels of aircraft noise are not healthy educational environments.

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Long-Term Exposure to Traffic-Related Air Pollution and the Risk of Coronary Heart Disease Hospitalization and Mortality

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Background: Epidemiologic studies have demonstrated that exposure to road traffic is associated with adverse cardiovascular outcomes.

Objectives: We aimed to identify specific traffic-related air pollutants that are associated with the risk of coronary heart disease (CHD) morbidity and mortality to support evidence-based environmental policy making.

Methods: This population-based cohort study included a 5-year exposure period and a 4-year follow-up period. All residents 45–85 years of age who resided in Metropolitan Vancouver during the exposure period and without known CHD at baseline were included in this study (n = 452,735). Individual exposures to traffic-related air pollutants including black carbon, fine particles [aerodynamic diameter ≤ 2.5 μm ($PM_{2.5}$)], nitrogen dioxide (NO_2), and nitric oxide were estimated at residences of the subjects using land-use regression models and integrating changes in residences during the exposure period. CHD hospitalizations and deaths during the follow-up period were identified from provincial hospitalization and death registration records.

Results: An interquartile range elevation in the average concentration of black carbon (0.94×10^{-5}/m filter absorbance, equivalent to approximately 0.8 μg/m^3 elemental carbon) was associated with a 3% increase in CHD hospitalization (95% confidence interval, 1–5%) and a 6% increase in CHD mortality (3–9%) after adjusting for age, sex, preexisting comorbidity, neighborhood socioeconomic status, and copollutants ($PM_{2.5}$ and NO_2). There were clear linear exposure–response relationships between black carbon and coronary events.

Conclusions: Long-term exposure to traffic-related fine particulate air pollution, indicated by black carbon, may partly explain the observed associations between exposure to road traffic and adverse cardiovascular outcomes.

Key words: air pollution, cohort studies, coronary heart disease, particulate matter, vehicle emissions. *Environ Health Perspect* 119:501–507 (2011). doi:10.1289/ehp.1002511 [Online 16 November 2010]

A number of epidemiologic studies have demonstrated that long-term exposure to road traffic as indicated by residential proximity to major roadways or residential traffic intensity is associated with adverse cardiovascular outcomes including coronary artery atherosclerosis (Hoffmann et al. 2007), deep vein thrombosis (Baccarelli et al. 2009), fatal and nonfatal coronary events (Kan et al. 2008; Tonne et al. 2007), and cardiopulmonary mortality (Gehring et al. 2006; Hoek et al. 2002). In a previous analysis of this population-based cohort, Gan et al. (2010) observed that living close to road traffic was associated with an increased risk of coronary heart disease (CHD) mortality and that change in residential proximity to road traffic was associated with an altered risk of CHD mortality: moving close to traffic was associated with an increased risk, whereas moving away from traffic was associated with a decreased risk. In addition to exposure to traffic noise (Selander et al. 2009), residential proximity to road traffic may reflect exposure to multiple traffic-related air pollutants (Brauer et al. 2003; Künzli et al. 2000; Zhu et al. 2002). Identifying traffic-related air pollutants responsible for adverse cardiovascular outcomes is important for evidence-based environmental policy making and cost-effective air pollution intervention.

Metropolitan Vancouver, located on the west coast of Canada, has relatively low levels of air pollution compared with other metropolitan areas. For example, in this region, the annual average concentration of fine particles [aerodynamic diameter ≤ 2.5 μm ($PM_{2.5}$)] is 5 μg/m^3 (Brauer et al. 2008), in contrast to 8.7 μg/m^3 in Toronto, Canada (Jerrett et al. 2009), 14.0 μg/m^3 in metropolitan areas of the United States (Pope et al. 2004), 28.3 μg/m^3 in the Netherlands (Beelen et al. 2008), and 22.8 μg/m^3 in the Ruhr area, Germany (Hoffmann et al. 2007). As in most urban areas, motor vehicles are recognized as a major contributor to ambient air pollution and are responsible for much of the spatial variability in pollutant concentrations in this region (Henderson et al. 2007).

Based on our previous analyses (Gan et al. 2010), we conducted a large population-based cohort study to identify specific traffic-related air pollutants that might be responsible for the observed association between exposure to road traffic and the risk of CHD mortality. We also examined the relationships between traffic-related air pollutants and the risk of CHD hospitalization.

Materials And Methods

Study design. This population-based cohort study included two periods: a 5-year exposure period (January 1994–December 1998) and a 4-year follow-up period (January 1999–December 2002) for which mortality data were available. Average concentrations of traffic-related air pollutants were estimated at residences of the subjects using land-use regression (LUR) models and integrating changes in residences during the exposure period. Hospitalization and mortality information during the follow-up period was retrieved from provincial hospitalization records and death registration records, respectively. This study was approved by the Institutional Review Board of The University of British Columbia (Behavioural Research Ethics Board certificate H08-00185).

Population. As described previously, we used linked administrative databases from the universal health insurance system of British Columbia to assemble a population-based cohort (Gan et al. 2010). All Metropolitan Vancouver residents who met the following criteria at baseline (January 1999) were included in the cohort: registered with the provincial health insurance plan, which provides universal coverage to nearly all residents in the study region; resided in the study region during the 5-year exposure period; 45–85 years of age; and no previous diagnosis of CHD.

Air pollution exposure assessment. We used a high-resolution LUR model combined with residential histories to estimate individual

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exposure to traffic-related air pollutants including black carbon, $PM_{2.5}$, nitrogen dioxide (NO_2), and nitric oxide (NO) during the 5-year exposure period. This method has been described in detail elsewhere (Brauer et al. 2008; Henderson et al. 2007; Larson et al. 2009). Briefly, NO and NO_2 concentrations were measured using Ogawa passive samplers (Ogawa USA, Pompano Beach, FL, USA) at 116 sites. $PM_{2.5}$ concentrations were measured using Harvard Impactors (Air Diagnostics and Engineering, Harrison, ME, USA) at a subset of 25 locations. Light-absorbing carbon (black carbon) concentrations were measured using a particle soot absorption photometer (Radiance Research, Seattle, WA, USA) in a mobile monitoring campaign at a subset of 39 sites during the summer season (Larson et al. 2009). In the study region, the concentrations of black carbon based on the particle light absorption coefficient are highly correlated with the concentrations of elemental carbon measured by traditional thermal/optical reflectance (R^2 = 0.7–0.8); 10^{-5}/m black carbon is approximately equivalent to 0.8 µg/m^3 elemental carbon (Rich 2002). Based on these measurements and after adjusting for temporal variation, we calculated annual average concentrations of these pollutants for each site.

Meanwhile, a total of 55 variables were generated in a geographic information system (GIS) (ArcGIS; ESRI, Redlands, CA, USA) to describe the land use characteristics of each site. Measured air pollutant concentrations and the most predictive land use characteristics were modeled using multiple linear regression techniques. As described previously (Brauer et al. 2008), we used the coefficient of determination (R^2) and estimated mean error from leave-one-out cross validation analysis to evaluate the performance of these models. Overall, the performance was similar to those of previous studies (Hoek et al. 2008). For NO [R^2 = 0.62, mean error (± SD) = 2.02 ± 15.5 µg/m^3], the model included the length of highways within a 100-m and a 1,000-m radius, the length of major roads within a 100-m radius, the population density within a 2,500-m radius, around each sampling site, and the elevation of each site. For NO_2 (R^2 = 0.56, mean error = 0 ± 5.2 µg/m^3), the model included all variables in the NO model and also the area of commercial land within a 750-m radius. For $PM_{2.5}$ (R^2 = 0.52, mean error = 0 ± 1.50 µg/m^3), the model included the areas of commercial and industrial land within a 300-m radius, the area of residential land within a 750-m radius, and the elevation. For black carbon (R^2 = 0.56, mean error = 0 ± 0.23 × 10^{-5}/m), the model included the length of major roads within a 100-m radius, distance to the nearest highway, and the area of industrial land within a 750-m radius. Overall, the performance (SD of mean error/sample mean) of the models for NO (10%), NO_2 (18%), and black carbon (14%) was better than that for $PM_{2.5}$ (36%).

Based on the LUR models, we generated a predicted spatial surface for annual average concentrations for each pollutant in a GIS with a resolution of 10 m. We then applied month–year adjustment factors derived from regulatory monitoring data to estimate monthly concentrations. The monthly air pollution data were assigned to subjects through their six-digit residential postal codes (area centroids). In urban areas of Metropolitan Vancouver, a six-digit postal code represents one side of a city block, but may represent a larger area in less densely populated regions. After integrating changes in residences, we calculated average concentrations of black carbon, $PM_{2.5}$, NO_2, and NO during the 5-year exposure period for each study subject.

Because the air pollution exposure assessment did not cover the whole study region, air pollution data were not available for a small proportion of study subjects. These subjects were thus excluded from the analyses. Meanwhile, because of changes in residences, some subjects had partially missing air pollution data; those with missing data in more than a total of any 15 months or in more than 3 consecutive months during the 5-year exposure period were also excluded from the analyses.

Case definitions. The outcomes of this study included CHD hospitalizations and CHD deaths that occurred during the 4-year follow-up period.

A CHD hospitalization case is a record of hospitalization with the following *International Statistical Classification of Diseases, 9th Revision* codes, ICD-9, 410–414 and 429.2 [World Health Organization (WHO) 1977] or *10th Revision* (ICD-10), I20–I25 (WHO 2007), as the principal diagnosis (the most responsible diagnosis) for a hospital admission in the provincial hospitalization database.

A CHD death is a death record with CHD as the cause of death in the provincial death registration database.

A broader definition was used to identify prior CHD cases. Subjects who had a hospitalization record with CHD as the principal or primary (the diagnosis that had a substantial influence on hospital length of stay) diagnosis before baseline (based on data from January 1991 to December 1998) were regarded as previously diagnosed CHD cases. These prior cases were excluded from the analysis to examine the association of incident CHD with traffic-related air pollution.

Covariates. We included age, sex, preexisting comorbidity, and neighborhood socioeconomic status (SES) as covariates in the data analysis. We used the following ICD codes to identify preexisting comorbidity including diabetes (Pearson et al. 2002) (ICD-9, 250; ICD-10, E10–E14), chronic obstructive pulmonary disease (COPD) (Hole et al. 1996) (ICD-9, 490–492 and 496; ICD-10, J40–J44), and hypertensive heart disease (Pearson et al. 2002) (ICD-9, 401–404; ICD-10, I10–I13) that are independent risk factors for CHD. In addition, these chronic diseases and CHD share common behavioral risk factors such as cigarette smoking. Given a lack of individual data on behavioral risk factors in this study, we used the preexisting comorbidity as a proxy variable of common behavioral risk factors (Pope et al. 2009). To sufficiently control for the influence of the comorbidities and the common behavioral risk factors, all diagnoses in a hospitalization record (up to 16 diagnoses before 2001 and up to 25 diagnoses since 2001) were used to identify subjects with these comorbidities. One hospitalization record with the diagnosis of any of these diseases during January 1991–December 1998 was defined as the presence of comorbidity.

Neighborhood SES reflects neighborhood disadvantages and is a risk factor for CHD (Diez Roux et al. 2001; Sundquist et al. 2004). In addition, because individual SES data were not available in this study, we used neighborhood SES to approximate individual SES (Domínguez-Berjón et al. 2006; Krieger 1992). The neighborhood income quintiles from the 2001 Statistics Canada Census were assigned to study subjects using their residential postal codes. For the 2001 Census, a dissemination area with 400–700 persons was the smallest census geographic unit for which all census data were disseminated. Within a census metropolitan area, all dissemination areas were ranked by household size–adjusted average family income and divided into quintiles (Gan et al. 2010).

Statistical analysis. The baseline characteristics between study subjects with different outcomes were compared using a chi-square test for categorical variables and *t* test for continuous variables. Correlations between these pollutants were examined using Spearman's rank correlation.

The Cox proportional hazards regression model was used to determine the associations of each air pollutant with CHD hospitalization and mortality. CHD hospitalization and CHD death were regarded as independent events; for CHD hospitalization analysis, CHD deaths without a hospitalization record were treated as censored cases like those who died from other diseases; for CHD mortality analysis, CHD hospitalization cases without a death record were treated the same way as those without a CHD event. Person-years were calculated for study subjects from baseline to the date of the first CHD hospitalization, CHD death, or end of follow-up. For those who died from other diseases or those who moved out of the province, person-years were calculated from baseline to the date of death or the last known date in the province. We first calculated relative risks (RRs) of CHD events in response to an interquartile range (IQR) elevation in the average concentration of each pollutant using bivariable and multivariable models. In the multivariable analysis, we gradually adjusted for age, sex, preexisting comorbidity (diabetes, COPD, or hypertensive heart disease), neighborhood income quintiles, and copollutants. We further examined exposure–response relationships by dividing study subjects into quintiles based on the concentrations of each pollutant. RRs of CHD events were calculated for quintile 2 to quintile 5, using quintile 1 (lowest) as the reference category. Linear trend across quintile groups was examined by using quintiles of a pollutant as a continuous variable.

For those pollutants strongly associated with CHD hospitalization and mortality, we performed stratification analyses to examine effect modification by age, sex, preexisting comorbidity, and neighborhood SES. In this analysis, age was categorized into three groups (< 60, 60–69, ≥ 70 years) as used in previous studies (Miller et al. 2007; Pope et al. 2002). Neighborhood SES was categorized into two groups: low (neighborhood income quintile 1–3) and high (neighborhood income quintile 4–5).

All statistical analyses were performed using SAS 9.2 software (SAS Institute Inc., Cary, NC, USA).

Results

At baseline, a total of 466,727 subjects who met the inclusion criteria were included in this study. Among these subjects, 13,992 (3.0%) with missing air pollution data were excluded, which left 452,735 subjects for the present analysis. During the 4-year follow-up period, 17,542 (3.9%) moved out of the province and 16,367 (3.6%) died from other diseases, leaving 418,826 (92.5%) subjects at the end of follow-up. Of these subjects, 45.9% were male; the average age (SD) was 58.9 (10.5) years (range, 45–83 years).

Although multiple ICD-9 and ICD-10 codes were used to identify CHD cases, acute myocardial infarction (ICD-9 code 410 and ICD-10 codes I21, I22) was the leading cause of hospitalization (41.2%) and death (56.8%). Compared with the subjects without CHD event, hospitalization cases and death cases were older and more likely to be male and have preexisting comorbidity and lower neighborhood SES, especially for death cases (Table 1).

Descriptive statistics and Spearman's rank correlation coefficients for these pollutants are summarized in Table 2. Overall, except for the correlation between NO_2 and NO, these pollutants were weakly correlated with each other.

Traffic-related air pollution and CHD hospitalization. During the follow-up period, 10,312 subjects were hospitalized for CHD (hospitalization rate, 6.0 per 1,000 person-years). Exposure to black carbon was associated with CHD hospitalization. For an IQR elevation in black carbon concentration (0.94×10^{-5}/m), CHD hospitalization increased 4% [95% confidence interval (CI), 3–6%]. Adjusting for age, sex, preexisting comorbidity, and neighborhood SES reduced the effect estimate, whereas additional adjustment for copollutants ($PM_{2.5}$ and NO_2) increased the effect estimate (Table 3). $PM_{2.5}$ was similar to black carbon in the magnitude of association with CHD hospitalization; whereas NO_2 and NO were inversely associated with CHD hospitalization in adjusted models (Table 3).

CHD hospitalization gradually increased in response to quintiles of black carbon concentrations in bivariable and fully adjusted models, but not in the partially adjusted model (Figure 1A). In contrast, there was no linear exposure–response relationship between $PM_{2.5}$ and CHD hospitalization and some evidence of inverse associations of NO_2 and NO with CHD hospitalization (Figure 1A).

Stratification analysis shows that CHD hospitalization in response to an IQR elevation in black carbon concentrations was higher for people < 70 years of age and for those living in the areas with higher neighborhood SES (Figure 2A).

Traffic-related air pollution and CHD mortality. A total of 3,104 subjects died from CHD (mortality rate, 1.8 per 1,000 person-years) during the follow-up period. Exposure to black carbon was strongly associated with CHD mortality. For an IQR elevation in black carbon concentration (0.94×10^{-5}/m), CHD mortality increased 14% (95% CI, 11–17%). Adjusting for age, sex, preexisting comorbidity, and neighborhood SES greatly reduced the effect estimate; additional adjustment for copollutants ($PM_{2.5}$ and NO_2) did not change

Table 1. Baseline characteristics of study subjects (%).

Characteristic	Subjects without CHD event (*n* = 406,232)	Hospitalization cases* (*n* = 10,312)	Mortality cases* (*n* = 3,104)
Men	45.3	66.4	61.5
Age (years)[a]	58.7 ± 10.4	65.4 ± 10.1	72.5 ± 8.9
Comorbidity			
Diabetes	1.8	7.9	13.3
COPD	1.0	2.8	9.8
Hypertensive heart disease	3.6	10.8	19.3
Any of the above	5.5	17.2	31.2
Income quintiles[b]			
1	17.9	19.8	26.2
2	18.9	19.5	21.6
3	19.5	19.4	18.3
4	20.7	20.7	18.1
5	23.1	20.5	15.8

[a]Data are presented as mean ± SD. [b]Quintile 1 represents the lowest neighborhood income and quintile 5 the highest income. *$p < 0.05$ for all comparisons with subjects without CHD event.

Table 2. Average concentrations of traffic-related air pollutants during the 5-year exposure period and Spearman correlation coefficients.

					Spearman correlation coefficient*			
Pollutant	Mean ± SD	Median	IQR	Range	BC	$PM_{2.5}$	NO_2	NO
BC (10^{-5}/m)	1.49 ± 1.10[a]	1.02	0.94	0–4.98	1.00	–	–	–
$PM_{2.5}$ (μg/m^3)	4.08 ± 1.63	4.03	1.58	0–10.24	0.13	1.00	–	–
NO_2 (μg/m^3)	32.1 ± 8.0	30.6	8.4	15.3–57.7	0.39	0.47	1.00	–
NO (μg/m^3)	32.0 ± 11.9	29.3	13.2	8.8–126.0	0.42	0.43	0.67	1.00

BC, black carbon.
[a]Equivalent to approximately 1.19 ± 0.88 μg/m^3 elemental carbon (10^{-5}/m black carbon ≈ 0.8 μg/m^3 elemental carbon).
*$p < 0.001$ for each correlation coefficient.

Table 3. RRs (95% CIs) of CHD hospitalization and mortality for an IQR elevation in average concentrations of traffic-related air pollutants.

Model	BC (0.94×10^{-5}/m)[a]	$PM_{2.5}$ (1.58 μg/m^3)[a]	NO_2 (8.4 μg/m^3)[a]	NO (13.2 μg/m^3)[a]
Hospitalization				
Model 1: unadjusted single pollutant	1.04 (1.03–1.06)	1.03 (1.01–1.05)	1.02 (1.00–1.04)	0.99 (0.97–1.02)
Model 2: + sex, age, comorbidity, SES	1.01 (1.00–1.03)	1.00 (0.98–1.02)	0.97 (0.95–0.99)	0.96 (0.94–0.98)
Model 3: + two other pollutants[b]	1.03 (1.01–1.05)	1.02 (1.00–1.05)	0.96 (0.94–0.98)	0.95 (0.92–0.97)
Mortality				
Model 1: unadjusted single pollutant	1.14 (1.11–1.17)	1.13 (1.09–1.16)	1.19 (1.15–1.23)	1.13 (1.09–1.17)
Model 2: + sex, age, comorbidity, SES	1.06 (1.03–1.09)	1.01 (0.98–1.05)	1.04 (1.01–1.08)	1.06 (1.02–1.10)
Model 3: + two other pollutants[b]	1.06 (1.03–1.09)	1.00 (0.96–1.03)	1.03 (0.99–1.07)	1.03 (0.99–1.08)

+, additionally adjusted for covariates.
[a]IQR. [b]Additionally adjusted for $PM_{2.5}$ and NO_2 for black carbon, black carbon and NO_2 for $PM_{2.5}$, black carbon and $PM_{2.5}$ for NO_2 and NO.

the effect estimate (Table 3). NO_2 and NO (but not $PM_{2.5}$) had a similar magnitude of association with CHD mortality.

We also observed a strong exposure–response relationship between exposure to black carbon and CHD mortality in bivariable and multivariable models (Figure 1B). For NO_2 and NO, an exposure–response relationship was present in the bivariable models and in the multivariable models including age, sex, preexisting comorbidity, and neighborhood SES, but not after further adjustment for black carbon and $PM_{2.5}$ (Figure 1B). For $PM_{2.5}$, a linear trend was evident in the bivariable model but not in any of the adjusted models (Figure 1B).

Stratification analysis shows that CHD mortality associated with an IQR elevation in black carbon concentration was higher for men and for those 60–69 years of age, although there was considerable overlap in the risk estimates (Figure 2B).

During the 4-year follow-up period, there was no evident change in traffic-related air pollution such as $PM_{2.5}$ and NO_2 in this study region (Greater Vancouver Regional District 2003). Our exposure assessment accounted for changes in residences during the exposure

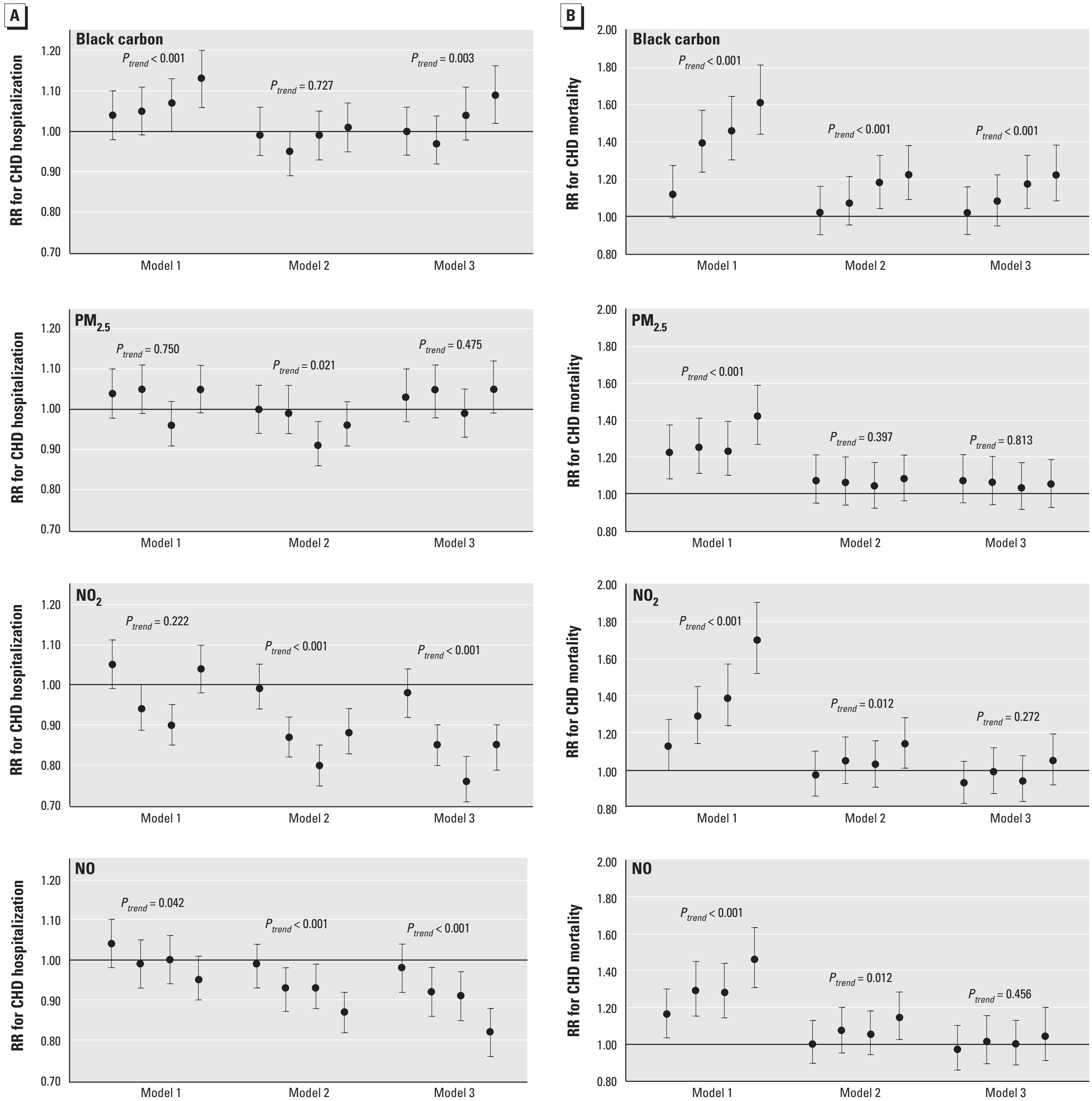

Figure 1. RRs and 95% CIs of CHD hospitalization (*A*) and mortality (*B*) for quintiles of black carbon, $PM_{2.5}$, NO_2 and NO. Quintile 1 (lowest) was the reference category. From left to right, each error bar represents RR and 95% CI of CHD hospitalization (*A*) or mortality (*B*) for quintiles 2–5, respectively, compared with quintile 1. p_{trend} indicates linear trend across quintile groups. Model 1, bivariable analysis; model 2, adjusted for age, sex, preexisting comorbidity, and neighborhood SES; model 3, additionally adjusted for copollutants ($PM_{2.5}$ and NO_2 for black carbon, black carbon and NO_2 for $PM_{2.5}$, black carbon and $PM_{2.5}$ for NO_2 and NO).

period. Futher, a sensitivity analysis showed that the effect estimates remain unchanged after excluding those who changed their residences during the 4-year follow-up period.

Discussion

This large population-based cohort study demonstrated that long-term exposure to higher concentrations of black carbon was associated with increased risks of CHD hospitalization and mortality in an exposure–response fashion. The observed association with CHD mortality was particularly strong.

Black carbon results mainly from incomplete combustion of diesel fuels and is a surrogate for diesel exhaust particles (Schauer 2003). It may also be emitted from other sources such as gasoline-powered vehicles and wood combustion (Schauer 2003). Metropolitan Vancouver is a highly urbanized region; road traffic is the predominant source of black carbon and determines much of the spatial variability in the concentrations, especially during the summer season. In general, black carbon can be regarded as an indicator of the traffic-related component of fine particulate air pollution (Gold et al. 2005; Schwartz et al. 2005).

A recent case–control study used measured black carbon and NO_2 levels to estimate traffic particle levels and found that an IQR (0.2×10^{-5}/m) elevation in modeled traffic particle concentration was associated with a 10% (95% CI, 4–16%) increase in acute myocardial infarction (Tonne et al. 2009). In a 9-year Dutch cohort study, a 10-µg/m^3 increase in annual average concentration of black smoke was associated with a nonsignificant 4% increase in cardiovascular mortality (Beelen et al. 2008). A recent time-series study of 12 million Medicare enrollees in 119 U.S. urban communities found that an IQR (0.4 µg/m^3) elevation in daily elemental carbon concentration was associated with a 0.8% (95% CI, 0.3–1.3%) increase in same-day cardiovascular hospitalizations. Elemental carbon was the only component of $PM_{2.5}$ associated with cardiovascular hospitalizations (Peng et al. 2009). Similarly, in a time-series study, Laden et al. (2000) observed that traffic-related fine particles were more strongly associated with CHD mortality than with respiratory mortality, whereas coal-derived fine particles were more strongly associated with respiratory mortality than with CHD mortality. The findings of our study are consistent with those from previous studies, demonstrating that black carbon, as an indicator of traffic-related fine particulate air pollution, may be partly responsible for the observed associations between exposure to road traffic and adverse cardiovascular outcomes.

There is also strong evidence linking black carbon to various subclinical pathophysiological responses. Controlled exposure studies in healthy human volunteers demonstrated that short-term exposure to diesel exhaust can cause acute artery vasoconstriction (Peretz et al. 2008), vascular endothelial dysfunction (Mills et al. 2005; Törnqvist et al. 2007), and marked pulmonary and systemic inflammation (Nightingale et al. 2000; Salvi et al. 1999; Törnqvist et al. 2007). Further, exposure to ambient black carbon or elemental carbon in fine particles has been associated with airway (Jansen et al. 2005) and systemic inflammation (Delfino et al. 2008), platelet activation (Delfino et al. 2008), plasma homocysteine (Park et al. 2008), heart rate variability (Schwartz et al. 2005), cardiac arrhythmia (Dockery et al. 2005), and myocardial ischemia (Chuang et al. 2008; Gold et al. 2005; Mills et al. 2007). These findings suggest multiple biological mechanisms for the associations between black carbon and coronary events.

We did not find evidence of a linear exposure–response relationship between $PM_{2.5}$ and CHD hospitalization or mortality, as reported in some previous studies (Miller et al. 2007; Pope et al. 2002). This finding was, however, consistent with the results of several other studies (Beelen et al. 2008; Hoffmann et al. 2007; Jerrett et al. 2009). As mentioned before, in this study region, $PM_{2.5}$ levels were substantially lower compared with those of other metropolitan areas. In addition, road traffic was just one of numerous sources for ambient $PM_{2.5}$. Therefore, the spatial distribution of $PM_{2.5}$ is relatively more homogeneous. The null exposure–response relationship between $PM_{2.5}$ and CHD probably reflects the inability of our exposure assessment method to differentiate spatial variability of $PM_{2.5}$ in this intra-urban study.

Some studies have reported associations between long-term residential exposure to NO_2 (Rosenlund et al. 2008, 2009) or NO_x (Nafstad et al. 2004) and CHD mortality. In these studies, NO_2/NO_x was used as a surrogate for within-city traffic-related air pollution. In our study, we also observed a linear exposure–response relationship between NO_2 or NO and CHD mortality. However, this relationship was mostly attenuated after adjustment for black carbon, suggesting that black carbon played a more important role than NO_2 and NO in association with CHD mortality in this study region.

This study has several strengths that support the validity of the findings. First, this large population-based cohort study included 452,735 subjects without known CHD at baseline. The large sample size and statistical power enabled this study to detect small adverse coronary effects with relatively higher precision. Second, this study used two different coronary outcomes, hospitalization and mortality (from different data sources), to evaluate the adverse effects of these pollutants. The associations between black carbon and these two outcomes were consistent. Third, we collected detailed residential history information. Average concentrations of air pollutants were calculated for each subject after integrating changes in residences during the 5-year exposure period. As previously demonstrated (Gan et al. 2010), this method can effectively reduce exposure misclassification from residence relocation. Fourth, we used LUR models with high spatial resolution for exposure assessment. This approach facilitates spatial variability of pollutant concentrations and provides increased exposure contrasts and statistical power.

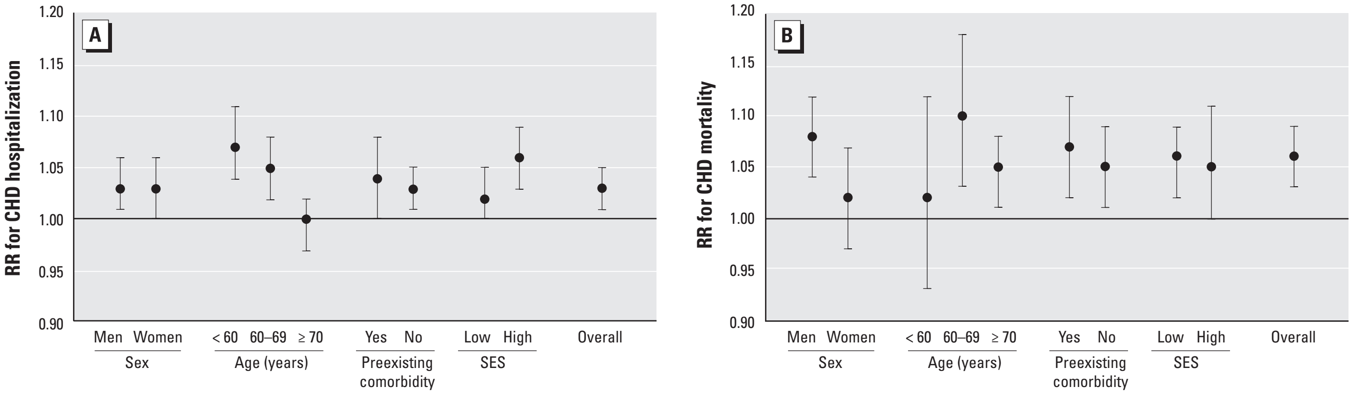

Figure 2. Adjusted RRs and 95% CIs for CHD hospitalization (*A*) and mortality (*B*) associated with an IQR elevation in black carbon concentration, stratified by each covariate and adjusted for all other covariates in the figure and copollutants $PM_{2.5}$ and NO_2.

This study also has some limitations. First, the cohort was constructed using provincial health insurance registry and linked administrative health databases. As previously discussed (Gan et al. 2010), some important information about individual cardiovascular risk factors such as cigarette smoking was not available and thus could not be controlled in data analysis. We adjusted for age, sex, preexisting comorbidity (diabetes, COPD, hypertensive heart disease), and neighborhood SES. Because these comorbidities and CHD share common behavioral risk factors, adjusting for these comorbidities to some extent was able to reduce the influence of some uncontrolled risk factors and these comorbidities themselves on the effect estimates (Pope et al. 2009). On the other hand, because diabetes, COPD, and hypertensive heart disease might serve as intermediate variables for the association between traffic-related air pollution and coronary events, adjusting for these comorbidities might lead to underestimations of the true adverse effects (Schisterman et al. 2009).

Second, cigarette smoking is the single most important risk factor for CHD and was not measured in this study (Ockene and Miller 1997). However, previous studies have shown that cigarette smoking did not substantially affect the associations between fine particulate air pollution and adverse cardiovascular outcomes such as coronary atherosclerosis (Hoffmann et al. 2007), carotid intima-media thickness (Künzli et al. 2005), and CHD mortality (Pope et al. 2004). Based on these previous findings, we believe that the observed associations in this study are unlikely to be due to the confounding effects of cigarette smoking.

Third, low individual SES is a risk factor for CHD (Kaplan and Keil 1993) and may be also related to exposure to traffic-related air pollution (Gunier et al. 2003). Individual SES is thus a possible confounder for the observed association. As mentioned before, because individual SES was not available in this study, we used neighborhood income quintiles to approximately estimate individual SES. There is some evidence that this approach is valid for control of individual SES (Domínguez-Berjón et al. 2006; Krieger 1992); however, this approach was unlikely to control all confounding effects related to individual SES (Geronimus and Bound 1998).

Fourth, like those used in previous studies, the exposure assessment in this study can only approximately reflect the exposure levels at subjects' residences (postal code centroids). Many factors such as air infiltration, individual mobility, and outdoor activity might substantially affect actual individual exposure to traffic-related air pollution. This exposure assessment method did not take into account these individual factors and thus cannot precisely reflect actual individual exposure levels. Nevertheless, these factors are most likely to cause nondifferential exposure misclassification, leading to underestimations of the true adverse coronary effects (Van Roosbroeck et al. 2008).

Fifth, exposure to traffic-related air pollution may be associated with exposure to traffic noise (Davies et al. 2009). Some evidence has indicated that exposure to traffic noise is associated with CHD events (Selander et al. 2009). In the present study, traffic noise might also play a role in the association between black carbon and CHD events.

Sixth, because of privacy protection, we were unable to contact CHD cases or access their original medical records. As a result, we were unable to evaluate the accuracy of CHD diagnosis recorded in the provincial hospitalization database and death registration database. There were up to 16 diagnoses (1991–2000) or up to 25 diagnoses (2001–2002) in each hospitalization record. To reduce the possibility of misdiagnosis, we used only the principal diagnosis (the most responsible diagnosis for a hospital admission) to identify hospitalization cases. This stringent definition for hospitalization case might improve the accuracy of the CHD classification; however, we might inevitably lose some hospitalization cases for which CHD was not the principal diagnosis and thereby underestimate the true adverse effects.

Finally, although air pollution exposures were estimated based on residential postal codes, because of privacy protection, residential postal codes were eliminated from data files after data linkage. Therefore, we were unable to access residential postal codes of the subjects and cannot adjust for spatial clustering of the air pollution data, which might lead to underestimations of the standard errors in Cox regression models.

Conclusions

This large, population-based cohort study demonstrated that long-term exposure to higher concentrations of black carbon was associated with an increased risk of CHD hospitalization and mortality in an exposure–response fashion. These findings suggest that traffic-related fine particulate air pollution, indicated by black carbon, may be partly responsible for the observed associations between exposure to road traffic and adverse cardiovascular outcomes.

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Guest Editorial

Noise and Health

Wolfgang Babisch

Noise affects everybody in everyday life—at home, at leisure, during sleep, when traveling, and at work. However, human organisms are not prepared to shut off the noise. Hearing is a permanent process using cortical and subcortical structures to filter and interpret acoustical information; the analysis of acoustical signals is essential for human survival and communication. Noise is detrimental to health in several respects, for example, hearing impairment, sleep disturbance, cardiovascular effects, psychophysiologic effects, psychiatric symptoms, and fetal development (Stansfeld et al. 2000). Furthermore, noise has widespread psychosocial effects including noise annoyance, reduced performance, and increased aggressive behavior [American Academy of Pediatrics 1997; World Health Organization (WHO) 2001].

Noise causes acute mechanical damage to hair cells of the cochlea in the inner ear when the short-term sound intensity or peak impulse noise levels are very high {L_{AF} (A-weighted sound pressure level) > 120 dB; L_{Cpk} (C-weighted peak sound pressure level) > 135 A-weighted decibels [dB(A)]}. In the long run, average sound pressure levels (L_{Aeq}) of > 85 dB(A) are likely to cause significant hearing loss due to metabolic exhaustion [International Organization for Standardization (ISO) 1990]. This is not only relevant in occupational settings but also with respect to leisure activities, including firecrackers, toy pistols, and other noisy toys; loud music in discotheques, concerts, and when listening via headphones; and noisy machines and tools (Maassen et al. 2001). Particularly, children and adolescents are affected (Bistrup et al. 2001). The WHO and the U.S. Environmental Protection Agency consider a daily average sound exposure equivalent to L_{Aeq} = 70 dB(A) to be safe for the ear (WHO 2000). The large numbers of young people with hearing impairments should serve as a warning. "Noise hygiene" can be improved, particularly through education at school.

Even ear-safe sound levels can cause nonauditory health effects if they chronically interfere with recreational activities such as sleep and relaxation, if they disturb communication and speech intelligibility, or if they interfere with mental tasks that require a high degree of attention and concentration (Evans and Lepore 1993). The signal–noise ratio (in terms of signal processing) should be at least 10 dB(A) to ensure undisturbed communication. High levels of classroom noise have been shown to affect cognitive performance (Bistrup et al. 2001). Reading and memory have been reported to be impaired in schoolchildren who were exposed to high levels of aircraft noise (Hygge et al. 2002). Some studies have shown higher stress hormone levels and higher mean blood pressure readings in children exposed to high levels of community noise (Babisch 2000; Passchier-Vermeer 2000).

During sleep, electrophysiologic awakening reactions can be detected in an electroencephalogram for event-related maximum noise levels above L_{AF} = 40–45 dB(A) in the bedroom (e.g., aircraft overflights). Recent studies suggest even lower thresholds. The long-term somatic consequences of such arousals are still a matter of discussion and research (WHO Regional Office for Europe 2004). Sleep deprivation, however, is associated with an increased risk of accidents and injuries. Cardiovascular responses found during sleep were independent of sleep disturbance. A subject may sleep during relatively high noise levels but still show autonomic responses.

Among other nonauditory health end points, short-term changes in circulation (including blood pressure, heart rate, cardiac output, and vasoconstriction) as well as in levels of stress hormones (including epinephrine, norepinephrine, and corticosteroids) have been studied in experimental settings for many years (Babisch 2003; Berglund and Lindvall 1995). From this, the hypothesis emerged that persistent noise stress increases the risk of cardiovascular disorders including high blood pressure and ischemic heart disease. Classical biologic risk factors have been shown to be elevated in subjects who were exposed to high levels of traffic noise. Nowadays the biological plausibility of the association is established (Babisch 2002). Its rationale is the general stress concept:

- Sound/noise is a psychosocial stressor that activates the sympathetic and endocrine systems.
- Acute noise effects do not occur only at high sound levels in occupational settings, but also at relatively low environmental sound levels when, more importantly, certain activities such as concentration, relaxation, or sleep are disturbed.

The following questions need to be answered:

- Do these changes observed in the laboratory habituate, or do they persist under chronic noise exposure?
- If they habituate, what are the physiologic costs; if they persist, what are the long-term health effects?

There is no longer any need to prove the noise hypothesis as such. Decision making and risk management rely on quantitative risk assessment, but not all biologically notifiable effects are of clinical relevance. The results of epidemiologic noise studies suggest an increase in cardiovascular risk with increasing noise exposure (e.g., Babisch 2000). Unfortunately, most of the individual studies that have been carried out lack statistical power. Over the years the quality of studies has improved, and many potential confounding factors have been considered. Some expert groups have rated the evidence of an association as sufficient (overview by Babisch 2002; Passchier-Vermeer 2003). Transportation noise from road and air traffic is the predominant sound source in our communities; outdoor sound levels for day–evening–night (L_{den}) > 65–70 dB(A) were found to be associated with odds ratios of 1.2–1.8 in exposed subjects compared with unexposed subjects [< 55–60 dB(A)] (Babisch 2000). Because large parts of the population are exposed to such noise levels [European Environmental Agency (EEA) 2004], noise policy can have a significant impact on public health (Kempen et al. 2002; Neus and Boikat 2000). For noise levels below an L_{den} of 55 dB(A), no major annoyance reactions or adverse health effects are to be expected.

Studies use magnitude of effect, dose–response relationship, biological plausibility, and consistency of findings among studies as issues in epidemiologic reasoning. Environmental and health policy must determine acceptable noise standards that consider the whole spectrum from subjective well-being to somatic health. This means that limit values may vary depending on the severity of outcomes. Future noise research should focus on source-specific differences in risk characterization, combined effects, differences between objective (sound level) and subjective (annoyance) exposure on health, sensitive/vulnerable groups, sensitive periods of the day, coping styles, and other effect-modifying factors.

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Observation of Elevated Air Pollutant Concentrations in a Residential Neighborhood of Los Angeles California Using a Mobile Platform

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Abstract

We observed elevated air pollutant concentrations, especially of ultrafine particles (UFP), black carbon (BC) and NO, across the residential neighborhood of the Boyle Heights Community (BH) of Los Angeles, California. Using an electric vehicle mobile platform equipped with fast response instruments, real-time air pollutant concentrations were measured in BH in spring and summer of 2008. Pollutant concentrations varied significantly in the two seasons, on different days, and by time of day, with an overall average UFP concentration in the residential areas of ~33 000 cm^{-3}. The averaged UFP, BC, and NO concentrations measured on Soto St, a major surface street in BH, were 57 000 cm^{-3}, 5.1 $\mu g\ m^{-3}$, and 67 ppb, respectively. Concentrations of UFP across the residential areas in BH were nearly uniform spatially, in contrast to other areas in the greater metropolitan area of Los Angeles where UFP concentrations exhibit strong gradients downwind of roadways. We attribute this "UFP cloud" to high traffic volumes, including heavy duty diesel trucks on the freeways which surround and traverse BH, and substantial numbers of high-emitting vehicles (HEVs) on the surface streets traversing BH. Additionally, the high density of stop signs and lights and short block lengths, requiring frequent accelerations of vehicles, may contribute. The data also support a role for photochemical production of UFP in the afternoon. UFP concentration peaks (5 s average) of up to 9 million particles cm^{-3} were also observed immediately behind HEVs when they accelerated from stop lights in the BH neighborhood and areas immediately adjacent. Although encounters with HEV during mornings accounted for only about 6% and 17% of time spent monitoring residential areas and major surface streets, HEV

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contributed to about 28% and 53% of total ultrafine particles measured on the route, respectively. The observation of elevated pollutant number concentrations across the Boyle Heights community highlights how multiple factors combine to create high pollutant levels, and has important human exposure assessment implications, including the potential utility of our data as inputs to epidemiological studies.

Keywords

Vehicle emissions; Mobile Platform; Exposure Assessment; Ultrafine Particle; Freeway; New particle formation; Boyle Heights

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1. Introduction

Numerous urban air pollutants, including ultrafine particles (UFP), black carbon (BC), oxides of nitrogen (NOx), particle-bound polycyclic aromatic hydrocarbon (PB-PAH), carbon monoxide (CO), carbon dioxide (CO_2), and volatile organic compounds (VOC), are strongly associated with local combustion sources such as motor vehicle emissions. During the daytime, vehicle-related pollutant concentrations exhibit sharp gradients downwind of roadways, spiking at the roadways and then decaying to background levels at about 200–300 m downwind (Hitchins et al. 2000, Zhu et al. 2002). Recently, it has been shown that during pre-sunrise hours the impact distances from roadways are much longer, extending downwind more than 2000 m (Hu et al. 2009), during nocturnal temperature inversions and low wind speeds.

Pollutant concentration gradients surrounding local sources such as roadways are critically important in determining exposure at the individual level. Numerous epidemiological studies have linked close proximity to heavily traveled roadways with significantly increased adverse health effects, including both morbidity and mortality (e.g., Brunekreef et al. 1997; Knox and Gilman 1997; Pearson et al. 2000; Hoek et al. 2002; Lin et al. 2002; Gauderman et al. 2007; Kan et al. 2007; Sandstrom and Brunekreef 2007; Brauer et al. 2008; Hart et al. 2009). Vehicles equipped with fast-response monitoring instruments have recently been providing many insights into pollutant gradients and “hot spots” from a variety of sources (Bukowiecki et al. 2002; Kittelson et al. 2004j; Isakov et al. 2007; Baldauf et al. 2008; Fruin et al. 2008; Hu et al. 2009; Kozawa et al. 2009; Ning et al. 2010). While traveling at normal vehicle speeds and on fixed routes, mobile instrumented platforms can capture pollutant concentrations and gradients in proximity to local emission sources, and contrast these with background pollutant concentrations measured in adjacent residential areas (Kozawa et al. 2009).

The current study used a mobile platform (MP) to generate data on vehicle-related pollutant concentrations and gradients in Boyle Heights (BH), California, an area bounded by half a dozen freeways and traversed by several major surface streets with heavy traffic flows, including heavy-duty diesel trucks (HDDT) and high-emitting gasoline vehicles (HEGV). Concentrations of pollutants (primarily UFP, BC, NOx, PB-PAH, CO and CO_2) on roadways, near freeways, and in the residential areas were measured in BH in spring and summer of 2008 to characterize local pollutant sources and their impacts in an area containing and surrounded by an unusually dense occurrence of traffic-related sources.

2. Methods

2.1 Mobile Platform and Data Collection

A Toyota RAV4 sub-SUV electric vehicle free from self pollution served as the mobile platform. Table 1 lists of sampling instruments and equipment installed on the mobile platform. The time resolution for most instruments is between 5 to 20 seconds; the Aethalometer has one minute time resolution. The average speed of the mobile platform was about 6 m/s which determined the average spatial resolution of our measurement, e.g. an instrument having a 5s time resolution would have a spatial resolution of about 30 m. The instrument power supply and sampling manifold is similar to that described by Westerdahl et al. (2005). Calibration and flow checks were conducted on a bi-monthly and daily basis, respectively, as described in Hu et al. (2009) and Kozawa et al. (2009).

Measurement times and associated meteorological conditions are listed in Table 2. For each season, measurements were conducted 4–5 weekdays between Monday and Friday and each day had two measurement periods, one in the morning and one in the afternoon, of about 30–50 min duration. For each morning/afternoon run, the mobile platform was driven on a route developed for BH, starting at approximately the same time each day. In the spring, measurements were also collected on the BH route on a Saturday.

Real-time traffic flow on the freeway was obtained from the Freeway Performance Measurement System (PeMS) provided by the UC Berkeley Institute of Transportation.

2.2 Route

Figure 1 shows the Boyle Heights route. The community is located east of Downtown Los Angeles, separated by the Los Angeles River. The north, west, and south sides of the BH area are bounded by rail lines, and the east side abuts the community of City Terrace. BH occupies a relatively small area, 5 500 m by 3 500 m, but the community is surrounded or traversed by segments of five freeways, as well as six major surface streets and tens of minor surface streets, forming a dense roadway network. Houston et al. (2004) showed that although BH and other minority and high-poverty neighborhoods in Los Angeles have among the lowest vehicle ownership rates, they experience more than two times the level of traffic density compared to the rest of the southern California region. Based on the 2000 Census, the population in BH was about 87 000, with 36% under age 18, with about 22 000 housing units (Los Angeles Times database, Laalmanac.com). Land use is primarily residential, with about 5 000 residents per square kilometer, but also includes commercial shops and amenities.

The MP route was selected to collect representative air pollutant concentrations and concentration gradients near freeways, on major surface streets with higher traffic densities (such as Soto St and Cesar Chavez Blvd) and in the interiors of the residential neighborhoods in Boyle Heights.

2.3 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 PB-PAH concentrations measured by the PAS instrument, which had the fastest response time. NO, UFP, and BC were selected in the present study for detailed spatial analysis because of their large variation on and near roadways.

To account for the different pollutant sources and associated impacts, two microenvironments were investigated: (a) Residential area: measurements on minor surface streets at least 200 m down wind and 50 m upwind of freeways and major surface streets; and (b) On-road: measured on one of the six major surface streets, including E Cesar E Chavez Ave, N Soto St, E 4th St, N Lorena St, S Indiana St, and E Olympic Blvd.

3. Results

3.1 Traffic flows on the I-5 freeway

Daily total traffic volumes on the I-5 freeway bordering BH averaged 283 000 vehicles, varying within 4.3% from day-to-day on weekdays (Fig. 2). The weekend day (April, 5, 2008) had about 3.8% more traffic than the weekday average. Traffic flows were nearly constant from 06:00 to 13:00 at ~1300 vehicles per 5 min. They then decreased slowly to ~1100 vehicles per 5 min at 19:00, and dropped off more steeply after that.

High daily truck volumes were recorded on the section of I-5 freeway in the BH area, averaging 17 500 counts per day, accounting for about 6% of the daily total traffic counts (Figure 2(b)). Between 08:00–19:00, total truck volumes remained above 80 counts per 5 minutes, and two rush hour peaks above 100 per 5 min occurred in the morning and afternoon.

The diurnal patterns of speeds on the section of I-5 freeway in BH are shown in Figure 2(c). In general, vehicle speeds were above 40 MPH in both north and south directions during most of the day, except between 15:00–19:00 when speeds were significantly slower in the south lanes. During this period, speeds dropped to about 20 MPH for about two hours.

3.2. Meteorological conditions

Meteorological conditions, including atmospheric stability, temperature, wind speed and wind direction, play an important role in determining air pollutant concentrations and gradients in ambient air, especially in the vicinities of roadways (e.g., Calder, 1973, Zhu et. al. 2005, Kozawa et al. 2009, Hu et al. 2009). A wide variety of meteorological parameters are available from various data sources for the dates of our measurements, from national weather archives, local airports, the South Coast Air Quality Management District (SCAQMD), including the North Main site located 2 km from Boyle Heights. Data collected with the mobile platform when stopped (Table 2), and vertical structure data are provided here to give a brief qualitative description of prevailing meteorology on the measurement days.

Temperatures fell in narrow ranges for each period: 15–20 °C and 18–20 °C, during spring and summer mornings, respectively; spring and summer afternoons averaged in the 24–29 °C and 26–28 °C ranges, respectively. Relative humidities also varied little from day to day in each season (Table 2) and time period, with values somewhat higher in the mornings. Averaged wind speeds measured by the mobile platform were 0.8–1.6 m/s in the mornings and 1.2–3.2 m/s in the afternoons for both the spring and summer seasons. Figure 3 shows the wind roses and vector-averaged wind orientations for mornings and afternoons in the spring and summer seasons. Averaged wind directions measured by the MP were predominantly W/SW/NW during most of the measurement periods. Under these conditions, BH was downwind of the I-5 freeway.

Vertical temperature structure data collected by the SCAQMD at Los Angeles Airport (LAX), ~ 18 km southwest of the Boyle Heights, from 130 to ~850 m provides insights into day-to-day variations and comparability of mixing heights. The summer profiles indicate the typical poor mixing common in summer in the Los Angeles area. On July 16, the vertical profile was inverted at the lower edge of the measurements, indicating a mixing height of no more than 130 m. For all other summer dates, profiles exhibited a clear inversion base between 200–400 m (other dates) and were strongly sub-adiabatic below the inversion base, changing little over the course of the day. Spring days were much more variable from day-to-day, and within days, ranging from neutrally stable (April 3, 7) to sub adiabatic (March 27, April 5) to inverted (March 26, April 4).

3.3. Air pollutant concentrations observed in Boyle Heights

The overall average UFP concentrations (mornings and afternoons and both seasons combined) in the residential area and on the major streets in BH were 33 000 cm^{-3}, 57 000 cm^{-3}, respectively. The average levels in the BH residential areas were approximately double the average levels observed in residential areas in West Los Angeles made under similar meteorological conditions within 2 weeks of the Boyle Heights measurements (Winer et al., 2010). They also appear to be about 25% higher than the average of other adjacent and nearby residential neighborhoods, including University Park, Downtown and Southeast Los Angeles, observed on the same measurement days (Winer et al., 2010). Average concentrations of other pollutants such as BC and NO, were also elevated in the on-road, near-road, and residential microenvironments.

3.3.1 Real-time temporal and spatial distributions of pollutants in BH—Figure 4 shows representative time series of the UFP concentrations measured in the residential and on-road microenvironments (morning of July 16), together with “threshold” UFP levels, which are discussed below. The residential trace presents a fairly uniform background with scattered encounters with HEV. In contrast, the on-road data do not have a clear background due to continual encounters with HEV plumes in various states of dilution. Figure 5 shows time-series plots of UFP concentrations in BH for all measurement days for the residential areas and on the major streets. For the residential microenvironment (route segments that were at least 50 m upwind and 200 m downwind of freeways and major streets during the MP measurement), UPF concentrations fall mostly in a range between 20 000 and 30 000 cm^{-3} in the morning and 20 000 and 45 000 in the afternoon. UFP spikes due to HEV encounters were more frequent in the morning than in the afternoon, as the mobile platform appears to have encountered more high-emitting vehicles in the morning, possibly associated with a greater volume of high-emitting delivery or service vehicles in the morning. The UFP spikes, although brief, corresponded to UFP concentrations of up to 1.5×10^6 cm^{-3}, 30–50 times the residential area background levels and 15 –30 the on-road levels. Table 2 includes the coefficients of variance (COV) for the residential and on-road data, with and without the high emitters removed. This metric somewhat over-represents the variability in the residential areas because the average UFP concentration is smaller in the residential areas compared to on roadways; however it generally provides support for the interpretations, illustrated in both Figures 4 and 5, that the UFP concentrations are relatively uniform in the residential neighborhoods, and there is more influence of high emitting vehicles in the mornings.

3.3.2 Daily pollutant concentrations in BH—Figures 6–7 show the averages and ranges of UFP, BC, and NO in the residential areas and on the major surface streets in the morning and afternoon for all measurement days. By most metrics (with a few exceptions) spring mornings were the most variable, summer afternoons the least variable, with spring afternoons and summer mornings falling in between. Temperature structure and mixing heights were more variable in spring and winds speeds were generally higher in the afternoons, both factors that are consistent with the observed trends of the pollutant concentrations.

3.3.2.1 Residential Areas: NO and BC exhibited divergent diurnal trends from UFP, and in some respects from each other (Figure 6): NO and BC concentrations were more variable in the morning while UFP was more variable in the afternoon. Both NO and BC were higher in the mornings, while UFP concentrations were usually higher in the afternoon. NO was larger by a factor of 3.1 and BC by a factor of 1.8 in the morning compared to the afternoon for all data. The larger difference between morning and afternoon for NO vs. BC is likely due to more rapid photochemical conversion of NO to NO_2 in the afternoon, while BC is a relatively conservative pollutant. Elevated primary pollutant concentrations in the morning relative to the afternoons are commonly observed (e.g., Kozawa et al. 2009, Hu et al. 2009) in the SoCAB due to lower wind speeds in the morning vs afternoon, sometimes accompanied by lower mixing heights.

The overall average afternoon UFP concentrations were about 30% higher than morning, and the median UFP concentration was lower in the afternoon on only two of the measurement days. Higher UFP concentrations in the afternoon vs. morning are in sharp contrast to observations obtained with the mobile platform at the ports of the Los Angeles region (Kozawa et al. 2009) and in W. Los Angeles (Hu et al. 2009), both coastal areas with persistent low levels of photochemical oxidants on most days. Higher UFP concentrations in the afternoon vs. the morning have also been observed at a measurement station on the east side of I-110 in Downtown Los Angeles (Moore et al. 2007; Ning et al. 2007) and attributed to fresh particle nucleation in the afternoon (Moore et al. 2007; Ning et al. 2007). This observation is discussed further below.

3.3.2.2 On-road: Pollutant concentrations on the major streets in BH (Fig. 7) were highly elevated compared to residential areas. Average UFP, BC, and NO concentrations during mornings were 63 000 cm^{-3}, 7.0 $\mu g\ m^{-3}$, and 84 ppb, respectively, 1.6–2.0 times the residential area concentrations. During the afternoons, the average UFP, BC, and NO concentrations were 51 000 cm^{-3}, 3.6 $\mu g\ m^{-3}$, and 55 ppb, respectively, 1.5–2.3 times the residential area concentrations. In contrast to residential areas, UFP concentrations on major surface streets were mostly higher in the mornings than in the afternoons, a typical diurnal pattern expected based on lower AM wind speeds and somewhat higher traffic flows.

3.4 Contribution of photochemical formation of UFP

Photochemical particle formation offers a plausible explanation for our observation of higher UFP in the afternoons in BH residential areas compared to the mornings. Over the time scale of a few hours, BC and CO are both reasonably conserved markers of combustion, their concentrations controlled primarily by the competing effects of source emissions, atmospheric dilution, and some coagulation and deposition of smaller BC particles. UFP are emitted by the same sources, but have higher loss rates due primarily to rapid coagulation and in some cases, evaporation and evaporation-enhanced coagulation (Jacobson et al. 2005). Since each of the three effects should increase with the higher temperatures typical of the afternoons, their effect should, if anything, be to decrease relative levels of UFP compared to CO and BC in the afternoons relative to mornings. This is opposite of the observed trend, and consistent with photochemical production of freshly nucleated particles.

The fact that the trend goes in the opposite direction supports the notion of a large role for freshly nucleated particles from photochemical processing of upwind aerosol precursors (Zhang et al. 2005; Robinson et al. 2007; Moore et al. 2007; Ning et al. 2007). The PM ratios of UFP/BC, UFP/CO, and UFP/CO_2 are 1.9, 2.1, and 1.1 times what they are in the AM, respectively (Table 3). This indicates an extra source of UFP in the afternoons. CO_2 also increases in the afternoon, but is less straightforward to use as a reference pollutant because of its large background, which is somewhat variable and difficult to define in urban areas. Boyle Heights is about 24 km from the ocean, allowing for about 2–4 hours of photochemical processing from the time of initial emissions in the coastal areas upwind to arrive in BH in the afternoon, sufficient time for substantial oxidation of aerosol precursors.

4 Contribution of high emission vehicles

To estimate the contribution of UFP from HEV to the average UFP concentration, we attribute all UFP associated with each (5 s avg.) point above a set threshold (55 000 and 77 000 cm^{-3} for residential and on-streets, respectively—see Section 4.1 below) to the HEV. A more detailed description of the calculation is provided in the supplementary information. HEV includes high-emitting gasoline vehicles (HEGV; including cars and pickup trucks) and heavy-duty diesel trucks (HDDT; trash trucks, street sweepers, cement trucks and construction and other vehicles). High concentrations of UFP were also frequently observed associated with CNG buses. HEV can generate very high numbers of particles per kg fuel burned, especially during hard acceleration. Encounters with HEVs accelerating directly in front of the MP were characterized by isolated 5 second average UFP spikes over 10^5 cm^{-3} and even over 10^6 cm^{-3}. HEV accelerate frequently due to the short lengths of street blocks (most are 50–150m along the measurement route) in the area, and ubiquitous stop signs and stop lights, an urban design feature that may exacerbate pollutant concentrations and be an underlying factor leading to the relatively uniform spatial distribution of pollutant concentrations in the BH residential areas.

4.1 Fraction of UFPs in BH attributable to HEV

Over the past 20 years many studies have shown that a relatively small fraction of the light-duty motor vehicle fleet (typically 5–10%) have been responsible for a large fraction (as much as 50% or more) of the total fleet emissions of pollutants such as CO, VOC, and NOx (Lawson et al. 1990; Stephens and Cadle 1991; Stedman et. al 1995). To date, however, we are not aware of a similar demonstration for emissions of UFPs, although we emphasize our study did not directly measure tailpipe emissions of UFP.

To estimate the contribution of HEV, we chose 55 000 and 77 000 cm^{-3} as threshold UFP concentrations values in the residential area and surface street microenvironments of BH, respectively. Concentrations above this level assigned to high-emitting vehicles and were in almost all cases directly attributable to a visually observed vehicle likely to be an HEV.

Arguments can be made for various threshold values, and the estimated contribution to UFP from HEV is sensitive to the choice of threshold value. A simple approach such as the average particle number concentration plus one or two standard deviations yields a threshold value that will increase as the number of high emitters encountered increases. A more robust approach is to remove the high emitters first, and find the standard deviation of the resulting “background” (with HEVs removed). This approach is slightly sensitive to the (arbitrary) choice for the HEV cutoff. For the analysis here, we chose 80 000 cm^{-3} in the residential areas and 100 000 cm^{-3} on-road as the HEV cutoffs to remove HEV. The resulting average backgrounds plus two standard deviations of the background result in the threshold concentrations of 55 000 cm^{-3} and 77 000 cm^{-3} for the residential and on-road areas, respectively (Figs 4 and 5) we use here.

We emphasize that for the purposes of the following calculations we are employing an empirical definition of high-emitting vehicles. Concentrations observed by the MP will be highly dependent on plume capture and how close the MP was to an emitting vehicle. For a more formal definition of high-emitting vehicles see ARB (2006).

Elevated UFP concentrations are well known to be associated with 1) vehicle cold starts, 2) hard accelerations, 3) vehicles in need of repair, and 4) high-emitting vehicles under many or all modes of operation. Encounters with gasoline vehicles during cold start (generally the 1st minute after an engine is turned on) were limited during our MP measurements in BH. While undiluted exhaust of newer vehicles can have high UFP concentrations during hard accelerations, by the time exhaust has reached our samplers, it is generally diluted by a factor of 1000 or more (Zhang et al. 2004). Thus hard acceleration of clean vehicles also seems unlikely to have contributed significantly to our UFP observations. Indeed, we have observed hundreds of incidences in which we saw little or no change in UFP concentrations when new or newer gasoline vehicles accelerated rapidly directly in front of the MP.

4.2 Residential Areas

For the residential areas in the AM, UFP concentrations above the 55 000 cm^{-3} threshold were associated with HEV about 5% of the time, but contributed up to 28% of the ultrafine particles measured on the route in BH (Table 4). In the afternoons, UFP concentrations were above the 55 000 cm^{-3} threshold for a similar fraction of the time, about 5%, but contributed a much smaller fraction, about 13% of the total ultrafine particles (Table 4). The lower contributions of HEV to UFP counts in the afternoons may be due to the significant contribution of secondary aerosol formation in the afternoon, as noted above.

4.3 Surface Streets

On the major surface streets in the AM, UFP concentrations were above the 77 000 cm^{-3} threshold due to HEV encounters about 17% of the time, but contributed 53% of the ultrafine particles measured on our route. In the afternoon HEV encounters were much less frequent (10%), but the ratio of HEV encounters to total UFP above the threshold (27%) was almost identical. While new particle formation is sufficient to affect UFP concentrations in the neighborhoods, vehicles and especially HEVs appear control concentrations on roadways in BH.

5. Conclusion

Elevated pollutant concentrations were observed in the residential areas, and on the major surface streets in Boyle Heights, an area bounded by dense freeways and traversed by several heavily travelled surface streets during the spring and summer of 2008. The overall average concentrations of UFP, BC, and NO were about 33 000 cm^{-3}, 2.9 $\mu g\ m^{-3}$, and 35 ppb, respectively, in the residential areas. We attribute the elevated pollutant concentrations in the BH community to high traffic flows on surrounding freeways, the significant incidence of high emission vehicles in this low socioeconomic area, contributions of secondary aerosol formation in the afternoon, and possibly short block lengths and high density of stop signs and lights, requiring frequent accelerations of the vehicle fleet. Additionally, it appears that a relatively small fraction of the vehicles on major surface streets and in the residential areas in Boyle Heights may make a significant contribution to ultrafine particles in this community, suggesting that focusing emission control efforts on a relatively small number of high-emitting vehicles would yield disproportionate benefits for improving air quality in this community.

The pollutant concentrations we observed in BH may have important implications for human exposure for the residents of this area, including the potential utility of our data as inputs to epidemiological studies of UFP impacts on urban populations.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

- We monitored primary pollutants throughout in a low income Los Angeles neighborhood
- Multiple factors lead to elevated ultrafine particles in residential areas
- High traffic density, many high emitters and ubiquitous stop signs all contribute
- Photochemical production appears to elevate ultrafine particles in the afternoon

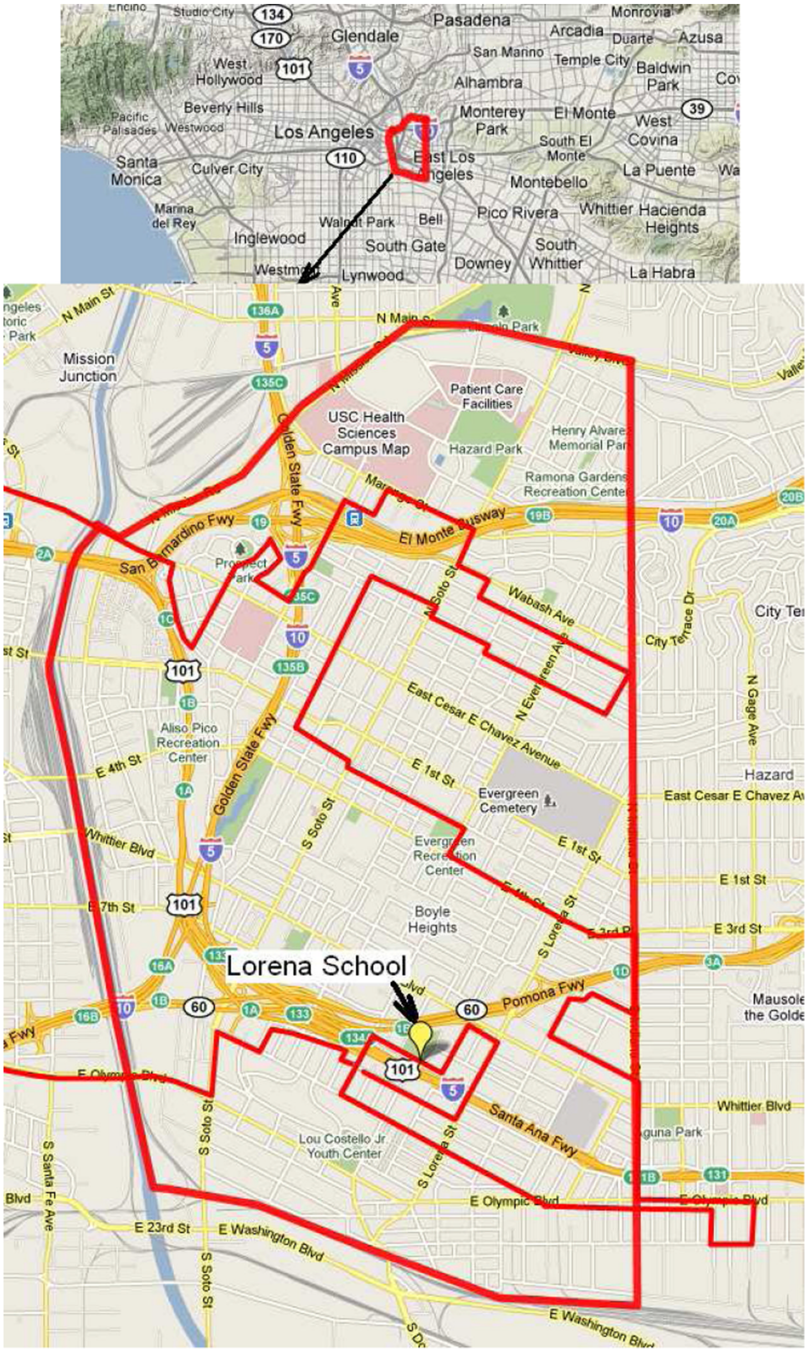


Figure 1.

Route for Boyle Heights. The thick line represents the boundary of the Boyle Heights community.

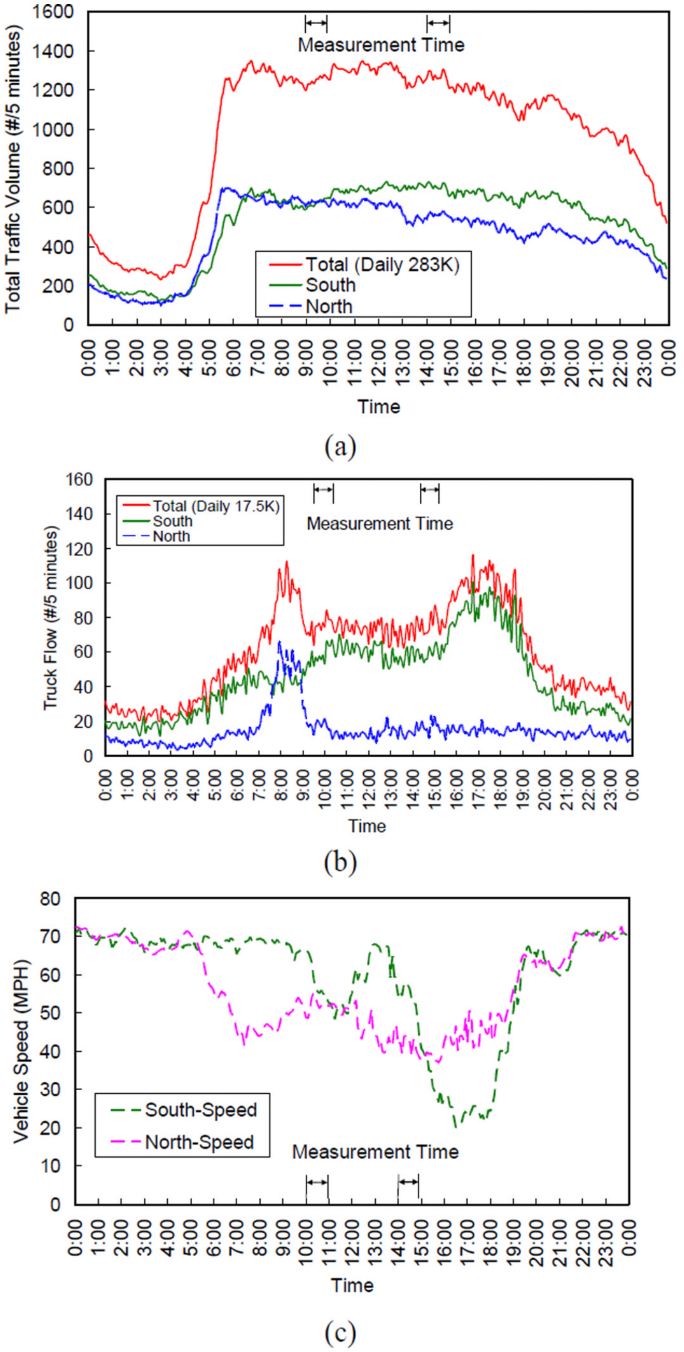


Figure 2.

Diurnal traffic patterns on the I-5 freeway in Boyle Heights. (a) Total traffic volumes; (b) Truck volumes; (c) Speed.

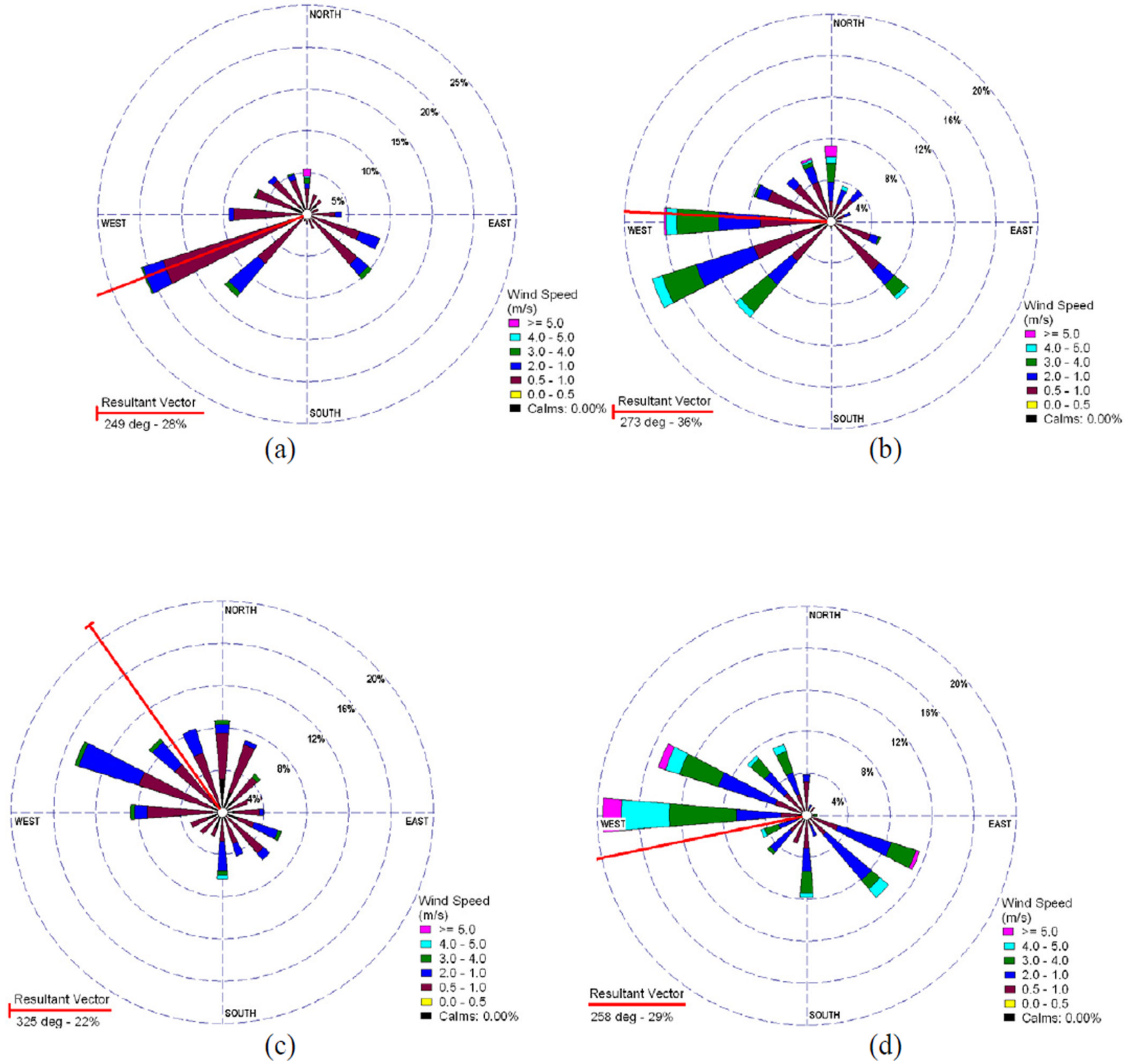
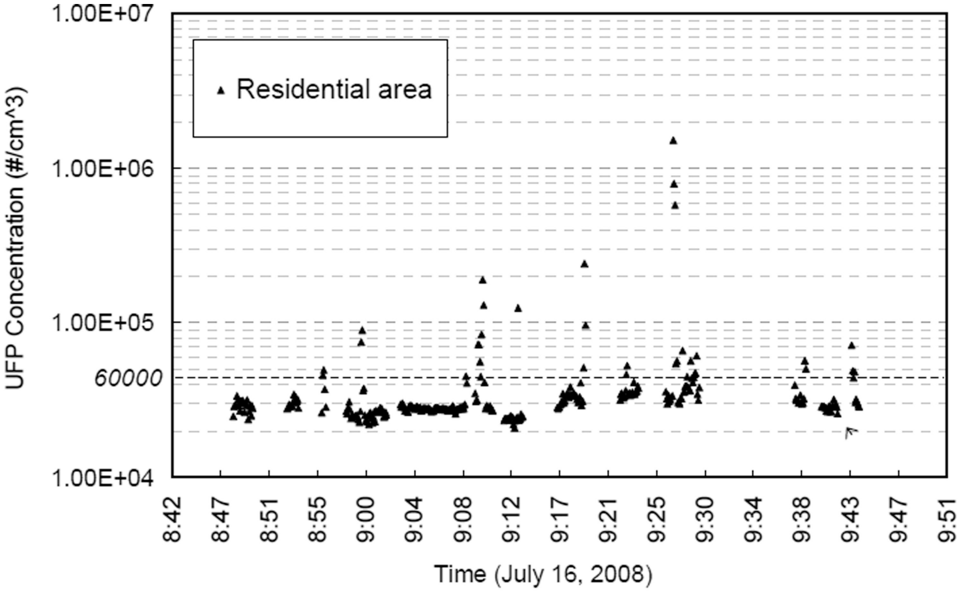
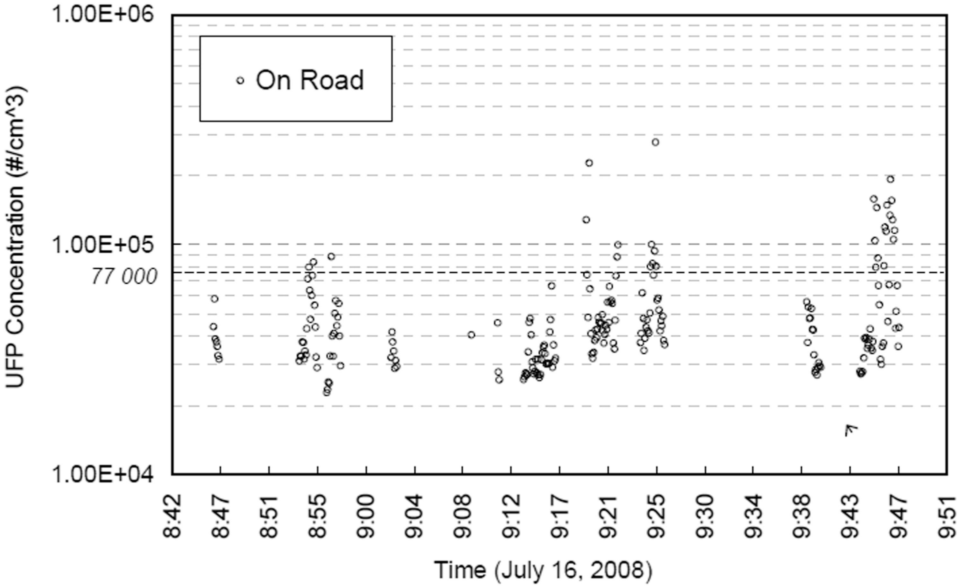


Figure 3.

Wind roses for the measurement times in BH. (a) Spring mornings; (b) Spring afternoons; (c) Summer mornings; (d) Summer afternoons;



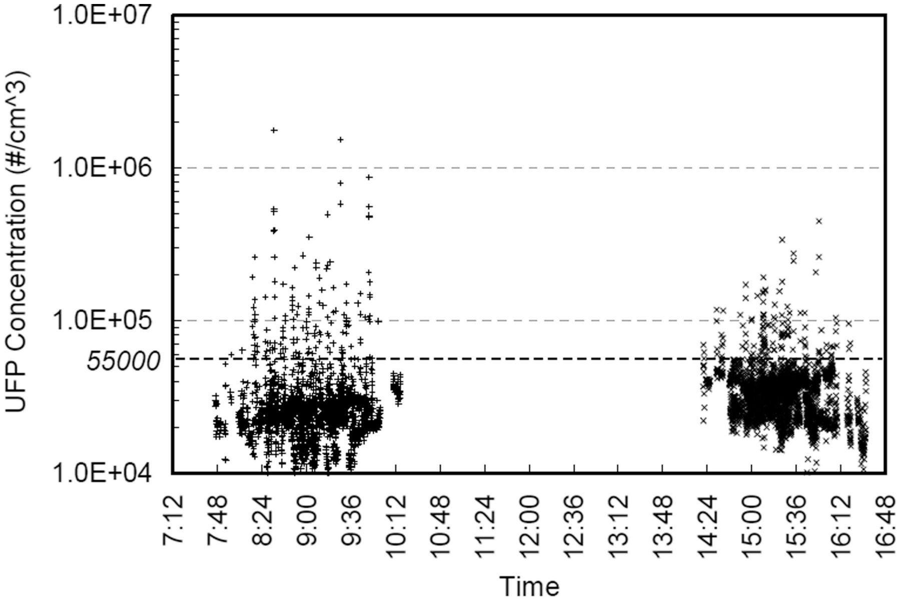
(a)



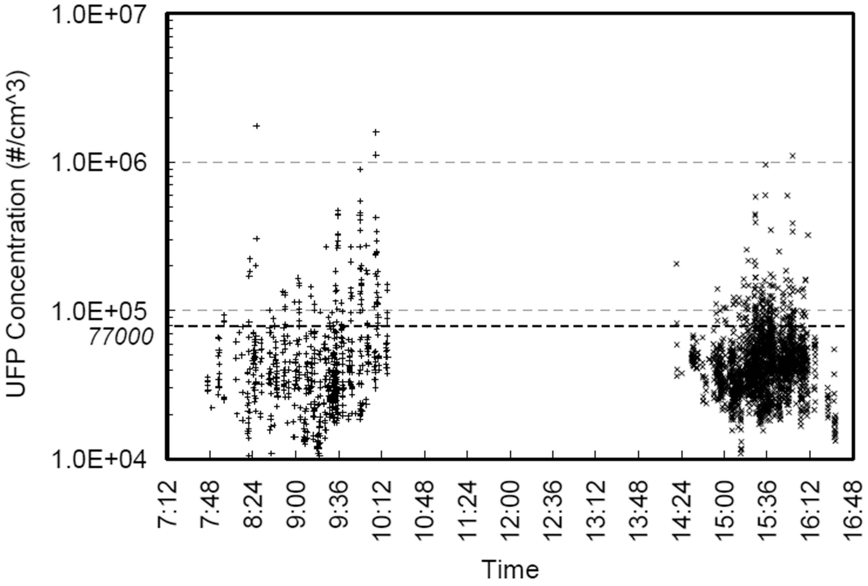
(b)

Figure 4.

Time series plot of UFP concentrations measured in BH on the morning of July 16, 2008. (a). Residential area; (b). On road. The dashed lines indicate HEV threshold concentrations, 55 000 cm^{-3} and 77 000 cm^{-3} in the residential area and on road, respectively (see discussion in Section 4.1.1).



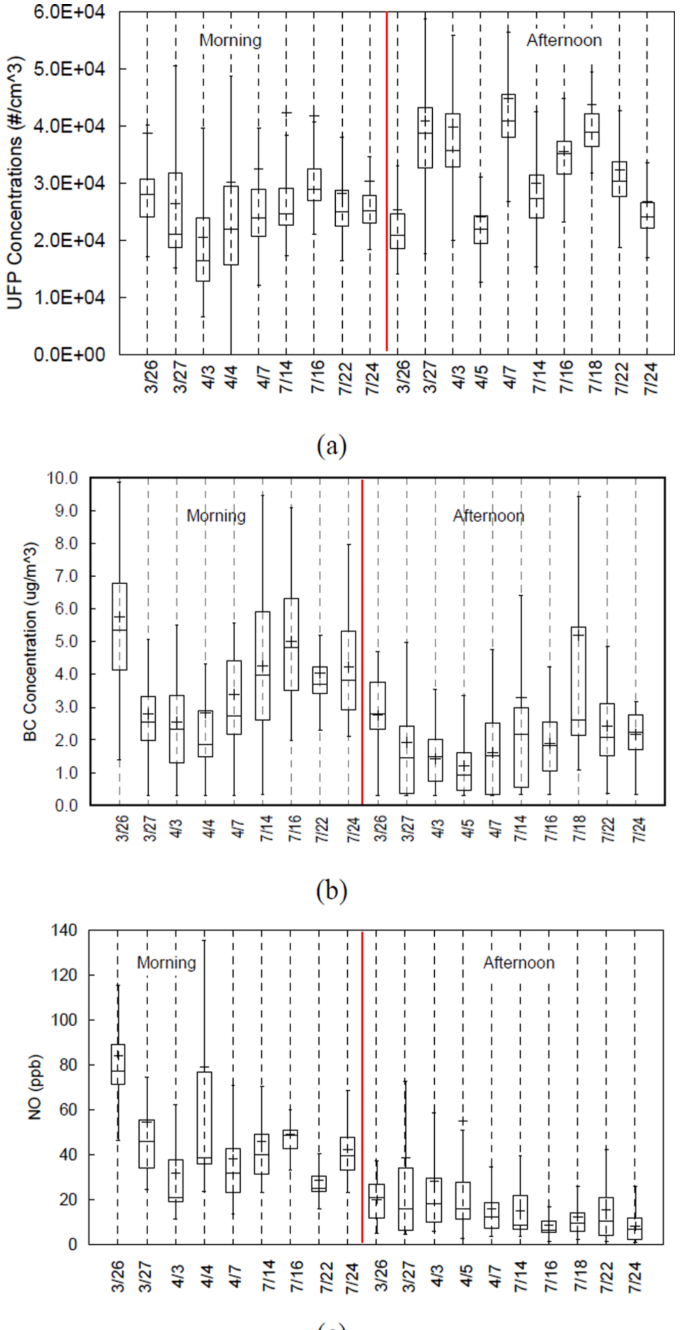
(a)



(b)

Figure 5.

Time series plot of UFP concentrations measured in BH on all the measurement days. (a) In the residential areas; (b) On surface streets.



(a)

(b)

(c)

Figure 6.

Daily average pollutant concentrations in the residential areas in BH. (a) UFP; (b) BC; (c) NO. The symbol + in the box means the average and line in the box indicates median.

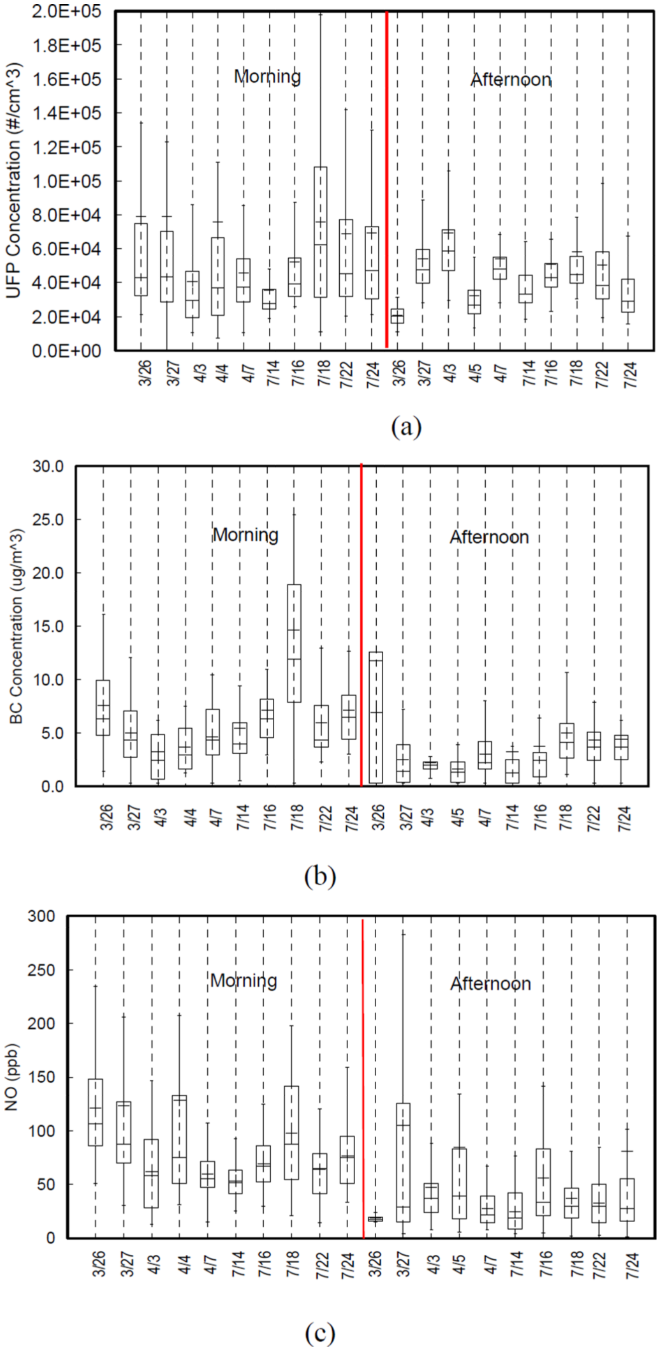


Figure 7.

Daily average pollutant concentrations on the major streets in BH. (a) UFP; (b) BC; (c) NO. The symbol + in the box means the average and line in the box indicates median.

Table 1

Monitoring instruments on the mobile platform.

Instrument	Measurement Parameter	Time Resolution
TSI Portable CPC, Model 3007	UFP Count (10 nm-1um)	*5 s*
TSI FMPS, Model 3091	UFP Size (5.6–560 nm)	*5 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*

Table 2

Measurement times and meteorological conditions (2008).

Date	Day	Relative Humidity[a](%)		Temperature[a] (°C)		Wind Speed[b] (m/s)		Wind Direction [b](degree)	
		AM	**PM**	**AM**	**PM**	**AM**	**PM**	**AM**	**PM**
March 26	Wednesday	*70*	*59*	*17.8*	*20*	*1.0*	*1.7*	*254*	*282*
March 27	Thursday	*54*	*41*	*19.7*	*20.2*	*0.9*	*1.7*	*264*	*262*
April 3	Thursday	*75*	*63*	*14.7*	*18.3*	*1.3*	*1.7*	*275*	*266*
April 4	Friday	*64*	-	*19.2*	-	*0.9*	-	*200*	-
April 5	Saturday	*65*	*63*	*16.4*	*17.7*	*1.6*	*1.2*	*116*	*119*
April 7	Monday	*59*	*56*	*18.3*	*18.3*	*0.9*	*1.7*	*98*	*354*
July 14	Monday	*54*	*41*	*27.1*	*28.3*	*1.2*	*3.2*	*300*	*287*
July 16	Wednesday	*51*	*52*	*28.6*	*28.1*	*1.2*	*1.9*	*340*	*143*
July 18	Friday	*68*	*61*	*24.4*	*26.7*	*1.6*	*2.0*	*142*	*265*
July 22	Tuesday	*59*	*55*	*25.6*	*27.5*	*0.8*	*1.9*	*293*	*308*
July 24	Thursday	*61*	*55*	*24.1*	*25.9*	*0.9*	*1.8*	*360*	*287*

[a] Data were obtained from a preliminary database provided by California Air Resources Board for the North Main Street air monitoring station about 2 km north of Boyle Heights.

[b] Data were obtained from the instruments on the mobile platform.

Table 3

Concentration ratios of UFP to other pollutant [a]

Ratio	UFP/BC	UFP/CO	UFP/CO2
AM Ratio [b]	*8 420*	*69 700*	*65*
PM Ratio [c]	*15 900*	*145 200*	*72*
PM Ratio/AM Ratio	*1.9*	*2.1*	*1.1*

[a] The units of UFP, BC, CO, and CO2 concentrations are count cm^{-3}, μg m^{-3}, ppm, and ppm, respectively.

[b] The average UFP, BC, CO, and CO2 concentrations in the mornings were 32 000 count cm^{-3}, 3.8 μg m^{-3}, 0.46 ppm, and 493 ppm, respectively.

[c] The average UFP, BC, CO, and CO2 concentrations in the afternoons were 35 000 count cm^{-3}, 2.2 μg m^{-3}, 0.24 ppm, and 485 ppm, respectively.

Table 4

Percentages of time and ultrafine particles from HEV in BH

	Morning	**Afternoon**	**Overall**
In residential neighborhoods:			
Coefficient of Variance (All Data)	*1.8*	*0.56*	*1.3*
Coefficient of Variance (HEV removed)	*0.33*	*0.28*	*0.31*
Percent of time HEV encountered	*6%*	*5%*	*5%*
Percent of total UFPs from HEV	*28%*	*13%*	*20%*
On major surface streets:			
Coefficient of Variance (All Data)	*1.8*	*0.99*	*1.4*
Coefficient of Variance (HEV removed)	*0.49*	*0.38*	*0.4*
Percent of time HEV encountered	*17%*	*10%*	*12%*
Percent of total UFPs from HEV	*53%*	*27%*	*35%*

Potential Role of Ultrafine Particles in Associations between Airborne Particle Mass and Cardiovascular Health

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Numerous epidemiologic time-series studies have shown generally consistent associations of cardiovascular hospital admissions and mortality with outdoor air pollution, particularly mass concentrations of particulate matter (PM) ≤ 2.5 or ≤ 10 µm in diameter ($PM_{2.5}$, PM_{10}). Panel studies with repeated measures have supported the time-series results showing associations between PM and risk of cardiac ischemia and arrhythmias, increased blood pressure, decreased heart rate variability, and increased circulating markers of inflammation and thrombosis. The causal components driving the PM associations remain to be identified. Epidemiologic data using pollutant gases and particle characteristics such as particle number concentration and elemental carbon have provided indirect evidence that products of fossil fuel combustion are important. Ultrafine particles < 0.1 µm (UFPs) dominate particle number concentrations and surface area and are therefore capable of carrying large concentrations of adsorbed or condensed toxic air pollutants. It is likely that redox-active components in UFPs from fossil fuel combustion reach cardiovascular target sites. High UFP exposures may lead to systemic inflammation through oxidative stress responses to reactive oxygen species and thereby promote the progression of atherosclerosis and precipitate acute cardiovascular responses ranging from increased blood pressure to myocardial infarction. The next steps in epidemiologic research are to identify more clearly the putative PM casual components and size fractions linked to their sources. To advance this, we discuss in a companion article (Sioutas C, Delfino RJ, Singh M. 2005. Environ Health Perspect 113:947–955) the need for and methods of UFP exposure assessment. ***Key words:*** **cardiovascular diseases, cytokines, diesel, epidemiology, oxidative stress, particle size, toxic air pollutants. *Environ Health Perspect* 113:934–946 (2005). doi:10.1289/ehp.7938 available via *http://dx.doi.org/* [Online 16 March 2005]**

Coronary heart disease (CHD) is the leading cause of death and hospitalization among adults 65 or more years of age (Desai et al. 1999), which makes the identification of preventable causes for heart disease morbidity and mortality an important research goal. Numerous epidemiologic time-series studies have shown generally consistent associations of outdoor (ambient) air pollution with cardiovascular hospital admissions (Burnett et al. 1995, 1997a, 1997b, 1999; D'Ippoliti et al. 2003; Le Tertre et al. 2002; Linn et al. 2000; Mann et al. 2002; Morris et al. 1995; Peters et al. 2001a; Poloniecki et al. 1997; Samet et al. 2000a; Schwartz 1999; Schwartz and Morris 1995; Zanobetti and Schwartz 2001; Zanobetti et al. 2000a, 2000b). Consistent associations of ambient air pollution have also been found with cardiovascular mortality (Clancy et al. 2002; Dockery et al. 1993; Goldberg et al. 2001a, 2001b; Hoek et al. 2001; Kwon et al. 2001; Laden et al. 2000; Pope et al. 2004a; Rossi et al. 1999; Samet et al. 2000b; Schwartz et al. 1996; Wichmann et al. 2000; Zanobetti et al. 2003). The National Research Council (NRC) Committee on Research Priorities for Airborne Particulate Matter has identified research needed to explain the morbidity and mortality associations in the time-series studies (NRC 1998, 1999, 2001, 2004). One priority is to identify the pathophysiologic mechanisms and causal pollutant components driving these associations (Seaton et al. 1995).

The causal components driving the relationship between particulate matter (PM) and cardiovascular morbidity and mortality remain to be identified. Historically, the difficulty in accomplishing this in epidemiologic studies is related to the common use of ambient air pollution data from monitoring stations located at central regional sites. This has led to both exposure misclassification and high correlations between different pollutants. Both of these problems can be addressed with measurements of personal and/or microenvironmental exposures (Sarnat et al. 2000, 2001). Another problem is that the importance of particle size and chemistry has been limited by reliance on the same government monitoring data. In the United States, these data generally include only particle mass concentrations in air at two particle size cuts, PM_{10} ($PM \leq 10$ µm in aerodynamic diameter) and more recently $PM_{2.5}$ ($PM \leq 2.5$ µm). However, there is sufficient reason to believe that ultrafine particles (UFPs; PM < 0.1 µm) are important in morbidity and mortality associations otherwise attributed to larger-size fractions.

Major characteristics of UFPs that support their potential importance include a high pulmonary deposition efficiency, magnitudes higher particle number concentration than larger particles, and thus a much higher surface area. The UFP's surface can carry large amounts of adsorbed or condensed toxic air pollutants (oxidant gases, organic compounds, transition metals) (Oberdörster 2001). Many of these toxic air pollutants have been identified as having pro-inflammatory effects in part through the action of reactive oxygen species (ROS), but relevant exposure data are rarely available to epidemiologists. Available surrogate measures of fossil fuel combustion such as elemental carbon (EC) or black smoke are of some use in this regard. Results from a study in southern California showed that a large proportion of urban UFPs is made up of primary combustion products from mobile source emissions (particularly diesel and automobile exhaust) and includes organic compounds, EC, and metals (Kim et al. 2002). Because exposure to mobile emissions can be variable across short distances and depends on personal activity patterns, assessing such exposures requires methods that go beyond the use of government monitoring data alone. These issues regarding the characteristics of UFPs are more thoroughly discussed in a companion article (Sioutas et al. 2005).

In the present review we discuss evidence for adverse effects of air pollution on cardiovascular health with an emphasis on findings that suggest a role for UFPs and related toxic air pollutant components. To date, there are fewer direct epidemiologic data on UFPs. We

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review studies using other particle size fractions, other particle measurements such as black smoke, and gas-phase pollutants to provide a rationale for investigations of UFPs. The focus of this article is on epidemiologic studies that have followed individual subjects over time. Several excellent reviews of experimental data and methods can be found elsewhere (Donaldson et al. 2001; Utell et al. 2002).

Evidence of Causal Pollutant Components in Epidemiologic Time-Series, Cohort, and Cross-Sectional Studies

The National Morbidity, Mortality, and Air Pollution Study (NMMAPS) is the largest of the air pollution time-series studies to date (Samet et al. 2000a, 2000b). Results show positive associations of PM_{10} with cardiopulmonary mortality and with hospital admissions for cardiovascular disease, chronic obstructive pulmonary disease (COPD), and pneumonia in patients 65 or more years of age living in varied environments across up to 90 cities in the United States. A subsequent analysis to correct for statistical errors showed an increase of 0.34% [95% confidence interval (95% CI), 0.1–0.57] in combined cardiorespiratory mortality for each 10 μg/m^3 of air increase in PM_{10} (Dominici et al. 2003). Another reanalysis of hospitalizations in 14 U.S. cities by Janssen et al. (2002) broke down the PM_{10} concentrations using information on source categories. The authors found that for cardiovascular admissions, and to a lesser extent COPD admissions, PM_{10} from highway vehicle and diesel emissions and from oil combustion showed the strongest associations with the most stable regression coefficients in co-regressions with other source categories. These findings are supported by an analysis of PM data collected for the Harvard Six Cities Study (Dockery et al. 1993) by Laden et al. (2000) using elemental profiles of $PM_{2.5}$ samples. They showed that associations between daily total mortality and mobile source (largely traffic related) particles for the six metropolitan areas were twice those for sulfate-rich coal combustion particles. This difference was most clearly demonstrated for deaths from CHD.

Additional information regarding causal pollutant components has come from analyses of ambient gaseous air pollutants under U.S. federal regulation [carbon monoxide, nitrogen dioxide, sulfur dioxide, and ozone]. These pollutants can be strongly correlated with PM in ambient air. A European study by Katsouyanni et al. (2001) of 29 cities showed a positive association between total mortality and PM_{10} and that this association was not confounded by SO_2 or O_3. However, they did find that in cities with higher versus lower average NO_2, the association with PM_{10} was significantly greater (0.80% vs. 0.19% increase in mortality per 10 μg/m^3 PM_{10}, respectively). The NMMAPS study found that PM_{10} associations with mortality were largely independent of NO_2, SO_2, and O_3 (Samet et al. 2000a). Goldberg et al. (2001a, 2001b), Moolgavkar (2000), and Venners et al. (2003) have also found robust associations between cardiovascular mortality and pollutant gases that often were stronger than particle associations. In a time-series study of the Los Angeles air basin, Linn et al. (2000) found that significant associations of daily cardiovascular hospital admissions were strongest for CO, followed by NO_2, and then much weaker associations for PM_{10}, but daily PM data were limited by fewer stations. Morris et al. (1995) and Morris and Naumova (1998) found that hospital admissions for congestive heart failure (CHF) were associated with CO independent of other gaseous pollutants in several large U.S. cities. Mann et al. (2002) also found significant associations of daily CHD hospital admissions with NO_2 and CO in Los Angeles, particularly among cases with a secondary diagnosis of CHF or arrhythmia. Lin et al. (2003) found that an interquartile range increase in CO was associated with an increase of 6.4% in daily angina and acute myocardial infarction (MI) emergency department visits in São Paulo, Brazil. A time-series study of seven European areas found cardiovascular hospital admissions, especially CHD, were associated with SO_2 (Sunyer et al. 2003). Associations between gases and hospital admissions for CHD and CHF have been found in several other studies (e.g., Burnett et al. 1997b, 1999; Koken et al. 2003; Morris et al. 1995, 1998).

Some of the time-series investigators have hypothesized that pollutant gases could be acting as indicators for a causal mixture of pollutants, including PM-related components. Ambient CO is highly correlated with UFPs near combustion sources such as freeways (discussed more fully below). Although it is possible that some of the effects detected with CO are due to the formation of carboxyhemoglobin in the blood and carboxymyoglobin in muscle, reported ambient concentrations are low (< 6 ppm). A postulated mechanism for increased susceptibility to low CO doses is the attainment of a nominal threshold of reduced O_2 transport to the heart and further compromised cardiac myoglobin, particularly in CHF patients (McGrath 2000).

Additional evidence of causal components linked to UFPs comes from European studies that have used a nongravimetric PM measure called black smoke, which is roughly representative of EC. Le Tertre et al. (2002) conducted a time-series analysis of cardiovascular hospital admissions in eight European cities and found that CHD admissions were associated with PM_{10} and black smoke. The association with PM_{10}, but not with black smoke, was reduced by adding CO to the model and eliminated by adding NO_2. Both Le Tertre et al. (2002) and the European study by Katsouyanni et al. (2001) reported above hypothesized that their results were attributable to traffic exhaust and its consequent high emissions of CO, NO_2, black smoke, and air toxics. It is relevant to point out that traffic exhaust, particularly from diesel engines, is a major contributor to UFP mass in urban areas (Kittelson 1998; Tobias et al. 2001), and in general, UFPs are both strongly linked to mobile source emissions and laden with toxic constituents (Kim et al. 2002; Shi et al. 2001).

Although time-series investigations have provided important information regarding the overall public health impact of ambient air pollutants on severe outcomes such as mortality, studies of individual subjects have provided insights into the underlying acute or chronic exposure–response relationships. Below we review studies of individuals using various epidemiologic designs, including cohort and panel studies, focusing only on findings for cardiovascular outcomes. Details for selected studies are presented in Table 1 and follow the discussion in the text.

Time-series studies have provided evidence for acute effects of air pollutants on cardiovascular morbidity and mortality. However, there are still gaps in the literature regarding chronic health impacts from long-term pollutant exposures. Cohort studies are best suited to address this gap. Dockery et al. (1993) reported evidence from the Harvard Six Cities Study that ambient $PM_{2.5}$ was associated with risk of cardiopulmonary mortality in a cohort of 8,111 adults (Table 1). Pope et al. (2004a) used 16 years of data from more than 500,000 adults in 151 U.S. cities that participated in the Cancer Prevention Study II of the American Cancer Society. The authors found that a 10-μg/m^3 elevation in $PM_{2.5}$ was associated with 8–18% increases in mortality due to ischemic heart disease, dysrhythmias, heart failure, and cardiac arrest. Mortality from various respiratory causes was not associated with $PM_{2.5}$ (Table 1). In contrast, a cohort study of 6,338 Seventh Day Adventists living in California found associations of long-term exposure to PM and O_3 with respiratory mortality but not with cardiovascular mortality (Abbey et al. 1999) (Table 1). Differences in findings might be due to exposure misclassification from the use of central regional air pollutant data. Hoek et al. (2002) tried to address this issue by evaluating effects of traffic exposures near the home in a cohort study of 5,000 adults followed 8 years in the Netherlands (Table 1). They showed that living near a major road was more strongly associated with cardiopulmonary mortality than

Table 1. Cardiovascular effects[a] associated with personal and ambient air pollution exposure: selected studies.

Studies	Design and population	Outcomes	Findings for PM mass and components	Findings for gases
Cohort and cross-sectional studies				
Dockery et al. 1993	Cohort study examining ambient air pollution exposure and mortality in 8,111 adults in six U.S. cities with 14–16 years of follow-up	Cardiopulmonary mortality	Compared with the least polluted city, the most polluted city had an adjusted RR for cardiopulmonary mortality of 1.37 (95% CI, 1.11–1.68)	No association with O_3, but SO_2 and NO_2 tracked between-city trends in PM concentrations
Pope et al. 2004a	Cohort study examining ambient PM exposure and cardiovascular mortality in 319,000–500,000 persons in the Cancer Prevention Study II, with 16 years of follow-up across U.S. urban areas	Cardiovascular mortality: ischemic heart disease, dysrhythmias, heart failure, and cardiac arrest	A 10-µg/m^3 increase in $PM_{2.5}$ was associated with 8–18% increases in mortality due to ischemic heart disease, dysrhythmias, heart failure, and cardiac arrest	Not assessed
Abbey et al. 1999	Cohort study examining ambient PM_{10} exposure, total suspended sulfates, SO_2, O_3, and NO_2 in relation to mortality in 6,338 non-smoking California Seventh-Day Adventists with 19 years of follow-up	Cardiopulmonary mortality	No associations	No associations
Hoek et al. 2002	Cohort study examining ambient traffic-related air pollutant exposure (black smoke, NO_2) and cause-specific mortality in 5,000 persons with 8 years of follow-up in the Netherlands Cohort Study on Diet and Cancer	Cardiopulmonary mortality	Cardiopulmonary mortality was associated with living near high traffic density (100 m to freeway or 50 m to major urban road) adjusted RR = 1.95 (95% CI, 1.09–3.52) and was associated with an increase of 10 µg/m^3 black smoke from background (central sites) plus local sources (street proximity), RR = 1.71 (95% CI, 1.10–2.67)	Cardiopulmonary mortality was associated with an increase of 30 µg/m^3 background plus local NO_2, RR 1.81 (95% CI, 0.98–3.34)
Künzli et al. 2004	Cross-sectional study on the relationship between ambient $PM_{2.5}$ and CIMT, using baseline data from two clinical trials in Los Angeles; annual mean $PM_{2.5}$ exposure was estimated using data from 23 monitoring stations linked to home addresses with geostatistical models	CIMT	For each increase of annual mean 10 µg/m^3 $PM_{2.5}$, CIMT increased by 5.9% (95% CI, 1–11%); adjustment for age reduced the coefficients, but further adjustment for covariates indicated robust estimates in the range of 3.9–4.3%	Estimates for O_3 linked to ZIP code centroids were positive in relation to CIMT but not significant and smaller than $PM_{2.5}$
Cardiac ischemia and related outcomes				
Pekkanen et al. 2002	Panel study examining ambient PM, NO_2, and CO exposure and ischemia during 342 submaximal exercise tests in 45 subjects with CHD in Helsinki, Finland	ECG ST segment depression > 0.1 mV	Increased risk for ST depression (72 events) was associated with a change of lag-2 1,000 particles/cm^3 $NC_{0.1–1}$, OR = 3.29 (95% CI, 1.57–6.92), 10 µg/m^3 $PM_{2.5}$, OR = 2.84 (95% CI, 1.42–5.66), and 10,000 UFP/cm^3 $NC_{0.01–0.1}$, OR = 3.14 (95% CI, 1.56–6.32); UFPs were independent of $PM_{2.5}$	NO_2 and CO were also associated with an increased risk for ST depression.
de Hartog et al. 2003	Panel study examining ambient exposure to PM and NO_2, SO_2, and CO in relation to HRV and BP in 131 subjects with CHD in Helsinki, Finland; Amsterdam, the Netherlands; and Erfurt, Germany	Cardiorespiratory symptoms: chest pain, shortness of breath,avoidance of activities	A 10-µg/m^3 increase in $PM_{2.5}$ associated with shortness of breath, OR = 1.12 (95% CI, 1.02–1.24) and avoidance of activities, OR = 1.10 (95% CI, 1.01–1.19)	Not assessed
Peters et al. 2004	Case-crossover study examining ambient traffic-related air pollution exposure and MI in 691 subjects from the Augsburg Myocardial Infarction Registry who had survived 24 hr postinfarct; time–activity diary data on activities during the 4 days before symptom onset were used to assess traffic exposures	MI	Exposure to traffic was associated with onset of MI 1 hr afterward, OR = 2.92 (95% CI, 2.22–3.83); a significant association was also seen for exposure to traffic 2 hr before onset, and there was evidence for effects up to 6 hr; key exposures influencing overall associations with traffic included times spent in cars and in public transportation; associations changed minimally, adjusting for exercise, and there was no confounding by reports of extreme anger or joy	As with PM, gases were not directly assessed, but traffic exposures involve pollutant gases as well as particles

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Table 1. Continued

Studies	Design and population	Outcomes	Findings for PM mass and components	Findings for gases
Blood pressure (BP)				
Linn et al. 1999	Panel study in Los Angeles, California, examining BP and lung function in 30 subjects with COPD, with only 4 consecutive days of air sampling: personal exposure to $PM_{2.5}$, indoor and outdoor home $PM_{2.5}$ and PM_{10}, and ambient PM_{10}, O_3, NO_2, and CO	BP	Systolic BP increased 0.172 mm Hg for every 1-µg/m^3 increase in ambient lag-1 PM_{10} ($p = 0.006$); diastolic BP increased 0.095 mm Hg for every 1-µg/m^3 increase in PM_{10} ($p = 0.03$); outdoor home PM_{10} was similarly associated with BP, but no significant associations were reported for $PM_{2.5}$ or any indoor or personal PM measurement	No association of BP with exposure to central site O_3, NO_2, or CO
Brauer et al. 2001	Panel study examining personal exposure over 7 nonconsecutive days to $PM_{2.5}$ and sulfate, and ambient exposure to $PM_{2.5}$, PM_{10} , sulfate, and gaseous pollutants, in relation to BP, HRV, and lung function in 16 COPD patients in Vancouver, Canada	BP, HRV, SVE	Weak associations were observed between particle concentrations and increased SVE and with decreased systolic BP; ambient PM_{10} had the largest effect on cardiovascular end points and the only statistically significant association (SVE); use of personal exposure measurements did not show a larger or more consistent effect	CO was inversely associated with systolic BP and reduced estimates for ambient PM
Ibald-Mulli et al. 2001	Retrospective analysis examining the relationship between ambient air pollution exposure (TSP, SO_2, and CO) and BP in 2,607 men and women 25–64 years of age from a general population survey in Augsburg, Germany	Systolic BP	A 90-µg/m^3 increase in TSP was associated with an increase in systolic BP of 1.79 mm Hg (95% CI, 0.63–2.95); in subgroups with high plasma viscosity levels or increased HR, systolic BP increased by 6.93 mm Hg (95% CI, 4.31–9.75) and 7.76 mm Hg (95% CI, 5.70–9.82) in association with TSP, respectively	An 80-µg/m^3 increase in SO_2 was associated with an increase in systolic BP of 0.74 mm Hg (95% CI, 0.08–1.40)
Ibald-Mulli et al. 2004	Panel study examining ambient exposure to PM and NO_2, SO_2, and CO in relation to HRV and BP in 131 subjects with CHD in Helsinki, Finland; Amsterdam, the Netherlands and Erfurt, Germany	BP and HR	A small decrease in systolic BP (–0.72 mm Hg; 95% CI, –1.92 to 0.49) and diastolic BP (–0.70 mm Hg; 95% CI, –0.02 to –1.38) was found to be associated with a 5-day average increase of 10,000 UFPs/cm^3 ($NC_{0.01–0.1}$); slightly stronger and more significant associations were found for accumulation mode particle number concentration ($NC_{0.1–1.0}$), but smaller associations were found for a 10 µg/m^3 increase in $PM_{2.5}$ mass; small decreases in HR were also found for PM exposures	The magnitude and significance of inverse BP associations with CO were similar to those of $PM_{0.1–1.0}$; a small decrease in HR (–0.40 beats/min; 95% CI, –0.82 to 0.01) was found for an increase of lag-1, 5 µg/m^3 SO_2
Zanobetti et al. 2004	Panel study examining ambient $PM_{2.5}$, O_3, NO_2, SO_2, and CO in relation to BP among 62 patients with preexisting heart disease using data from 631 repeated visits for cardiac rehabilitation in Boston	BP	Increasing from the 10th to the 90th percentile in 5-day mean $PM_{2.5}$ (10.5 µg/m^3) resulted in increases of 2.8 mm Hg (95% CI, 0.1–5.5) in systolic, 2.7 mm Hg (95% CI, 1.2–4.3) in diastolic, and 2.7 mm Hg (95% CI, 1.0–4.5) in mean arterial BP; black carbon was associated with diastolic BP	Diastolic BO was associated with 120-hr average SO_2 (3.9% increase; 95% CI, 0.3–76), O_3 (2.7% increase; 95% CI, 0.02–5.4)
Autonomic control of cardiac rhythm				
Holguin et al. 2003	Panel study in Mexico City examining indoor and outdoor nursing home measurements of $PM_{2.5}$ and ambient exposure to O_3, NO_2, CO, and SO_2 in relation to HRV in 34 elderly residents followed every other day for 3 months; personal $PM_{2.5}$ was predicted using indoor and outdoor home $PM_{2.5}$ plus time–activity data	HRV, frequency domain	A 10-µg/m^3 increase in predicted personal $PM_{2.5}$ was associated with a 5.0% decrease in high-frequency HRV ($\beta = –0.049$; 95% CI, –0.090 to –0.007); associations with indoor $PM_{2.5}$ were stronger than outdoor home $PM_{2.5}$; among 13 subjects with hypertension, the association with predicted personal $PM_{2.5}$ was stronger (–7.1%)	O_3 was inversely associated with high- and low-frequency HRV among 13 subjects with hypertension (2% decrease per 10 ppb O_3), but this association was confounded by $PM_{2.5}$
Pope et al. 2004b	Panel study of ambient exposure to PM and HRV and blood markers in 88 elderly subjects living in Salt Lake City and Provo/Orem, Utah	HRV	A 100-µg/m^3 increase in $PM_{2.5}$ was associated with a 35 (SE = 8) msec decrease in SDNN and a 42 (SE = 11) msec decrease in r-MSSD	Not assessed

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Table 1. Continued

Studies	Design and population	Outcomes	Findings for PM mass and components	Findings for gases
Autonomic control of cardiac rhythm				
Magari et al. 2001, 2002a, 2002b	Panel study examining personal exposure to PM in relation to HRV in 20 (Magari et al. 2002a), 40 (Magari et al. 2001), and 39 (Magari et al. 2002b) healthy boilermakers exposed to welding fumes and residual oil fly ash	HRV	Each 100-µg/m^3 increase in 3-hr average PM$_{2.5}$ (laser photometer light scatter) was associated with a 1.4% (95% CI, –2.1 to –0.6%) decrease in 5-min SDNN in the 20 subjects (Magari et al. 2002a); in the 40 subjects, each 1-mg/m^3 increase in 4-hr average PM$_{2.5}$ was associated with a 2.66% (95% CI, –3.75 to –1.58%) decrease in 5-min SDNN SDNN (Magari et al. 2001); however, in 39 of these 40 subjects, PM$_{2.5}$ metals on filters, lead and vanadium, were associated with an increase in workday average of the 5-min SDNN (Magari et al. 2002b)	Not assessed
Riediker et al. 2004	Panel study of in-vehicle exposure to PM and HRV and blood markers of inflammation in 9 healthy male North Carolina Highway Patrol troopers	HRV	In-vehicle 10-µg/m^3 PM$_{2.5}$ increase was associated with increased ectopic beats throughout exposure (20%, $p = 0.005$); PM$_{2.5}$ was positively associated with heart beat cycle length (6%, $p = 0.01$) as well as HF HRV and SDNN the next morning after exposure	NO$_2$ and CO were not significant
Chan et al. 2004	Panel study in Taipei,Taiwan, examining personal exposure to submicrometer particles and HRV over one 16-hr daytime period in 9 young healthy adults 19–29 years of age (2 females) and 10 older male subjects 42–97 years of age with lung function impairments (FEV$_1$/FVC < 85%)	HRV	Personal exposure to NC$_{0.02–1}$ was associated with decreased in both time-domain and frequency-domain HRV indices; in young subjects, a 10,000 particles/cm^3 increase in the last 1–4 hr average NC$_{0.02–1}$ was associated with 0.68–1.35% decrease in SDNN, 1.85–2.58% decrease in r-MSSD; in the older panel they found 10,000-particles/cm^3 increase in the last 1- to 3-hr average NC$_{0.02–1}$ was associated 1.72–3.00% decreases in SDNN and 2.72–4.65% decreases in r-MSSD; there were similar associations for high- and low-frequency domain indices	Not assessed
Tarkiainen et al. 2003	Panel study in Kuopio, Finland, examining personal exposure to carbon monoxide and HRV in 6 subjects with CHD followed for three separate 24-hr ambulatory monitoring periods	HRV	Not assessed	r-MSSD increased by 2.4 msec ($p = 0.03$) with exposure to CO (> 2.7 ppm)
Peters et al. 2000	Panel study of arrhythmias in 100 subjects in eastern Massachusetts with implanted defibrillators (63,628 person-days of follow-up) with ambient measurements of PM mass, black carbon, NO$_2$, CO, O$_3$, and SO$_2$	Defibrillator discharge interventions for ventricular tachycardias or fibrillation (33 subjects with at least one)	Only 6 subjects with ≥ 10 defibrillator discharges had increased arrhythmias associated with black carbon and PM$_{2.5}$, which showed a weaker association; both PM metrics were confounded by NO$_2$, but the effect estimate of NO$_2$ was unchanged	26-ppb increase in NO$_2$ lagged 1 day was associated with increased defibrillator interventions in the full panel (OR = 1.8; 95% CI, 1.1–2.9). Subjects with ≥ 10 defibrillator discharges had increased arrhythmias associated with CO and NO$_2$ across several lags
Systemic inflammation and thrombosis				
Seaton et al. 1999	Panel study examining 3-day personal exposure estimated (from a one 24-hr personal exposure measurement) and city center ambient exposure to PM$_{10}$ in relation to hematologic factors in 112 elderly subjects in Belfast and Edinburgh, UK	Hematologic factors: hemoglobin, packed red cells, red blood cell count, platelets, white blood cell count, CRP, fibrinogen, factor VII, IL-6	An increase of 100 µ/m^3 in personal PM$_{10}$ and ambient PM$_{10}$ exposure resulted in significant decreased mean percentage changes of ≤ 1% in hemoglobin concentration, packed cell volume, and red blood cell count; only personal PM$_{10}$ was associated with an 11% decrease in platelets and a 7% decrease in factor VII; CRP increased with ambient PM$_{10}$ (+147%; 95% CI, 20–477), but not with personal PM ($p = 0.73$); fibrinogen decreased with ambient PM$_{10}$ (–9%; 95% CI, –19 to 0)	Not assessed

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with ambient background air pollutant levels. This finding suggests that pollutants more closely associated with traffic, which include UFPs and associated toxic air pollutants, could be causal components in the mortality associations.

Künzli et al. (2004) conducted a cross-sectional study of 798 healthy adults with elevated low density lipoprotein (LDL) cholesterol or homocysteine living on Los Angeles (Table 1). Subjects were in a dietary supplement clinical trial with ultrasound data on carotid intima-media thickness (CIMT) as an estimate of atherosclerosis. Exposure included an estimate using geostatistical models to link subject address to annual mean $PM_{2.5}$ from 23 local air-monitoring stations. They found positive associations between CIMT and $PM_{2.5}$, adjusting for host risk factors. Associations were larger for women, older subjects (≥ 60), subjects on lipid-lowering medications, and never smokers.

Evidence for Pathophysiologic Mechanisms and Causal Components in PM-Related Cardiovascular Effects

The following section looks at epidemiologic panel studies designed to evaluate the relationship between repeated air pollutant exposures and cardiovascular outcomes in individual subjects. We augment this discussion with a few selected human clinical studies that extend the panel study findings using controlled exposures, particularly those that aim to replicate ambient air mixtures. The discussion is divided by related groups of cardiovascular outcomes.

Cardiac ischemia and related outcomes. One published study has examined evidence for the relationship of particulate air pollutant exposure to cardiac ischemia in humans. An epidemiologic study of 45 adults with stable CHD conducted by Pekkanen et al. (2002) analyzed data from repeated biweekly in-clinic electrocardiographic (ECG) measurements during submaximal exercise testing and outdoor UFPs and fine particles measured at a central regional site of Helsinki, Finland (Table 1). They found significant associations between risk of ST segment depression and ambient $PM_{2.5}$ mass, number concentrations of ultrafine mode particles 0.01–0.1 μm in diameter ($NC_{0.01–0.1}$), and number concentrations of accumulation-mode particles 0.1–1.0 μm in diameter ($NC_{0.1–1}$) (Table 1). Odds ratios (ORs) were around 3.0 for all particle metrics

Table 1. Continued

Studies	Design and population	Outcomes	Findings for PM mass and components	Findings for gases
Systemic inflammation and thrombosis				
Schwartz 2001	Cross-sectional study examining the relationship between ambient PM_{10}, NO_2, SO_2, and blood biomarkers using data from a cohort study (NHANES III)	Fibrinogen, and platelet and white blood cell counts	For an interquartile range change in PM_{10} (26 μg/m^3), the relative odds for being above the 90th percentile of fibrinogen was 1.77 (95% CI, 1.26–2.49); platelets, 1.27 (95% CI, 0.97–1.67); and white blood cells, 1.64 (95% CI, 1.17–2.30)	SO_2 was positively associated with white cell counts, and NO_2 with platelet counts and fibrinogen, but both gases were confounded by PM_{10}
Pekkanen et al. 2000	Cross-sectional study examining the association between ambient PM_{10}, NO_2, CO, SO_2, O_3, and fibrinogen among 7,205 subjects in London at baseline enrollment in a cohort study	Fibrinogen	No association between PM_{10} and fibrinogen was seen after adjustment for confounders	NO_2 increase from the 10th to the 90th percentile was associated with a 1.5% higher fibrinogen concentration (95% CI, 0.4–2.5%); similar increase for CO resulted in 1.5% higher fibrinogen concentration (95% CI, 0.5–2.5%); no association with SO_2 or O_3
Peters et al. 1997a, 2001b	Cohort study in Augsburg, Germany, examining relationships of ambient TSP, SO_2, and CO exposure to CRP in 631 men 45–64 years of age with no history of MI at their baseline assessment; two CRP measurements were 3 years apart	CRP	An increase of 26 μg/m^3 (5-day mean) in TSP increased the odds of observing a CRP level above the 80th percentile, OR = 1.31 (95% CI, 1.09–1.56); CRP and plasma viscosity (Peters et al. 1997a) were increased during an air pollution episode in 1985	An increase of 30 μg/m^3 (5-day mean) in SO_2 increased the odds of observing a CRP level above the 90th percentile, OR = 1.24 (95% CI, 1.03–1.49)
Pope et al. 2004b	Panel study of ambient exposure to PM and HRV and blood markers in 88 elderly subjects living in Salt Lake City and Provo/Orem, Utah	CRP, white blood cell count, whole blood viscosity, granulocytes, lymphocytes, monocytes, basophils, eosinophils, red blood cells, platelets	A 100-μg/m^3 increase in $PM_{2.5}$ was associated with a 0.81 (SE = 0.17) mg/dL increase in CRP; one subject's data had a strong influence on estimates; there was no association with other outcomes	Not assessed
Riediker et al. 2004	Panel study of in-vehicle exposure to PM and HRV and blood markers of inflammation in 9 healthy male North Carolina Highway Patrol troopers	CRP, plasminogen, von Willebrand factor, lymphocyte count, lymphocytes, neutrophils, hematocrit, red blood cell indices, uric acid	In-vehicle 10-μg/m^3 $PM_{2.5}$ increase was associated with decreased lymphocytes (–11%, $p = 0.03$), increased red blood cell indices (1%, $p = 0.03$), neutrophils (6%, $p = 0.04$), CRP (32%, $p = 0.02$), and von Willebrand factor (12%, $p = 0.02$)	NO_2 and CO were not significant

Abbreviations: FEV1/FVC, forced expiratory volume in 1 sec/forced vital capacity; HF, high frequency; RR, relative risk; SVE, supraventricular ectopic heartbeat.
[a]The focus is on cardiovascular outcomes. Although some studies may have examined other outcomes, they are not reported.

for an increase around their interquartile distribution. Smaller but significant associations were also found for the gases NO_2 and CO, which were moderately correlated with the co-located particle measurements. The association with UFP number concentration was independent of $PM_{2.5}$ mass concentration. It is surprising that associations for outdoor ambient $NC_{0.01–0.1}$ were as strong as for $PM_{2.5}$, given the expectation that human exposure to UFPs is less consistently represented by central site PM monitoring than is exposure to $PM_{2.5}$ monitoring, which shows much lower spatial variability than UFPs (reviewed by Pekkanen and Kulmala 2004; Sioutas et al. 2005).

Cardiorespiratory symptoms potentially related to cardiac ischemia were assessed by de Hartog et al. (2003) in elderly patients with CHD. The authors found that although chest pain was not associated with PM exposure, a 10 μg/m^3 increase in ambient $PM_{2.5}$ was associated with shortness of breath and avoidance of activities (Table 1).

A case-crossover study of 691 subjects from the Augsburg Myocardial Infarction Registry found a 2- to 3-fold increased risk of MI for time–activity diary reports of hours exposed to traffic, particularly for times spent in cars and public transportation in the hours leading up to cardiac symptom onset (Peters et al. 2004) (Table 1). No direct air pollutant measurements were available. However, as discussed in our companion article (Sioutas et al. 2005), exposures to UFPs can be magnitudes higher than background levels within vehicles and near busy highways, and to a much greater degree than larger particles. Accumulation-mode PM, volatile organic compounds, and gases such as CO could have also played a role in the findings of Peters et al. (2004).

Blood pressure. Two studies showing associations between air pollution and blood pressure (BP) followed subjects with COPD (Brauer et al. 2001; Linn et al. 1999; Table 1). Linn et al. (1999) found that for only 120 total person-observation times in 30 subjects, an increase of 33 μg/m^3 ambient PM_{10} (study mean) was associated with a 5.7 mm mercury (Hg) increase in systolic BP. In contrast, Brauer et al. (2001) found systolic BP was inversely but weakly associated with personal $PM_{2.5}$ in a pooled regression analysis of 16 subjects with COPD monitored on 7 separate days. This association was not confounded by inverse associations with ambient CO. Inverse associations with ambient PM_{10} were larger but were confounded by CO. Another study examined 2,607 German adults younger than 65 years evaluated on two occasions 3 years apart and found a positive association of systolic BP with ambient concentrations of both total suspended particulates (TSP) and SO_2 (Ibald-Mulli et al. 2001) (Table 1).

Ibald-Mulli et al. (2004) conducted one of the few panel studies to focus on the relationship between UFPs and BP (Table 1). They followed 131 adults with CHD in three European centers every 2 weeks for about 11 clinic visits. An increase of a 5-day average of 10,000/cm^3 UFPs ($PM_{0.01–0.1}$) was associated with small decrease in systolic BP (–0.72 mm Hg; $p < 0.01$) and diastolic BP (–0.70 mm Hg; $p < 0.01$). Comparably small associations were also found for CO, 1,000/cm^3 accumulation-mode particles, and 10 μg/m^3 $PM_{2.5}$. The authors hypothesized that BP medications in these CHD patients might have blunted or modified the response to air pollution exposure. However, these results contrast those of a panel study by Zanobetti et al. (2004), who found that ambient 5-day average $PM_{2.5}$ was positively associated with BP among 62 patients with preexisting heart disease, using data from 631 repeated visits for cardiac rehabilitation in Boston (Table 1).

Panel study results for $PM_{2.5}$ can be compared with two experimental human studies (Brook et al. 2002; Gong et al. 2003; not shown in Table 1). Gong et al. (2003) studied the effects of $PM_{2.5}$ concentrated ambient particles (CAPs) from Los Angeles air versus clean air on systolic BP in 12 healthy versus 12 asthmatic adults using a 2-hr rest–exercise exposure period in a chamber. CAPs are used to approximate the effects of "real-world" particles. They found inverse associations of $PM_{2.5}$ CAPs with systolic BP in asthmatics, but positive associations in healthy subjects. Results from two small studies by Brauer et al. (2001) and Gong et al. (2003) with relatively good exposure data show that $PM_{2.5}$ mass is inversely associated with BP in subjects with obstructive lung diseases. Brook et al. (2002) also studied the vascular effects of 150 μg/m^3 $PM_{2.5}$ CAPs from Toronto air, adding 120 ppb O_3, in 25 healthy adults using a 2-hr exposure period in a chamber. They found a significant but small 0.1 mm decrease in brachial artery diameter by ultrasonography for the joint exposures versus filtered air but no change in BP, flow-mediated diameter (endothelium dependent), or nitroglycerin-mediated dilatation (endothelium independent). A follow-up analysis showed that the organic and EC fractions of $PM_{2.5}$ CAPs were significant determinants of the effects on brachial artery diameter, which is a more sensitive biomarker of effect than BP (Urch et al. 2004).

Potential mechanisms for the observed PM-associated increases in BP have been suggested to include an increase in sympathetic tone and/or the modulation of basal systemic vascular tone due to increased concentrations of a plasma peptide known as endothelin-1 (Ibald-Mulli et al. 2001). Endothelin-1 has multiple cardiovascular actions, including vasoconstriction, leading to maintenance of basal vascular tone and BP (Haynes and Webb 1998) and accentuating BP elevation in more severe, sodium-sensitive hypertension (Schiffrin 2001). It is directly associated with the severity of CHF and risk of subsequent cardiac death in CHF patients (Galatius-Jensen et al. 1996; Tsutamoto et al. 1995). Endothelin-1 is produced and cleared in the lung and is generated in response to the presence of ROS (free radicals) and their metabolites (Haynes and Webb 1998). This leaves open the possibility that pollutants could induce an excess production of endothelin-1. Supporting evidence is that urban particles have been shown to increase endothelin-1 in rats (Bouthillier et al. 1998). Effects of endothelin-1 are partly counterbalanced by vasodilatory influences of endothelial nitric oxide (NO; Vanhoutte 2000). Endothelial NO synthase produces NO, which traverses the extracellular space to induce smooth muscle relaxation in the vessel wall. One ROS that can be produced in the presence of certain pollutant components is superoxide, which can react with NO to form the potent oxidant peroxynitrite. Peroxynitrite is likely involved in lipid peroxidation (O'Donnell and Freeman 2001). Therefore, an additional potential mechanism whereby pollutant components can increase BP includes superoxide-mediated inhibition of the actions of NO in inducing vasodilatation.

Despite the above data on potential biologic mechanisms, reviewed epidemiologic studies have found both a decrease and increase in BP in relation to air pollutant exposures. This may be because of differences between subject populations, differences in the types of regional air pollutants, or possibly due to medications used or underlying pathology (healthy, COPD, asthma, CHD, etc.). There is also a lack of data in most studies on other influences on BP, namely, emotional states and physical activity, which could have sustained influence on nonambulatory BP measurements. The above factors could result in contrasting shifts in sympathetic and vagal tone in response to inhaled air pollutants, or contrasting shifts in the balance between mediators such as endothelin-1 and endothelial NO. The time course of exposure–response relationships is also ill-defined, particularly periods of exposure averaging times ranging from minutes to days. None of the epidemiologic studies used ambulatory BP monitoring to assess acute effects of real time changes in exposure. Ambulatory BP monitoring is more closely associated with end organ damage (heart, kidney, brain) than isolated systolic or diastolic BP readings taken in clinic offices (Mancia and Parati 2000).

Autonomic control of cardiac rhythm. Heart rate variability (HRV) is a widely used noninvasive method to investigate cardiovascular autonomic control. Reduced HRV has been shown to be a predictor of increased mortality after MI (Kleiger et al. 1987; La Rovere et al. 1998) and has been related especially to sudden arrhythmic death (Hartikainen et al. 1996; Odemuyiwa et al. 1991). Fourier analysis of HRV can show the magnitude of variance in the heart's rhythm across different frequency bands. Different autonomic influences on cardiovascular function (HR and BP) are reflected by different frequency bands. The high-frequency (HF) band (0.15–0.40 Hz) has been used to estimate cardiac vagal control and is linked to respiratory influences (Task Force 1996). Lower frequencies (0.04–0.15 Hz) are believed to represent mixed sympathetic and parasympathetic influences (Task Force 1996). Time domain measurements are also used (described below).

One controlled exposure study showed significant decreases in HRV in 10 healthy elderly adults for 2-hr exposures to CAPs from Chapel Hill, North Carolina (mostly mobile source) compared with clean air, and the decrease persisted 24 hr later (Devlin et al. 2003). In epidemiologic studies discussed below, ambient PM has been associated with decreased HRV (Chan et al. 2004; Creason et al. 2001; Gold et al. 2000; Holguin et al. 2003; Liao et al. 1999; Magari 2002, Magari et al. 2001, 2002; Peters et al. 1999; Pope et al. 2004b, 1999) and cardiac arrhythmia (Peters et al. 2000). Only two studies to our knowledge have investigated effects of personal PM exposures on HRV (Chan et al. 2004; Magari et al. 2001), and one on personal CO (Tarkiainen et al. 2003).

Liao et al. (1999) showed that the largest inverse associations between nonambulatory HRV measures and $PM_{2.5}$ were for subjects with a history of cardiovascular conditions, although the number subjects (18) was small and the specific illnesses were not separated (not shown in Table 1). Another study of 56 elderly subjects showed inverse associations of nonambulatory high- and low-frequency HRV with indoor and outdoor 24-hr gravimetric $PM_{2.5}$ collected in a retirement home (Creason et al. 2001; not shown in Table 1). Using hourly ambient $PM_{2.5}$ data, they briefly reported that models using prior 4-hr average $PM_{2.5}$ and time-lagged 4-hr $PM_{2.5}$ were similar in magnitude to effects of the 24-hr $PM_{2.5}$ averages, suggesting a mixture of short-term and cumulative effects. Holguin et al. (2003) studied 34 elderly nursing home residents living in Mexico City and showed a strong decrease in the high-frequency component of HRV with high ambient $PM_{2.5}$ exposure, and the association was stronger for indoor home $PM_{2.5}$. Those with hypertension had the largest reductions in HRV (Table 1). Pope et al. (1999) also used ambulatory HR monitoring in 7 elderly subjects with respiratory and cardiovascular disease before, during, and after episodes of elevated pollution. They found that ambient PM_{10} was associated with decreased in the standard deviation (SD) of normal-to-normal (NN) intervals (SDNN), a time domain measure of overall HRV. However, they also found an increase in the square root of the mean of squared differences between adjacent NN intervals (r-MSSD; time domain measurement that corresponds to high-frequency variability and parasympathetic tone). A larger study using ambulatory ECG monitors by Pope et al. (2004b) found that ambient $PM_{2.5}$ was associated with a decrease in both SDNN and r-MSSD in 88 elderly subjects in Utah (Table 1). Magari et al. (2001) studied 40 workers occupationally exposed to welding fumes and residual oil fly ash with 24-hr monitoring using ambulatory HR monitors and personal real-time $PM_{2.5}$ measurements from a TSI Inc. DustTrak (Shoreview, MN) (Table 1). They found significant decreases in SD of average 5-min NN intervals in relation to increases in prior 1-hr moving averages of $PM_{2.5}$. They also found increasingly greater decreases in SDNN for higher $PM_{2.5}$ across longer $PM_{2.5}$ averaging times up to 9 hr. Magari et al. (2001) suggested inhaled particles directly affect autonomic function through a sympathetic stress response, represented by their acute response finding, and/or secondarily through airway inflammation and cytokine release into the circulation, represented by their cumulative response finding. Riediker et al. (2004) placed portable air-quality monitors in patrol cars of nine healthy male North Carolina Highway Patrol troopers who wore ambulatory ECG monitors (Table 1). In-vehicle $PM_{2.5}$ was positively associated with ectopic beats, heart beat cycle length, HF HRV, and SDNN.

Chan et al. (2004) conducted the only study to date to assess the relationship between HRV and particle number concentrations (dominated by UFPs) for particles 0.02–1.0 µm in diameter ($NC_{0.02–1}$) (Table 1). They followed 9 young healthy adults (2 females) and 10 elderly male subjects with obstructive lung function impairment. This was also the first study to examine the effects of personal exposure to UFPs on HRV. Subjects were monitored over only 10 daytime hours using a P-Trak Ultrafine Particle Counter (TSI Inc.) for $NC_{0.02–1}$. Subjects also wore ambulatory ECG monitors for continuous 5-min beat-to-beat intervals to assess HRV. Using linear mixed-effects models, they found that decreases in HRV indices (SDNN and r-MSSD) were associated with exposure to 1- to 4-hr moving averages of $NC_{0.02–1}$ before the 5-min HRV measurements, adjusting for age, sex, body mass index, environmental tobacco smoke exposure, and temperature (Table 1). Associations were stronger for the elderly panel, with the strongest effects from 2-hr average $NC_{0.02–1}$. These results along with those of Magari et al. (2001) suggest that the effect of personal PM exposure on autonomic function is acute, although the monitoring period (10 hr) was too short in the Chan et al. (2004) study to assess longer-term effects.

Tarkiainen et al. (2003) studied six patients with CHD for 1 day per week for 3 weeks with continuous personal CO exposure monitors, ambulatory ECG monitoring for HRV, and time–activity diaries and found r-MSSD increased in relation to high CO exposures (> 2.7 ppm peaks lasting 17 min, SD 8 min) (Table 1). This result contrasted results of most studies using PM exposures, except the study of Pope et al. (1999). No particle data were available, but it is again important to note that outdoor CO at sites close to dense traffic is highly correlated with UFPs (Zhu et al. 2002). It is conceivable that CO and/or UFPs increase vagal control and induce bradyarrhythmias.

In a study of arrhythmias and air pollution, investigators followed 100 subjects in eastern Massachusetts with implanted defibrillators (Peters et al. 2000; Table 1). They found that patients with 10 or more defibrillator discharge interventions for cardiac arrhythmias experienced increased arrhythmias in association with outdoor ambient NO_2, CO, and black carbon, but $PM_{2.5}$ was less strongly related. The most robust association was found for NO_2, which may have been a marker for local traffic-related pollution, whereas particle mass may have been additionally influenced by other sources. Exposure was represented by only one Boston monitoring site.

Systemic inflammation and thrombosis. The view that air-pollution–induced airway inflammation triggers systemic hypercoagulability (Seaton et al. 1995) has been supported in recent epidemiologic studies. It is relevant in this regard that, compared with unaffected people, patients with CHD (Lagrand et al. 1999; Mendall et al. 1997; Stec et al. 2000; Woods et al. 2000) or a complication of CHD, CHF (Pye et al. 1990; Torre-Amione et al. 1996), have increased levels of inflammatory cytokines such as interleukin (IL)-1β and IL-6, and tumor necrosis factor-α (TNF-α). They also have increased levels of circulating acute phase proteins such as C-reactive protein (CRP) and fibrinogen. In patients with CHD, CRP is also a strong independent predictor of future coronary events (Rifai and Ridker 2001). Cohort studies have shown that levels of acute phase proteins, cytokines, and hemostatic factors indicative of a thrombophilic state or endothelial activation are elevated at baseline in subjects at risk for future coronary occlusion or cardiovascular mortality (Cushman et al. 1999; Danesh et al. 2000; Folsom et al. 2001; Harris et al. 1999; Haverkate et al. 1997; Jager et al.

1999; Kuller et al. 1996; Lind et al. 2001; Malik et al. 2001; Ridker 2001; Ridker et al. 2000, 2001; Thompson et al. 1995). Air pollutant exposures that lead to acute increases in already elevated levels of inflammatory and hemostatic factors may also precipitate adverse health outcomes. This is a strong possibility in patients with diagnosed or underlying CHD, a population most likely driving the time-series associations. In addition, high air pollutant exposures that lead to chronic or repeated increases in systemic inflammation through oxidative stress responses to ROS may promote the progression of atherosclerosis in susceptible individuals.

Recent studies have shown acute associations between air pollutant exposures and systemic responses indicating inflammation and hypercoagulability. Seaton et al. (1999) studied 112 elderly individuals and used 1 day of personal PM_{10} data per person to predict the remaining 2 days using ambient (city center) PM_{10} data (Table 1). Results showed inverse associations of estimated personal PM_{10} with albumin-adjusted hemoglobin, packed cell volume, red blood cell count, platelets, and factor VII levels. They found no associations between PM_{10} and IL-6 or white blood cell count. Only ambient PM_{10} was positively associated with CRP concentrations, but it was also inversely associated with fibrinogen. The authors hypothesized that particles enter lung endothelial cells or erythrocytes and subsequently influence red cell adhesiveness, leading to peripheral sequestration of red cells. Contrasting results were found by Schwartz (2001), who used health data from the Third National Health and Nutrition Examination Survey (NHANES III) in the United States (Table 1). Results showed that outdoor PM_{10} levels on the day of subject visits or previous day was positively associated with fibrinogen levels and counts of platelets and white blood cells. Fibrinogen increased by 13 μg/dL (95% CI, 4.6–22.1) for an interquartile range change in PM_{10} of 26 μg/m^3. PM effects were independent of gaseous pollutants. Schwartz (2001) argued that the NHANES III results were consistent with data in controlled human exposure (Ghio et al. 2000) and animal studies (Gardner et al. 2000) that showed increased plasma fibrinogen after particle exposures. Pekkanen et al. (2000) found no association between PM_{10} and fibrinogen using cross-sectional data from another cohort study of 7,205 subjects in London. However, they did find associations between fibrinogen and two pollutant gases, NO_2 and CO, but not SO_2 or O_3. Epidemiologic studies in Augsburg, Germany, have also shown positive associations of ambient air pollution with plasma viscosity (Peters et al. 1997) and with CRP concentrations (Peters et al. 2001b) (Table 1). Another study of people exposed to forest fire smoke showed increased circulating levels of IL-1β and IL-6 (Van Eeden et al. 2001; not shown). A panel study by Pope et al. (2004b) (Table 1) with 88 elderly subjects in Utah showed a 0.81 mg/dL CRP increase in association with a 100 μg/m^3 increase in ambient $PM_{2.5}$. There was no association with white or red blood cell counts, platelets, or whole-blood viscosity. Riediker et al. (2004; discussed above) assessed the relationship between in-vehicle PM exposure and markers of inflammation in nine healthy male state troopers. An in-vehicle 10 μg/m^3 $PM_{2.5}$ increase was associated with decreased lymphocytes (–11%), increased red blood cell indices (1%), neutrophils (6%), CRP (32%), and von Willebrand factor (12%).

Summary and biologic plausibility. To date only three studies have directly evaluated the effects on cardiovascular health by UFPs or particle number concentration (Chan et al. 2004; Ibald-Mulli et al. 2004; Pekkanen et al. 2002). Results of Pekkanen et al. (2002) showing ST segment depression in relation to UFPs are the most compelling findings. Associations of ambient $NC_{0.01-0.1}$ with ST segment depression were independent of ambient $PM_{2.5}$, but it is unclear whether the ambient exposure data represented personal UFP exposures of subjects. Other indirect evidence that components of fossil fuel combustion are important comes from studies using surrogate measures of particle composition such as black smoke, proximity of homes to traffic, or source apportionment data. Epidemiologic associations for pollutant gases also seem to support the idea that cardiovascular effects may be linked to primary products of combustion emissions that include UFPs.

Because hypertension, ST segment depression, and cardiac arrhythmias are well-known risk factors for cardiac morbidity and mortality, the above findings of acute associations with PM from individual-level studies are relevant to the reported findings of time-series and cohort investigations of mortality and hospital morbidity. However, mixed findings for BP have not provided a coherent view of particle effects. Findings for HRV are largely consistent in finding a decrease in HRV except for the increase in r-MSSD with ambient PM among elderly subjects found by Pope et al. (1999) and increased HF HRV for in-vehicle PM among healthy men found by Riediker et al. (2004). The clinical importance of HRV to cardiovascular disease is unclear however (Task Force 1996), and many technical issues regarding the influence of respiratory patterns (respiratory sinus arrhythmia) and psychosocial stress (both unmeasured in the reviewed studies) remain unresolved (Sloan et al. 1994).

The reviewed epidemiologic studies on circulating biomarkers of effect show inconsistent relationships between air pollution and blood markers of inflammation and hypercoagulability, possibly because all but two studies used ambient exposure to PM. Currently, only the studies of Seaton et al. (1999) and Riediker et al. (2004) used any personal PM exposure measurements, but results are not consistent. In addition, the reviewed studies of circulating biomarkers did not target people with cardiovascular diseases, who are expected to be among the most susceptible population, as indicated in the time-series investigations.

The main limitation of most epidemiologic studies is exposure misclassification from dependence on central site rather than on personal or microenvironmental exposure data. However, studies reported above that do have personal exposure data also have limited numbers of subjects or days monitored. In general some major methodologic issues that remain involve choice of susceptible populations, personal exposure assessment, and timing of measurements to assess the temporality of exposure–dose–response relationships.

Despite the inconsistencies in epidemiologic data, sound postulated mechanisms support the biologic plausibility of many of the findings. Airway inflammation from PM likely involves inhalation of agents leading to the deposition or production in lung tissue of ROSs. The ROSs then induce subsequent oxidant injury and inflammatory responses (Pritchard et al. 1996; Schreck et al. 1991) both in the lungs and systemically. Inhalation of particle-bound airborne transition metals (copper, iron, nickel, vanadium) can lead to the production of ROSs in lung tissue. Residual oil fly ash containing high concentrations of transition metals but low in organic compounds have been shown to induce *in vitro* increases in IL-6 mRNA in human epithelial cells (Quay et al. 1998). Dogs exposed to CAPs from Boston air showed increased bronchoalveolar lavage macrophages and increased circulating neutrophils in relation to a vanadium/nickel factor, but no associations were shown with total mass (Clarke et al. 2000). This suggests that pollutant composition was important.

Organic constituents of PM are also capable of generating ROS. Nel et al. (2001) have presented evidence that polycyclic aromatic hydrocarbons (PAHs) from diesel exhaust particles (DEPs) and oxidized derivatives of PAHs, such as quinones, lead to the generation of ROSs and subsequent oxidant injury and inflammatory responses, including the production of nuclear transcription factor κB (NF-κB). NF-κB increases the transcription of cytokines and acute phase proteins (Schreck et al. 1991). Evidence has been presented that DEPs induce a broad polyclonal activation of cytokines from an adjuvant-like activity of DEP PAHs (Diaz-Sanchez et al. 1996, 1997; Fujieda et al. 1998; Nel et al. 1998, 2001).

Human pulmonary responses to DEPs include increased neutrophils and B-lymphocytes in lavage fluids, increased expression of endothelial adhesion molecules ICAM-1 (intercellular adhesion molecule-1) and VCAM-1 (vascular cell adhesion molecule-1) in bronchial biopsies, and increased neutrophils and platelets in peripheral blood (Salvi et al. 1999). Such DEP-induced effects from oxidative stress mechanisms would be expected to lead to increased systemic hypercoagulability, but to date supporting data in humans are limited.

Epidemiologic evidence in humans that PM exposure increases biomarkers of oxidative stress in blood is limited to one study of 50 healthy young adults in Copenhagen using air samplers carried by subjects (Sorensen et al. 2003). They found a positive association between personal black carbon exposure and 2-aminoadipic semialdehyde in plasma proteins, a protein oxidation product. However, no association with personal $PM_{2.5}$ mass was found, suggesting that traffic-related causal components may have been better represented by black carbon than by particle mass. A lipid peroxidation product (malondialdehyde), as well as red blood cell counts and hemoglobin concentrations, was positively associated with $PM_{2.5}$ exposure in women only.

There are also plausible linkages between pulmonary and cardiovascular responses to PM. Airway inflammatory responses have been demonstrated in animals exposed to particulate air pollutants (U.S. EPA 2003). As discussed above, there is growing evidence that airway responses may trigger systemic inflammation and hypercoagulability. In addition, PM can induce neurogenic inflammation in the lungs from activation of capsaicin-sensitive irritant receptors, leading to the release of tachykinins from sensory terminals and then airway inflammation and bronchoconstriction (Veronesi and Oortgiesen 2001). This response could then affect cardiovascular autonomic function (Carr and Undem 2001; Yeates 2000), but it is not yet clear to what extent these mechanisms explain epidemiologic findings of air pollutant associations with cardiac rhythm and BP. There is limited evidence for an effect of tachykinins on cardiac function (Maggi 1996). In addition, the linkage between airway inflammation, cytokine/chemokine release, and autonomic stress response has not been directly demonstrated in humans. There are some *in vitro* data linking actions of pro-inflammatory cytokines IL-1β and TNF-α to myocardial cell changes in contractility and action potentials (DeMeules et al. 1992; Finkel et al. 1992; Li and Rozanski 1993; Yokoyama et al. 1993) and to induction of arrhythmias (Weisensee et al. 1993).

There are experimental data indirectly supporting a linkage between cellular inflammation in the lungs and cardiovascular responses to air pollutants. An experiment in hyperlipidemic rabbits showed that intrapharyngeal instillation of ambient urban PM_{10} led to an increase in circulating polymorphonuclear neutrophils and caused an increase in the volume fraction of atherosclerotic lesions, which correlated with the number of alveolar macrophages that phagocytosed PM_{10} in the lung ($r = 0.5$) (Suwa et al. 2002). Particle-induced airway inflammation and translocation of UFPs and other pollutants into the circulation could lead to an increase in thrombogenic and inflammatory activity in the blood and to a disturbance in cardiovascular function. These extrapulmonary effects are expected to increase the risk of adverse cardiovascular outcomes such as hospitalization.

Other evidence links airway inflammation with cardiovascular effects. Cohort data have shown links of COPD with CHD risk independent of other risk factors (Jousilahti et al. 1999; Wedzicha et al. 2000), suggesting that pulmonary inflammatory processes may have pro-inflammatory effects on the vascular endothelium. This could occur in individuals with asthma or COPD who have depleted antioxidant defenses from oxidative stress compared with normal subjects, and their defenses are further lowered during disease exacerbations (Rahman et al. 1996). Zanobetti et al. (2000a) have shown that a positive association between hospital admissions for cardiovascular diseases and ambient air pollution was nearly doubled in elderly patients admitted with concurrent respiratory infections. Diabetics appear to be another susceptible group, with stronger associations between cardiovascular hospital admissions and ambient air pollution (Zanobetti and Schwartz 2001).

Several excellent reviews of experimental data examining acute pulmonary and cardiovascular responses to inhaled UFPs and fine particles have proposed pathophysiologic mechanisms (American Thoracic Society 1999; Dhalla et al. 2000; Donaldson et al. 2001; Godleski et al. 2000; MacNee and Donaldson 2000; Nel et al. 2001; Utell and Frampton 2000; Utell et al. 2002; van Eeden and Hogg 2002). We have synthesized these and other data into the following proposed sequence of events for UFPs that link pulmonary and cardiovascular end points (Figure 1). Most of these mechanisms likely also apply to larger PM size fractions, particularly soluble components

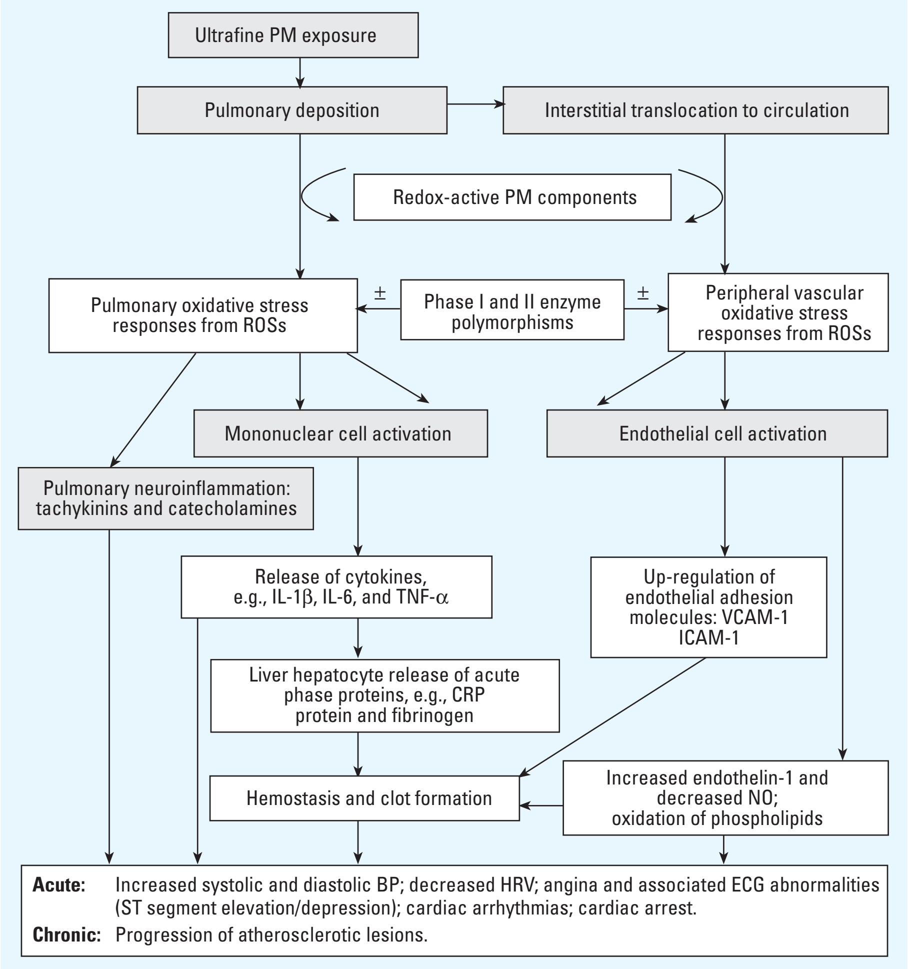

Figure 1. Hypothesized pathways leading to adverse cardiovascular health effects from exposure to UFPs.

of $PM_{2.5}$, and retained nonsoluble particles in the lung that may stimulate the bone marrow to induce similar systemic responses (van Eeden and Hogg 2002):

- UFP exposure is followed by high pulmonary deposition (Chalupa et al. 2004; Daigle et al. 2003; International Commission on Radiological Protection 1994). UFPs and associated air toxics translocate to the interstitium and gain entry into the circulation (Nemmar et al. 2002, 2004; Oberdörster et al. 2002).
- Redox-active components of PM lead to the production of ROSs in various cells in the lungs, blood, and vascular tissues.
- This is followed by oxidative stress responses in pulmonary epithelium and pulmonary vascular endothelium and in extrapulmonary vascular endothelium, leading to the production of oxidized phospholipids (especially LDL), lipid peroxidation (e.g., 8-iso-prostaglandin $F_{2\alpha}$), reduced antioxidant capacity (e.g., increase in the ratio of oxidized to reduced glutathione), and the production of superoxide anions by endothelial NADPH oxidase, all of which likely contribute to atherogenesis. Genetic polymorphisms in key metabolic enzymes likely play a role in susceptibility.
- Pulmonary and extrapulmonary peripheral vascular oxidative stress results in the activation and mobilization of mononuclear leukocytes and the expression of NF-κB, followed by increases in pro-inflammatory cytokines (e.g., IL-1β, IL-6, and TNF-α) and endothelial cell activation.
- Emigration of inflammatory cells from blood to tissue sites involves up-regulation of adhesion molecules (VCAM-1, ICAM-1) on vascular endothelium and circulating leukocytes.
- Increased release of cytokines by activated mononuclear cells in the lungs and in the blood leads to initiation of hepatic synthesis of acute phase proteins (e.g., CRP and fibrinogen).
- A hypercoagulable state then occurs with platelet activation, hemostasis, and blood clot formation followed by fibrinolytic activity; this increases the risk of a coronary event. Cytokines may also have direct effects on cardiac function.
- Endothelial cell activation also leads the expression of endothelin-1, which induces vasoconstriction, and increased systolic and diastolic BP, and the expression of extracellular superoxide dismutase (SOD). SOD catalyzes superoxide ($O_2^{\cdot-}$) to H_2O_2, which lowers endothelial NO-induced vasodilation. Neuroinflammatory responses involving tachykinins and catecholamines may also affect cardiovascular autonomic tone.
- The systemic inflammatory response also stimulates the bone marrow to release leukocytes and platelets, and polymorphonuclear leukocytes increasingly sequester in pulmonary capillaries to induce more inflammation.

Conclusion

As presented in this review, numerous studies have implicated particulate air pollution as an important contributor to morbidity and mortality from cardiovascular causes. Most of these data have been epidemiologic and have used available air pollution data from governmental monitoring stations. Because such data are collected to meet regulatory standards, they may not meet the needs of researchers trying to understand the causal pollutant components that lead to specific adverse health effects. UFPs and related toxic constituents and precursors are examples of air pollutants that have not been fully investigated, in part due to lack of available data. To date, data from epidemiologic studies indirectly implicate traffic- and other combustion-related pollutants, which include UFPs. Exposure assessment issues for UFPs are complex and need to be considered before undertaking epidemiologic investigations of UFP health effects (Sioutas et al. 2005).

A large body of evidence shows that inflammation and oxidative stress are related to both acute changes in cardiovascular health and chronic processes, including atherosclerosis. It is likely that redox-active components in UFPs from fossil fuel combustion reach target sites in the lungs, vasculature, and heart to induce inflammation and oxidative stress, adding to the burden of known lifestyle risk factors for cardiovascular disease such as diet, tobacco smoke, and stress.

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Traffic Noise and Risk of Myocardial Infarction

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The following document was submitted “for the record” to the Intermodal Container Transfer Facility (ICTF) Joint Powers Authority (JPA) during the Notice of Preparation/Initial Study (NOP/IS) comment period for the ICTF Modernization and Expansion Project.

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Traffic Noise and Risk of Myocardial Infarction

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Background: The biologic plausibility for noise stress-related cardiovascular responses is well established. Epidemiologic studies on the relationship between transportation noise and ischemic heart disease suggest a higher risk of myocardial infarction in subjects exposed to high levels of traffic noise.

Methods: To determine the risk of road traffic noise for the incidence of myocardial infarction (MI), we carried out a hospital-based case-control study in the city of Berlin. We enrolled consecutive patients (n = 1881), age 20–69 years, with confirmed diagnosis of MI from 1998 through 2001. Controls (n = 2234) were matched according to sex, age, and hospital. Outdoor traffic noise level was determined for each study subject based on noise maps of the city. Standardized interviews were conducted to assess possible confounding factors and the annoyance from various noise sources.

Results: The adjusted odds ratio for men exposed to sound levels of more than 70 dB(A) during the day was 1.3 (95% confidence interval = 0.88–1.8) compared with those where the sound level did not exceed 60 dB(A). In the subsample of men who lived for at least 10 years at their present address, the odds ratio was 1.8 (1.0–3.2). Noise-exposed women were not at higher risk.

Conclusions: The results support the hypothesis that chronic exposure to high levels of traffic noise increases the risk for cardiovascular diseases.

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Epidemiologic studies on the relationship between transportation noise and ischemic heart disease suggest a higher risk of myocardial infarction in subjects exposed to high levels of traffic noise.[1,2] Although the findings in these studies seem to be reasonably consistent, many of the individual studies have low statistical power. Expert groups have rated the evidence of the association from "limited" to "sufficient."[3,4] The existing data on the relationship between road traffic noise and ischemic heart disease suggest an average A-weighted sound pressure level of 65 to 70 dB(A) during the day as a possible threshold of effect. (The unit of sound measurement is decibels [dB]. "A-weighting" refers to a filter, which is used in sound meters to account for differences in hearing sensitivity at different sound frequencies; "dB(A)," is the common unit for the assessment of community noise and occupational noise.)

A previous population-based case-control study carried out in the area formerly known as West Berlin found an odds ratio (OR) for myocardial infarction of 1.32 (95% confidence interval = 0.89–1.96) in men who had lived for at least 15 years on streets with average A-weighted sound levels (6–22 hours) of more than 70 dB(A) compared with subjects who lived on streets with sound levels up to 60 dB(A).[5] The Noise and Risk of Myocardial Infarction (NaRoMI) study is a replication of the previous one using the same test hypothesis on a new sample. It includes a larger sample size, uses improved methods of exposure assessment, and considers a larger set of potentially confounding factors. It is a hospital-based case-control study covering the entire city of Berlin.

METHODS

Selection of Cases and Controls

To determine the potential risk of noise for the incidence of myocardial infarction (MI), a matched case–control study was carried out. Patients consecutively admitted to 32 major hospitals in Berlin with confirmed diagnosis of acute MI or survivors of sudden cardiac arrest (International Classification of Diseases, 9th revision code 410), age 20–69 years, were enrolled over a prospective period of 3 years from 1998 to 2001. The diagnostic criteria followed the World Health Organization definitions, including ischemic changes in the electrocardiogram, clinical symptoms, and enzymatic changes.

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Hospital controls were individually matched according to sex, age (5-year categories), and hospital. Because of the lower incidence rate of MI in women, a case:control ratio of 1:1 for men and 1:2 for women was applied to increase the statistical power for women. Control patients were admitted to the same hospitals for diagnoses that were presumably not related to noise, including hernia, goiter, colon or rectum problems, and accidents. Study participants were informed about the objective of the study and gave their written consent. The study was approved by the ethical commission of the Medical Faculty of the Humboldt, University of Berlin.

Covariates

After subjects were moved from intensive care, standardized interviews were conducted on the wards to assess the home environment, sociodemographic features, and potentially confounding factors. Data included family history of MI, smoking, education level, marital status, employment status, working hours (employment) >40 hours/week in any job during the past 10 years, shift work, second job or activity >5 hours per week, and Weinstein noise sensitivity.[6] We obtained clinical information on diagnoses regarding diabetes mellitus, hypertension, hyperlipidemia, and body mass index from clinical records. To account for possible confounding, all variables were included in the statistical models. As a result of possible incomplete assessment in controls, hyperlipidemia was considered only in sensitivity analyses.

Noise Assessment

The objective traffic noise exposure (sound level) of the subjects was assessed using noise maps from the city authorities and standardized questionnaires. We calculated traffic noise levels (12 months average A-weighted sound pressure levels as determined from noise maps) according to ANSI S1.4 and ISO 1996/1 with reference to the most affected facades of the dwellings for day (6–22 hours) and night (6–22 hours), taking seasonal variations into consideration. The noise maps were established in accordance with German standards for road (RLS 90) and rail traffic (SCHALL 03) and accounted for reflections from the buildings opposite. All main roads with more than 6000 vehicles per day were assessed by the traffic authorities, and exact noise levels at the facades of the houses were calculated for more than 6300 street segments (parts between intersections).[7] Streets with lower traffic volume (side streets) were categorized as "quiet." No exact sound levels can be given for these streets. However, the cutoff criterion of traffic volume refers to average A-weighted sound levels during the day of approximately 60 dB(A) and approximately 50 dB(A) during the night at a distance of 25 m from the streets (maximum speed 50 km/h, 5% heavy vehicles). The traffic noise exposure in side streets was validated using data of 4 of 12 Berlin District Councils that assessed the noise levels in all the side streets of their parts of the city (more than 5800 street segments). The speed limit in 85% of all the side streets was 30 km/h and 50 km/h in all other streets. The group of subjects living in side streets served as the reference group in the statistical analyses, which was in accordance with the test hypothesis and previous noise studies.

All subjects' houses were categorized in 5-dB(A) categories (as usually applied in noise regulations) according to the sound levels given in the traffic noise map. In the first step, we made the assessment for the home address (in most cases the street closest to the buildings). In the second step, all addresses were checked for noise from streets other than the home address. Using high-resolution GIS information, the distances to all main roads were measured for each house. When this sound level was higher than the one for the street of the address, we reallocated subjects into the higher sound-level category; otherwise, subjects remained in their initial category. All noise calculations were made separately with respect to the front (facing the street of the address) and back of the house.

To account for transportation noise other than from streets, dichotomous variables were created so that residence within the 60 dB(A) contours around airports or railway lines could be evaluated. These calculations were made according to the German aircraft noise regulations considering an exchange rate (ISO 1996/1) of 3 dB(A), the train noise module of the Berlin noise map, and the measured distance of houses from railway lines. The 2 variables (aircraft noise and train noise) were considered as covariates in the statistical analyses.

The 10-year worknoise exposure (sound level) was determined according to ISO 9921/1 assessing vocal effort for speech communication and according to catalogs for workplaces and machines, allowing for the use of ear protection. For the present analyses, we controlled for possible confounding by occupational noise exposure (in dB(A), corrected for use of ear protection: ≤55, 56–70, 71–85, >85, or no data or no job). Replacing this with other work noise indicators did not considerably change the effect estimates of the traffic noise factor.

The subjective experience of noise exposure ("annoyance") was assessed using a standardized questionnaire. Personal interviews were carried out in the hospitals. Environmental noise annoyance was determined using a 5-point scale ("Considering recent years, how much were you disturbed by noise at home? 1 = not disturbed at all, 5 = very disturbed"). We considered 8 noise sources around and in the subject's home: road traffic noise, aircraft noise, railway noise (excluding tram), noise from construction works, commercial noise (including noise from industries), other outdoor noise, impact noise, and other indoor noise. Annoyance during the day and the night was evaluated separately. To control for annoyance from occupational noise, we created an indicator variable (annoyance level: high/fairly high, fairly low/low, or no data/no job during the past

10 years). This variable was based on information taken from the noise questionnaire referring to noise from outside of the work room, from the subject's own machines or appliances, and from machines or appliances used by colleagues (sum score of annoyance, weighted by duration of employment).[8]

Statistical Analysis

Conditional logistic regression analyses were carried out (matched analyses) to calculate OR and CI, and to adjust the results for a set of potentially confounding factors. Because most of the previous noise studies were carried out in men, separate models were calculated for men and women. We calculated nonparametric regression coefficients to assess associations between the determinants of noise exposure. Associations between noise level and MI incidence were analyzed in the total sample and in a subsample of subjects who had been living at least for 10 years in their present homes. This enabled us to account for chronic noise stress conditions and the long induction period of the disease under study. The cutpoint of 10 years was determined on the basis of the distribution of the residence time on the one hand and on pragmatic grounds of sample size and statistical power on the other. To ensure that effect estimates obtained from the subsample were stable, other criteria were also applied (eg, 15 years).

RESULTS

Table 1 shows characteristics of the cases and the controls, including the number of subjects, the prevalence of risk factors, and the distribution of other covariates. The total

TABLE 1. Characteristics of Study Subjects, and Association Between Covariates and Myocardial Infarction

	Men		**Women**			
Variable*	**Cases (n = 1527)**	**Controls (n = 1527)**	**Cases (n = 354)**	**Controls (n = 707)**	**Men (n = 3054) OR† (95% CI)**	**Women (n = 1061) OR† (95% CI)**
Age (years); mean ± SD*	56 ± 8	56 ± 9	58 ± 9	58 ± 9		
Diabetes mellitus	17	10	25	11	1.84 (1.43–2.38)	3.00 (1.95–4.62)
Hypertension	43	25	48	31	2.24 (1.87–2.70)	1.99 (1.45–2.74)
Family history of myocardial infarction	31	17	37	22	2.11 (1.73–2.57)	2.00 (1.45–2.76)
Smoking status						
Current	54	45	48	29	2.69 (2.11–3.43)	3.85 (2.64–5.61)
Former	32	32	22	22	1.80 (1.41–2.30)	1.97 (1.31–2.96)
Never‡	14	23	30	49	1.0	1.0
Body mass index (kg/m^2)						
<25‡	37	45	38	46	1.0	1.0
25–29	46	39	35	34	1.22 (1.02–1.46)	1.14 (0.80–1.62)
≥30	15	16	27	20	0.89 (0.70–1.13)	1.42 (0.95–2.13)
Unknown	1	0	1	1	5.42 (1.93–15.2)	1.56 (0.23–10.5)
Current employment status						
Unemployed	11	13	10	7	0.74 (0.57–0.97)	1.09 (0.60–1.96)
Not in working for other reasons	42	46	61	64	0.57 (0.45–0.72)	0.52 (0.33–0.83)
Employed >10 hrs/wk	47	42	29	29	1.0	1.0
Employment >40 hrs/wk during past 10 yr	54	48	25	231	1.14 (0.97–1.35)	1.02 (0.71–1.46)
Second job >5 hrs/wk	19	17	17	140	1.11 (0.89–1.37)	1.23 (0.81–1.85)
Shift work	26	25	19	15	1.05 (0.87–1.27)	1.08 (0.71–1.65)
Living without partner	20	31	34	42	0.55 (0.45–0.67)	0.60 (0.44–0.83)
<12 yr at school	74.7	73.5	87.9	78.2	1.11 (0.91–1.36)	1.68 (1.07–2.62)
Noise sensitivity score (6-point scale); mean ± SD*§	2.8 ± 0.7	2.8 ± 0.7	2.9 ± 0.7	2.9 ± 0.7	1.14 (1.01–1.29)	1.05 (0.85–1.30)

*All characteristics are expressed in percent, unless otherwise indicated.

†Multivariate model, adjusted for all other variables in the table.

‡Reference category is the absence of the condition, except where indicated.

§Odds ratios are per unit of a 6-point scale.

number of 4115 study participants (response rate 86%) was made up of 3054 men (age mean ± standard deviation [SD]: 56 ± 8.5 years) and 1061 women (age mean ± SD: 58 ± 8.7 years).

Table 1 also shows adjusted risk estimates for the relationships between the covariates and the incidence of MI as derived from the multiple logistic models, in which only the nonnoise factors given in the table were considered. Established biologic and nonbiologic risk factors (diabetes mellitus, hypertension, family history of MI, smoking) were strongly associated with the occurrence of MI (odds ratios between 1.7 and 3.1) and were within the range of the usual findings in epidemiologic studies.[9–11] We found odds ratios of 5.5 in men and 4.5 in women, which are higher than in most other studies, presumably because of incomplete assessment of hyperlipidemia in the controls. However, the inclusion or exclusion of this variable did not considerably affect the estimates that were obtained for any of the noise-related factors in the later analyses.

Table 2 gives the distribution of traffic noise levels in the total sample and in the subsample of subjects who had lived at their current address for at least 10 years. This refers to the highest average sound level measured during the daytime at any outside wall of the subjects' houses. Because noncategorized day and night sound levels were highly correlated ($r = 0.98$, mean difference 7.3 dB(A)), only the results referring to the sound level during the day are given here. Most subjects lived in quiet side streets. Sixteen percent of the subjects' houses were exposed to sound levels of more than 65 dB(A) during the day. Two thirds (69%) of the subjects had lived at their present address for at least 10 years.

For risk analyses, all side streets were classified as "quiet" (sound level criterion: $L_{Day} \leq 60$ dB(A)). To validate this classification, we examined the sound level data for to the complete network of side streets in 2 inner and 2 outer Berlin districts that were available. Most sound levels during the day in these side streets were between 45 and 55 dB(A) (inner districts: 51%; outer districts: 71%) or between 56 and 60 dB(A) (inner districts: 33%; outer districts: 20%). Only a minor number of sound levels (inner districts: 16%; outer districts: 9%) were higher than 60 dB(A). This suggests that exposure misclassification in the reference group was not very likely to have affected (dilution of effect) the results.

Table 2 also gives the adjusted estimates of the relative risk of MI and 95% confidence intervals for men and women in each traffic noise category. In the total sample, we found a slight increase in risk with increasing sound level for men. For men in the highest noise category (>70 dB(A)) compared with the lowest (≤60 dB(A)), the odds ratio was 1.3 (95% CI = 0.88–1.8). There was no apparent risk among women (OR = 0.7; CI = 0.32–1.4).

In the subsample of subjects who had lived for at least 10 years at their present address, there was a stronger monotonic increase in risk for men across the noise categories (Table 2). For males in the highest noise category, the odds ratio for MI was 1.8 (1.0–3.2). The result was similar when 15 years of residence was considered (OR = 1.8; CI = 0.86–3.7). When we analyzed the subsample of women, the statistical model did not converge when including all covariates (as a result of the smaller sample size); we therefore created reduced models that included only the classic risk factors. No noise effect was found for women.

TABLE 2. Association Between Traffic Noise Level (dB(A), 6–22 hr) and Myocardial Infarction for Total Sample and for Subsample of Subjects Who Had Lived at Their Current Address for at Least 10 Years

	Men		Women	
Traffic Noise Level	**No.**	**OR (95% CI)***	**No.**	**OR (95% CI)***
		Total sample		
≤60[†]	2231	1.0	759	1.0
61–65	355	1.01 (0.77–1.31)	119	1.14 (0.70–1.85)
66–70	300	1.13 (0.86–1.49)	131	0.93 (0.57–1.52)
>70	168	1.27 (0.88–1.84)	52	0.66 (0.32–1.35)
		Subsample		
≤60[†]	1547	1.0	529	1.0
61–65	251	1.17 (0.81–1.69)	82	1.04 (0.55–1.97)
66–70	202	1.31 (0.88–1.97)	95	1.11 (0.62–1.98)
>70	111	1.81 (1.02–3.21)	37	0.90 (0.39–2.07)

*Odds ratios for men and for total sample of women are adjusted for the covariates listed in Table 1 and for indicator variables of work noise, aircraft noise, and railway noise. Odds ratios for subsample of women are adjusted only for diabetes mellitus, hypertension, family history of MI, and smoking as a result of small sample size.

[†] Reference category.

When the 2 highest noise categories were combined (for comparison with the literature) among men who lived in streets with outdoor traffic noise levels of more than 65 dB(A), we found odds ratios of 1.2 (0.93–1.5) for the total sample and 1.4 (1.0–2.0) for the subsample.

Within the reference group, 2 subgroups were identified (a posteriori). 82% of the subjects of the reference group lived in side streets, which were not in relevant distance to main roads or were completely shielded by sound barriers from these streets, so that noise from these streets could not affect these subjects. The remaining 18% of the reference group were potentially affected by noise from main roads in the near distance, although using exact calculations, the noise criterion of the reference group (L_{Day} ≤60 dB(A)) was not exceeded. A substantially lower MI risk was found in this small subgroup for men (OR = 0.7; CI = 0.5–0.9) and for women (OR = 0.5; CI = 0.3–0.8) when compared with the large subgroup.

Table 3 shows mean annoyance scores for the 2 subgroups of the reference group and the higher noise-exposed groups. Across the exposure groups, a steady increase of noise annoyance resulting from road traffic noise was found with increasing traffic noise level.

Appendix Table 1 (available with the electronic version of this article) shows the distributions of noise annoyances for day and night. During the day, approximately 15% were highly annoyed by road traffic noise (categories 4 and 5 on a 5-point scale), and during the night, approximately 8% were highly annoyed. Annoyance scores were lower for other sources of noise.

Table 4 shows the associations between noise annoyance and MI. To handle all 8 annoyance variables simultaneously, they were treated as continuous variables in the models. The odds ratios give an estimate of the relative risk per unit of the 5-point scale. All sound level-related variables were excluded from the analyses, as was noise sensitivity, for reasons of collinearity among variables. However, annoyance from noise at work was considered as a covariate. We found risk of MI to be elevated by road traffic noise annoyance at night in men (OR = 1.10; CI = 1.01–1.20) and aircraft noise annoyance at night in women (1.28; 1.01–1.63).

Although cases and controls were matched according to age, additional analyses were carried out, including age as a continuous variable in the models, to assess the impact of residual confounding. The maximum impact on any of the odds ratios was +0.02 when the noise level was considered and ±0.01 when annoyance was considered.

Occupational noise exposure was considered as a covariate in the analyses. Lower risks were found in men from all of the 3 higher occupational noise categories (56–70, 71–85, >85 dB(A)) in comparison with the reference category (≤55 dB(A)) showing odds ratios between 0.6 and 0.7. In women who were occupationally exposed to higher noise levels, odds ratios were between 1.1 and 1.2.

DISCUSSION

Other investigators have studied the nonauditory effects of noise, in particular, cardiovascular effects such as high blood pressure and ischemic heart diseases.[1,12–17] The biologic plausibility of the association is based on the general stress concept and has been established for a long time on the basis of laboratory and animal experiments.[1,18–21] It has been estimated that approximately 2% to 3% of ischemic heart diseases in the general population could be attributed to the traffic noise, if the noise hypothesis is true.[3,22]

TABLE 3. Association Between Traffic Noise Level (dB(A), 6–22 hr) and Mean Annoyance Score Resulting from Traffic Noise

		Men		Women	
Traffic Noise Level		**No.**	**Mean Score (95% CI)**	**No.**	**Mean Score (95% CI)**
			Annoyance during the day		
≤60	side streets	1808	1.8 (1.7–1.8)	629	1.9 (1.8–2.0)
≤60	side streets and main roads	423	2.0 (1.9–2.1)	130	2.2 (2.0–2.5)
61–65	main roads	355	2.3 (2.2–2.4)	119	2.4 (2.2–2.6)
66–70	main roads	300	2.8 (2.6–2.9)	131	2.8 (2.6–3.1)
>70	main roads	168	2.6 (2.4–2.8)	52	3.1 (2.7–3.5)
			Annoyance during the night		
≤60	side streets	1808	1.4 (1.3–1.4)	629	1.4 (1.3–1.4)
≤60	side streets and main roads	423	1.5 (1.4–1.6)	130	1.5 (1.3–1.6)
61–65	main roads	355	1.6 (1.5–1.7)	119	1.8 (1.6–2.0)
66–70	main roads	300	2.0 (1.8–2.1)	131	2.0 (1.8–2.3)
>70	main roads	168	1.6 (1.8–2.6)	52	2.2 (1.8–2.6)

TABLE 4. Association Between Noise Annoyance and Myocardial Infarction

	Men		Women	
Source of Noise	**Day OR (95% CI)***	**Night OR (95% CI)***	**Day OR (95% CI)***	**Night OR (95% CI)***
Road traffic	1.04 (0.97–1.12)	1.10 (1.01–1.20)	1.03 (0.90–1.18)	0.98 (0.84–1.14)
Aircraft	1.01 (0.93–1.10)	1.05 (0.93–1.19)	1.13 (0.97–1.32)	1.28 (1.01–1.63)
Rail	0.92 (0.82–1.04)	0.99 (0.85–1.15)	0.96 (0.78–1.18)	0.94 (0.71–1.24)
Industrial	1.06 (0.93–1.21)	0.91 (0.77–1.08)	1.11 (0.89–1.39)	1.02 (0.76–1.36)
Construction	1.08 (1.00–1.17)	1.10 (0.87–1.39)	1.05 (0.93–1.20)	1.17 (0.87–1.57)
Other outdoor	0.96 (0.88–1.05)	0.96 (0.86–1.07)	0.99 (0.85–1.15)	1.00 (0.82–1.22)
Impact noise	1.04 (0.95–1.14)	1.02 (0.90–1.16)	0.94 (0.79–1.11)	0.95 (0.75–1.20)
Other indoor	0.92 (0.84–1.02)	0.99 (0.87–1.12)	1.03 (0.88–1.21)	1.09 (0.89–1.33)

*Odds ratio per unit on a 5-point scale; separate models for males and females, day and night. Odds ratios are adjusted for the covariates listed in Table 1, work noise annoyance, and all other annoyance variables given in this table.

In the present study, findings from an earlier study using largely the same methods were confirmed. Male subjects who lived in streets with average A-weighted sound levels during the day of more than 70 dB(A) showed an increase in risk of MI compared with those who lived in streets with levels of less than or equal 60 dB(A). In the total sample, we found a modest odds ration of 1.3. In the subsample of subjects who had been living at their present for at least 10 years, the odds ratio was 1.8. There was a clear dose-response relationship of higher risk with increasing traffic noise. Noise levels of 65 dB(A) to 70 dB(A) outdoors have been considered as a relevant threshold of adverse health effects of noise.[3,23–25] When the 2 highest noise categories are combined (L_{Day} >65 dB(A)), the relative risk for men was 1.2 in the total sample and 1.4 in the subsample. The finding that the estimated effect is larger with longer residence is plausible and in accordance with the test hypothesis. The disease outcome under study has a long induction time. One would expect many years of chronic noise stress exposure before pathologic changes become manifest.[26,27] Residence time has also been found in other studies to be an important effect (exposure) modifier of the relationship between traffic noise and cardiovascular diseases.[5,28–30]

We found no higher MI risk among women with respect to traffic noise level, even after controlling for a large number of potentially confounding factors. Our finding of a slight increase in MI risk with increasing traffic noise level only in men is consistent with our finding of a positive relationship between noise annoyance resulting from road traffic noise and MI incidence only in men. The negative results among women were not controlled for possible differential effects of the intake of sex hormones, which may protect or promote adverse (noise-) stress effects.[31,32] In noise experiments, physiological reactions controlled by the autonomic nervous system were less pronounced in women than in men.[33,34] In large cross-sectional studies, a higher prevalence of high blood pressure was found among men exposed to traffic noise but not among exposed women.[35,36] Other authors have discussed the negative findings of a traffic noise and blood pressure study carried out on women with respect to the use of contraceptives.[37] Different time activity patterns may also contribute to differences in noise effects between the sexes. However, the sample of women was much smaller than the sample of men in our study, which could also contribute to the inconsistent findings.

No explanation can be given for the lower risk found in a subgroup of the reference group (a posteriori testing). Those subjects lived in side streets that were potentially affected by nearby main roads, although the noise exposure (L_{Day}) was below 60 dB(A) as for most of the reference group subjects who lived on side streets that were unaffected by main roads. It is possible that the subgroup with the lower risk was exposed to even higher traffic noise. The traffic volume dilutes with larger distances from main roads. Furthermore, those subjects were more annoyed by traffic noise than the rest of the reference group. Because monotonic trends between sound level and annoyance are repeatedly found in social surveys,[38,39] a higher traffic noise exposure, on average, can be inferred for those subjects. The difference in MI risk between the 2 subgroups is presumably the result of unknown factors unrelated to traffic noise. On acoustical grounds, no distinction can be made between the 2 subgroups (a priori testing).

The primary focus of the NaRoMI study was traffic noise. The noise exposure of each individual's home was precisely assessed within a range of the sound levels during the day between ≤60 and 80 dB(A). This means that subjects who lived only 20 or 30 yards from one another could differ in their outdoor noise exposure by 20 dB(A), which is a 100-fold range in terms of sound energy. It was impossible to be similarly precise with respect to occupational noise exposure. It was not possible to take noise measurements at each individual's workplace as a result of practical and legislative limitations (permission for measurement). Occupational noise exposure was therefore assessed by interviews of the subjects. Estimates of the noise exposure were made according to expert ratings regarding the noise exposure of characteristic occupational environments. The noise indicator used in the present analyses was negatively associated with MI incidence. The "healthy worker effect" may help to explain this finding.[40]

The study results support the hypothesis that chronic exposure to road traffic noise increases the risk for MI in men, thus confirming the results of the previous study using a similar case-control design. Although the previous study suggested a threshold effect, the data here suggest a monotonic increase in risk with increasing sound level. The effect estimates are larger than those of the previous study, particularly when the years of residence of the study subjects are considered in the analyses. This stronger association is probably the result of improvement in the assessment of noise exposure since the previous study, with the availability of noise maps embedded in a detailed graphic information system.

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ORIGINAL ARTICLE

Traffic-Related Air Pollution, Particulate Matter, and Autism

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Context: Autism is a heterogeneous disorder with genetic and environmental factors likely contributing to its origins. Examination of hazardous pollutants has suggested the importance of air toxics in the etiology of autism, yet little research has examined its association with local levels of air pollution using residence-specific exposure assignments.

Objective: To examine the relationship between traffic-related air pollution, air quality, and autism.

Design: This population-based case-control study includes data obtained from children with autism and control children with typical development who were enrolled in the Childhood Autism Risks from Genetics and the Environment study in California. The mother's address from the birth certificate and addresses reported from a residential history questionnaire were used to estimate exposure for each trimester of pregnancy and first year of life. Traffic-related air pollution was assigned to each location using a line-source air-quality dispersion model. Regional air pollutant measures were based on the Environmental Protection Agency's Air Quality System data. Logistic regression models compared estimated and measured pollutant levels for children with autism and for control children with typical development.

Setting: Case-control study from California.

Participants: A total of 279 children with autism and a total of 245 control children with typical development.

Main Outcome Measures: Crude and multivariable adjusted odds ratios (AORs) for autism.

Results: Children with autism were more likely to live at residences that had the highest quartile of exposure to traffic-related air pollution, during gestation (AOR, 1.98 [95% CI, 1.20-3.31]) and during the first year of life (AOR, 3.10 [95% CI, 1.76-5.57]), compared with control children. Regional exposure measures of nitrogen dioxide and particulate matter less than 2.5 and 10 μm in diameter ($PM_{2.5}$ and PM_{10}) were also associated with autism during gestation (exposure to nitrogen dioxide: AOR, 1.81 [95% CI, 1.37-3.09]; exposure to $PM_{2.5}$: AOR, 2.08 [95% CI, 1.93-2.25]; exposure to PM_{10}: AOR, 2.17 [95% CI, 1.49-3.16) and during the first year of life (exposure to nitrogen dioxide: AOR, 2.06 [95% CI, 1.37-3.09]; exposure to $PM_{2.5}$: AOR, 2.12 [95% CI, 1.45-3.10]; exposure to PM_{10}: AOR, 2.14 [95% CI, 1.46-3.12]). All regional pollutant estimates were scaled to twice the standard deviation of the distribution for all pregnancy estimates.

Conclusions: Exposure to traffic-related air pollution, nitrogen dioxide, $PM_{2.5}$, and PM_{10} during pregnancy and during the first year of life was associated with autism. Further epidemiological and toxicological examinations of likely biological pathways will help determine whether these associations are causal.

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AUTISM SPECTRUM DISORDERS are a group of developmental disorders commonly characterized by problems in communication, social interaction, and repetitive behaviors or restricted interests.[1] Although the severity of impairment for the autism spectrum disorders varies across the spectrum (full syndrome autism being the most severe), the incidence rate of all autism spectrum disorders is now reported to be as high as 1 in 110 children.[2] Emerging evidence suggests that environment plays a role in autism, yet at this stage, only limited information is available as to what exposures are relevant, their mechanisms of action, the stages of development in which they act, and the development of effective preventive measures.

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Recently, air pollution has been examined as a potential risk factor for autism.

Table 1. Spearman Correlations of Traffic-Related Air Pollution (TRP) and Regional Pollutants for 524 Children[a]

First Year of Life Estimates	All Pregnancy Estimates				
	TRP	$PM_{2.5}$	PM_{10}	Ozone	Nitrogen Dioxide
TRP	0.92[b]	0.36[c]	0.33[c]	−0.36[c]	0.60[c]
$PM_{2.5}$	0.25[d]	0.67[b]	0.77[c]	−0.11[c]	0.63[c]
PM_{10}	0.27[d]	0.84[d]	0.82[b]	0.13[c]	0.66[c]
Ozone	−0.31[d]	0.26[d]	0.27[d]	0.74[b]	−0.29[c]
Nitrogen dioxide	0.58[d]	0.60[d]	0.64[d]	−0.19[d]	0.89[b]

Abbreviations: $PM_{2.5}$, particulate matter less than 2.5 μm in aerodynamic diameter; PM_{10}, particulate matter less than 10 μm in aerodynamic diameter.
[a] All correlation measures were statistically significant ($P < .05$).
[b] Correlations of the same pollutant across time periods.
[c] Correlations across pollutants within pregnancy.
[d] Correlations across pollutants within the first year of life.

Using the Environmental Protection Agency's dispersion-model estimates of ambient concentrations of hazardous air pollutants, Windham and colleagues[3] identified an increased risk of autism based on exposure to diesel exhaust particles, metals (mercury, cadmium, and nickel), and chlorinated solvents in Northern California census tracts. Additional research using dispersion-model estimates of hazardous air pollutants also reported associations between autism and air toxics at the birth residences of children from North Carolina and West Virginia.[4] These epidemiologic findings on autism are supported by additional research[5,6] describing other physical and developmental effects of air pollution due to prenatal and early life exposure. For example, high levels of air pollutants have been associated with poor birth outcomes, immunologic changes, and decreased cognitive abilities.[5,6]

Recently, we reported an association between the risk of autism and an early life residence within 309 m of a freeway in the Childhood Autism Risks from Genetics and the Environment (CHARGE) study.[7] The near-source traffic-related air pollutant mixture has a large spatial variation, returning to near-background daytime levels beyond this distance.[8,9] Herein, we report associations of autism with estimates of exposure to the mixture of traffic-related air pollution and with regional measures of nitrogen dioxide, particulate matter less than 2.5 μm in aerodynamic diameter ($PM_{2.5}$), and particulate matter less than 10 μm in aerodynamic diameter (PM_{10}) in the CHARGE sample.

METHODS

The CHARGE study is a population-based case-control study of preschool children. The study design is described in detail elsewhere.[10] In brief, the participants in the CHARGE study were between the ages of 24 and 60 months at the time of recruitment, lived with at least one English- or Spanish-speaking biologic parent, were born in California, and lived in one of the study catchment areas. Recruitment was facilitated by the California Department of Developmental Services, the regional centers with which they contract to coordinate services for persons with developmental disabilities, and referrals from the MIND (Medical Investigation of Neurodevelopmental Disorders) Institute clinic at the University of California, Davis, and from other research studies. Population-based control children were recruited from the sampling frame of birth files from the state of California and were frequency matched by sex, age, and broad geographic area to the children with autism.

Each participating family was evaluated. Children with a previous diagnosis of autism were evaluated using the Autism Diagnostic Observation Schedules, and parents were administered the Autism Diagnostic Interview–Revised.[11,12] Children who received a diagnosis of developmental delay and control children from the general population were given the Social Communication Questionnaire to screen for the presence of autistic features.[13] If the Social Communication Questionnaire score was 15 or greater, the child was then evaluated using the Autism Diagnostic Observation Schedules, and the parent was administered the Autism Diagnostic Interview–Revised. In our study, autism cases were children with a diagnosis of full syndrome autism from both the Autism Diagnostic Observation Schedules and the Autism Diagnostic Interview–Revised. All children were also assessed using the Mullen Scales of Early Learning and the Vineland Adaptive Behavior Scales to collect information on motor skills, language, socialization, and daily living skills.[14,15] Controls were children from the general population who received a Social Communication Questionnaire score of less than 15 and who also showed no evidence of other types of delay (cognitive or adaptive).

Parents were interviewed to obtain, among other factors, demographic and medical information and residential histories. Race/ethnicity data were collected by self-report in categories defined by the US Census (**Table 1**). The residential data captured addresses and corresponding dates the mother and child lived at each location beginning 3 months before conception and extending to the most recent place of residence. Further details about the collection of clinical and exposure data have been previously reported.[10]

To obtain model-based estimates of exposure to traffic-related air pollution, we applied the CALINE4 line-source air-quality dispersion model.[16] The dispersion model was used to estimate average concentrations for the specific locations and time periods (trimesters of gestation and first year of life) for each participant. The principal model inputs are roadway geometry, link-based traffic volumes, period-specific meteorological conditions (wind speed and direction, atmospheric stability, and mixing heights), and vehicle emission rates. Detailed roadway geometry data and annual average daily traffic counts were obtained from Tele Atlas/Geographic Data Technology in 2005. These data represent an integration of state-, county-, and city-level traffic counts collected between 1995 and 2000. Because our period of interest was from 1997 to 2008, the counts were scaled to represent individual years based on estimated growth in county average vehicle-miles-traveled data.[17] Traffic counts were assigned to roadways based on location and street names. Traffic volumes on roadways without count data (mostly small roads) were estimated based on median volumes for similar class roads in small geographic regions. Meteorological data from 56 local monitoring stations were matched to the dates and locations of interest. Vehicle fleet average emission factors were based on the California Air Resource Board's EMFAC2007 (version 2.3) model. Annual average emission factors were calculated by year (1997-2008) for travel on freeways (65 mph), state highways (50 mph), arterials (35 mph), and collector roads (30 mph) (to convert to kilometers, multiply by 1.6). We used the CALINE4 model to estimate locally varying ambient concentrations of nitrogen oxides contributed by freeways, nonfreeways, and all roads located within 5 km of each child's home. Previously, we have used the CALINE4 model to estimate concentrations of other traffic-related pollutants, including elemental carbon and carbon monoxide, and found that they were almost perfectly correlated (around 0.99) with estimates for nitrogen oxides. Thus, our model-based concentrations should be viewed as an indicator of the traffic-related pollutant mixture rather than of any pollutant specifically.

A second approach was to use the regional air quality data for the exposure assignments for $PM_{2.5}$, PM_{10}, ozone, and nitrogen dioxide. These were derived from the US Environmental Protection Agency's Air Quality System data (http://www.epa.gov/ttn/airs/airsaqs) supplemented by University of Southern California Children's Health Study data for 1997 though 2009.[18] The Children's Health Study continuous PM data were used for a given monitoring station when no Federal Reference/Equivalent Method data for PM were available from the Air Quality System. The monthly air quality data from monitoring stations located within 50 km of each residence were made available for spatial interpolation of ambient concentrations. The spatial interpolations were based on inverse distance–squared weighting of data from up to 4 of the closest stations located within 50 km of each participant's residence; however, if 1 or more stations were located within 5 km of a residence, then only data from the stations within 5 km were used for the interpolation. Because special studies have shown large offshore-to-onshore pollutant gradients along the Southern California coast, the interpolations were performed with pseudostations (or theoretical locations used for estimating pollution gradients from extant data when geography did not permit observed data) located approximately 20 to 40 km offshore that had background concentrations based on long-term measurements (1994-2003) at clean coastal locations (ie, Lompoc, California).

Periods and locations relevant to the modeled traffic exposure were identified based on dates and addresses recorded on the child's birth certificate and from the residential history questionnaire. The birth certificate addresses corresponded to the mother's residence at the time of the child's birth, whereas the residential history captures both the mother's residences during pregnancy (required for estimation of prenatal exposure) and the child's residences after birth through the time of study enrollment. We determined the conception date for each child using gestational age from ultrasonographic measurements or the date of last menstrual period, as determined from prenatal records. We used these locations and dates to estimate exposure for the child's first year of life, for the entire pregnancy period, and for each trimester of pregnancy. When more than 1 address fell into a time interval, we created a weighted average to reflect the exposure level of the participant across the time of interest, taking into account changes in residence. Traffic-related air pollution was determined based on the required inputs reflecting change in each address over the study period. For the regional pollutant measures, we assigned $PM_{2.5}$, PM_{10}, and nitrogen dioxide measurements based on average concentrations for the time period of interest. For ozone, we calculated the averages for the period of interest based on the average range of ozone measurements from 1000 to 1800 hours (reflecting the high 8-hour daytime). Based on these methods, we were able to assign traffic-related air pollutant estimates and regional pollutant measures for 524 mother-child pairs.

Spearman correlations were calculated pairwise between traffic-related air pollutant estimates and regional pollution measures for pregnancy and the first year of life to assess the independence of these exposure metrics. We used logistic regression to examine the association between exposure to traffic-related air pollution and the risk of autism. Models of autism risk as a function of traffic-related air pollutant exposure levels from all road types were fitted separately for each time period. Categories of exposure were formed based on quartiles of the traffic-related air pollutant distribution for all pregnancy estimates because this provided the most comprehensive data for each child. Levels of regional pollutants were examined as continuous variables, and effect estimates were scaled to twice the standard deviation of the distribution for all pregnancy estimates. When levels of correlation permitted, we examined both traffic-related air pollutants and regional pollutants in a single model. Pertinent covariates were included in each model to adjust for potential confounding due to sociodemographic and lifestyle characteristics. We included children's sex and ethnicity, maximum education level of the parents, mother's age, and whether the mother smoked during her pregnancy, as described previously.[7] To examine whether our findings were affected by participants living in an urban or rural area, we included population density, which was obtained from Environmental Systems Research Institute Inc 2008 estimates of people per square meter using ArcGIS software version 9.2. We used the US Census Bureau cutoff of 2500 people per square meter to categorize population density into urban vs rural areas and included this variable as a covariate in our analysis of the effects of air pollution from the first year of life because these residences were the most recently recorded.

We also fitted logistic additive models to evaluate the relationship between autism and traffic-related air pollution. These models used the smoothing spline with 3 degrees of freedom for continuous traffic-related air pollution and used the same adjustment variables as in the linear logistic models already described. Statistical tests were conducted using an α level of .05, and 95% CIs were used to measure precision. All analyses were conducted using the R package version 2.9.2 (http://www.r-project.org). The institutional review boards of the University of Southern California and the University of California, Davis, approved the research.

RESULTS

The children in our study were predominantly male (84%), and most were non-Hispanic white (50%) or Hispanic (30%). No differences were found between cases and controls for any demographic, socioeconomic, or lifestyle variables that we examined (eTable, http://www.jamapsych.com). Details regarding the exposure distributions are presented in the eFigure, A and B. The Spearman correlations calculated for the first year of life and the pregnancy time periods are presented in Table 1. During pregnancy and during the first year of life, traffic-related air pollution was moderately correlated with $PM_{2.5}$ and PM_{10}, highly correlated with nitrogen dioxide, but inversely correlated with ozone. Among the regional pollutant measures, $PM_{2.5}$ and PM_{10} were nearly perfectly correlated, and both were highly correlated with nitrogen dioxide. Correlations with ozone were low and often negative, demonstrating an inverse relationship. We also ex-

Table 2. Risk of Autism for 524 Children, by Quartile[a] of Modeled Traffic-Related Air Pollution Exposure From All Road Types

	Odds Ratio (95% CI)		
Time Period	4th Quartile	3rd Quartile	2nd Quartile
First year of life			
Crude	2.97 (1.71-5.27)	1.00 (0.63-1.60)	0.88 (0.55-1.42)
Adjusted[b]	3.10 (1.76-5.57)	1.00 (0.62-1.62)	0.91 (0.56-1.47)
All pregnancy			
Crude	1.99 (1.22-3.28)	1.10 (0.67-1.78)	1.20 (0.74-1.95)
Adjusted[b]	1.98 (1.20-3.31)	1.09 (0.67-1.79)	1.26 (0.77-2.06)
First trimester			
Crude	1.91 (1.67-3.14)	1.28 (0.80-2.06)	1.28 (0.77-2.14)
Adjusted[b]	1.85 (1.11-3.08)	1.28 (0.79-2.08)	1.28 (0.77-2.15)
Second trimester			
Crude	1.69 (1.04-2.78)	1.15 (0.71-1.87)	0.89 (0.54-1.47)
Adjusted[b]	1.65 (1.00-2.74)	1.13 (0.69-1.84)	0.90 (0.54-1.49)
Third trimester			
Crude	2.04 (1.25-3.38)	0.92 (0.57-1.48)	1.12 (0.68-1.84)
Adjusted[b]	2.10 (1.27-3.51)	0.91 (0.56-1.46)	1.17 (0.71-1.93)

[a] Quartile cut points correspond to traffic-related air pollution exposure levels of 31.8 ppb or greater (fourth quartile), 16.9 to 31.8 ppb (third quartile), and 9.7 to 16.9 ppb (second quartile), compared with 9.7 ppb or less (first quartile [reference group]).

[b] Model adjusted for male sex of child, child's ethnicity (Hispanic vs white; black/Asian/other vs white), maximum education of parents (parent with highest of 4 levels: college degree or higher vs some high school, high school degree, or some college education), maternal age (>35 years vs ≤35 years), and prenatal smoking (mother's self-report of ever vs never smoked while pregnant).

amined correlations of each pollutant across time periods, and high levels of correlation were identified.

EXPOSURE TO TRAFFIC-RELATED AIR POLLUTION

An increased risk of autism was associated with exposure to traffic-related air pollution during a child's first year of life. Children residing in homes with the highest levels of modeled traffic-related air pollution were 3 times as likely to have autism compared with children residing in homes with the lowest levels of exposure (**Table 2**). Exposure in the middle quartile groups (second and third quartiles) was not associated with an increased risk of autism. In our analysis, which included population density, this association with the highest quartile of exposure was still evident (adjusted odds ratio [AOR], 3.48 [95% CI, 1.81-6.83]), and living in an urban area, compared with living in a rural area, was not associated with autism (AOR, 0.86 [95% CI, 0.56-1.31]). When we examined traffic-related air pollutant exposures during pregnancy, the highest quartile was also associated with autism risk (AOR, 1.98 [95% CI, 1.20-3.31]) compared with the lowest quartile. We further divided the pregnancy into 3 trimesters and modeled traffic-related air pollution based on these intervals. During all 3 trimesters of pregnancy, we found associations with the highest quartile of exposure (≥31.8 ppb), compared with the lowest quartile (≤9.7 ppb), and autism (Table 2). Inclusion of demographic and socioeconomic variables in the models did not greatly alter these associations (Table 2).

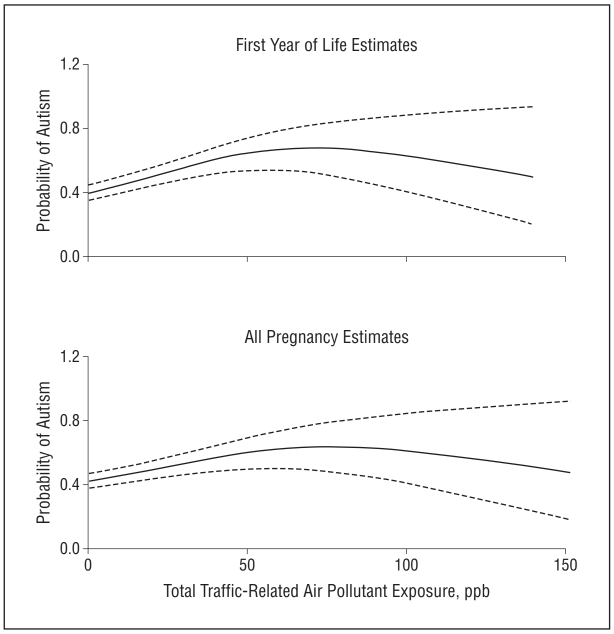

Figure. Probability of autism by increasing level of children's exposure to traffic-related air pollution during the first year of life and during gestation. The dashed lines indicate the 95% CI.

Because our quartile-based categories indicated that there is a threshold upon which traffic-related air pollutant exposure is detrimental, we also examined the relationship between traffic-related air pollutant exposure and autism using smoothed models for the first year of life and all of pregnancy. An increasing probability of autism was seen with increasing traffic-related air pollutant estimates, with the odds reaching a plateau when these estimates were above 25 to 30 ppb (**Figure**).

REGIONAL AIR POLLUTANT EXPOSURE

The higher levels of exposure to $PM_{2.5}$, PM_{10}, and nitrogen dioxide based on the Environmental Protection Agency's regional air quality monitoring program were associated with an increased risk of autism (**Table 3**). Specifically, for an 8.7-unit increase (micrograms per cubic meter) in $PM_{2.5}$ (corresponding to twice the standard deviation of the $PM_{2.5}$ distribution) exposure during the first year of life, children were 2.12 times more likely to have autism. Increases were also present for pregnancy and trimester-specific estimates of $PM_{2.5}$, with the smallest effects present in the first trimester. For PM_{10}, a 14.6-unit increase (micrograms per cubic meter) during the first year was associated with twice the risk of autism (Table 3). Associations were present for pregnancy and for each trimester, with the first trimester having the smallest magnitude. We did not find associations between levels of regional ozone and autism. Regional nitrogen dioxide exposure during the first year was associated with a 2-fold risk of autism. Similar effects were identified for nitrogen dioxide exposure during pregnancy. Although exposure during each of the 3 trimesters was associated with autism, the effects of the first trimester were the smallest. For all regional pollutant measures, adjustment for demographic and socioeconomic

Table 3. Risk of Autism for 524 Children Based on Continuous Regional Pollutant Exposure[a]

	Odds Ratio (95% CI)			
Time Period	**$PM_{2.5}$**	**PM_{10}**	**Ozone**	**Nitrogen Dioxide**
First year				
Crude	2.14 (1.48-3.09)	2.14 (1.47-3.10)	1.15 (0.72-1.84)	2.06 (1.39-3.06)
Adjusted[b]	2.12 (1.45-3.10)	2.14 (1.46-3.12)	1.15 (0.72-1.86)	2.06 (1.37-3.09)
All pregnancy				
Crude	2.11 (1.46-3.03)	2.17 (1.50-3.13)	1.08 (0.76-1.52)	1.82 (1.26-2.64)
Adjusted[b]	2.08 (1.93-2.25)	2.17 (1.49-3.16)	1.09 (0.76-1.55)	1.81 (1.23-2.65)
First trimester				
Crude	1.24 (0.99-1.56)	1.47 (1.10-1.98)	1.07 (0.86-1.33)	1.47 (1.07-2.01)
Adjusted[b]	1.22 (0.96-1.53)	1.44 (1.07-1.96)	1.08 (0.86-1.35)	1.44 (1.05-1.20)
Second trimester				
Crude	1.50 (1.16-1.93)	1.82 (1.35-2.45)	1.03 (0.84-1.27)	1.62 (1.17-2.25)
Adjusted[b]	1.48 (1.40-1.57)	1.83 (1.35-2.47)	1.04 (0.84-1.29)	1.61 (1.15-2.25)
Third trimester				
Crude	1.39 (1.11-1.75)	1.61 (1.21-2.13)	1.03 (0.84-1.27)	1.65 (1.19-2.27)
Adjusted[b]	1.40 (1.11-1.77)	1.61 (1.20-2.14)	1.03 (0.83-1.26)	1.64 (1.18-2.29)

Abbreviations: $PM_{2.5}$, particulate matter less than 2.5 µm in aerodynamic diameter; PM_{10}, particulate matter less than 10 µm in aerodynamic diameter.

[a] Regional pollution effects reflect risk of autism based on 2 SDs from the mean value, specifically per increase of 8.7 $\mu g/m^3$ of $PM_{2.5}$, 14.6 $\mu g/m^3$ of PM_{10}, 14.1 ppb of nitrogen dioxide, and 16.1 ppb of ozone.

[b] Models adjusted for male sex of child, child's ethnicity (Hispanic vs white; black/Asian/other vs white), maximum education of parents (parent with highest of 4 levels: college degree or higher vs some high school, high school degree, or some college education), maternal age (>35 years vs ≤35 years), and prenatal smoking (self-report of ever vs never smoked while pregnant).

variables did not alter the associations. As with traffic-related air pollution, when we included population density in the models that included exposure during the first year of life, the associations with $PM_{2.5}$, PM_{10}, and nitrogen dioxide did not change, nor did they change when living in an urban area vs a rural area was included (data not shown).

TRAFFIC-RELATED AIR POLLUTION, $PM_{2.5}$, AND PM_{10}

Because pairwise correlations between traffic-related air pollution and $PM_{2.5}$ and between traffic-related air pollution and PM_{10} were moderate, we included both in models to examine whether local pollution estimates (traffic-related air pollution) and regional pollution measures ($PM_{2.5}$ and PM_{10}) were independently associated with autism. In these analyses, we included the same set of covariates already described in the single pollutant analysis. When examined in the same model, the top quartile of traffic-related air pollutant exposure (AOR, 2.37 [95% CI, 1.28-4.45]) and the exposure to $PM_{2.5}$ (AOR, 1.58 [95% CI, 1.03-2.42]) during the first year of life remained associated with autism. Examining both traffic-related air pollution and PM_{10}, we found that the top quartile of traffic-related air pollutant exposure (AOR, 2.36 [95% CI, 1.28-4.43]) and the exposure to PM_{10} (AOR, 1.61 [95% CI, 1.06-2.47]) remained associated with autism. For the all pregnancy time interval, we found that the top quartile of traffic-related air pollutant exposure (AOR, 2.42 [95% CI, 1.32-4.50]) and the exposure to $PM_{2.5}$ (AOR, 1.60 [95% CI, 1.07-2.40]) were associated with autism when examined in the same model. Similarly, both the top quartile of traffic-related air pollutant exposure (AOR, 2.33 [95% CI, 1.27-4.36]) and the exposure to PM_{10} (AOR, 1.68 [95% CI, 1.11-2.53]) remained associated with autism when examined jointly.

COMMENT

Our study found that local estimates of traffic-related air pollution and regional measures of $PM_{2.5}$, $PM_{10,}$ and nitrogen dioxide at residences were higher in children with autism. The magnitude of these associations appear to be most pronounced during late gestation and early life, although it was not possible to adequately distinguish a period critical to exposure. Children with autism were 3 times as likely to have been exposed during the first year of life to higher modeled traffic-related air pollution compared with control children with typical development. Similarly, exposure to traffic-related air pollution during pregnancy was also associated with autism. Examination of traffic-related air pollution using an additive logistic model demonstrated a potential threshold near 25 to 30 ppb beyond which the probability of autism did not increase. Exposure to high levels of regional $PM_{2.5}$, PM_{10}, and nitrogen dioxide were also associated with autism. When we examined $PM_{2.5}$ or PM_{10} exposure jointly with traffic-related air pollutant exposure, both regional and local pollutants remained associated with autism, although the magnitude of the effects decreased.

We previously reported an association between living near a freeway (based on the location of the birth and third trimester address) and autism.[7] That result relied on simple distance metrics as a proxy for exposure to traffic-related air pollution. The present study builds on that result, demonstrating associations with both regional particulate and nitrogen dioxide exposure and to dispersion-modeled exposure to the near-roadway traffic mixture accounting for traffic volume, fleet emission factors, and wind speed and direction, in addition to traffic proximity. The results provide more convincing evidence that exposure to local air pollution from traffic may increase the risk of autism. Demographic or socioeconomic factors did not explain these associations.

Toxicological and genetic research suggests possible biologically plausible pathways to explain these results. Concentrations of many air pollutants, including diesel exhaust particles and other PM constituents, are increased near freeways and other major roads, and diesel exhaust particles and polycyclic aromatic hydrocarbons (commonly present in diesel exhaust particles) have been shown to affect brain function and activity in toxicological studies.[19-23] Polycyclic aromatic hydrocarbons have been shown to reduce expression of the *MET* receptor tyrosine kinase gene, which is important in early life neurodevelopment and is markedly reduced in autistic brains.[24,25] Other research indicates that traffic-related air pollution induces inflammation and oxidative stress after both short- and long-term exposure, processes that mediate the effects of air pollution on respiratory and cardiovascular disease and other neurological outcomes.[26-29] Data examining biomarkers suggest that oxidative stress and inflammation may also be involved in the pathogenesis of autism.[30-33]

Emerging evidence suggests that systemic inflammation may also result in damage to endothelial cells in the brain and may compromise the blood-brain barrier.[29] Systemic inflammatory mediators may cross the blood-brain barrier, activating brain microglia, and peripheral monocytes may migrate into the pool of microglia.[34-36] In addition, ultrafine particles ($PM_{0.1}$) may penetrate cellular membranes.[37,38] These particles translocate indirectly through the lungs and from the systemic circulation or directly via the nasal mucosa and the olfactory bulb into the brain.[39,40] Toxicity may be mediated by the physical properties of PM or by the diverse mixture of organic compounds, including polycyclic aromatic hydrocarbons, and oxidant metals adsorbed to the surface.[29] Neurodevelopmental effects of polycyclic aromatic hydrocarbons may be mediated by aryl hydrocarbon hydroxylase induction in the placenta, decreased exchange of oxygen secondary to disruption of placental growth factor receptors, endocrine disruption, activation of apoptotic pathways, inhibition of the brain antioxidant-scavenging system resulting in oxidative stress, or epigenetic effects.[21]

Our study draws on a rich record of residential locations of children with typical development and children with autism across California, allowing us to assign modeled pollutant exposures for developmentally relevant time points. However, our results could also be affected by unmeasured confounding factors associated with both autism and exposure to traffic-related air pollution. Although we did not find that including demographic or socioeconomic variables altered our estimates of effect, confounding by other factors could still occur. These might include lifestyle, nutritional, or other residential exposures, if they were associated with traffic-related air pollution or PM. We have also not explored indoor sources of pollution, such as indoor nitrogen oxide or secondhand tobacco smoke, although prenatal smoking was examined and did not influence the associations of ambient pollution with autism. In addition, confounding could have occurred if proximity to diagnosing physicians or treatment centers was also associated with exposure. We included population density as an adjustment in an analysis using estimates from the first year of life to examine the sensitivity of our results to urban or rural locations, for which population density is a surrogate. We did not find that living in a more densely populated area altered the association between risk of autism and exposure to traffic-related air pollution or regional pollutants. Despite our attempts to use residential history to examine specific time windows of vulnerability, to incorporate meteorology into our traffic-related air pollutant models, and to include pollutants with seasonal variation, we are currently unable to disentangle the trimester-specific effects during the first year of life because of the high level of correlation across these time periods.

Exposures to traffic-related air pollution, PM, and nitrogen dioxide were associated with an increased risk of autism. These effects were observed using measures of air pollution with variation on both local and regional levels, suggesting the need for further study to understand both individual pollutant contributions and the effects of pollutant mixtures on disease. Research on the effects of exposure to pollutants and their interaction with susceptibility factors may lead to the identification of the biologic pathways that are activated in autism and to improved prevention and therapeutic strategies. Although additional research to replicate these findings is needed, the public health implications of these findings are large because air pollution exposure is common and may have lasting neurological effects.

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ENVIRONMENTAL HEALTH

RESEARCH **Open Access**

Traffic-related air pollution and obesity formation in children: a longitudinal, multilevel analysis

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Abstract

Background: Biologically plausible mechanisms link traffic-related air pollution to metabolic disorders and potentially to obesity. Here we sought to determine whether traffic density and traffic-related air pollution were positively associated with growth in body mass index (BMI = kg/m^2) in children aged 5–11 years.

Methods: Participants were drawn from a prospective cohort of children who lived in 13 communities across Southern California (N = 4550). Children were enrolled while attending kindergarten and first grade and followed for 4 years, with height and weight measured annually. Dispersion models were used to estimate exposure to traffic-related air pollution. Multilevel models were used to estimate and test traffic density and traffic pollution related to BMI growth. Data were collected between 2002–2010 and analyzed in 2011–12.

Results: Traffic pollution was positively associated with growth in BMI and was robust to adjustment for many confounders. The effect size in the adjusted model indicated about a 13.6% increase in annual BMI growth when comparing the lowest to the highest tenth percentile of air pollution exposure, which resulted in an increase of nearly 0.4 BMI units on attained BMI at age 10. Traffic density also had a positive association with BMI growth, but this effect was less robust in multivariate models.

Conclusions: Traffic pollution was positively associated with growth in BMI in children aged 5–11 years. Traffic pollution may be controlled via emission restrictions; changes in land use that promote jobs-housing balance and use of public transit and hence reduce vehicle miles traveled; promotion of zero emissions vehicles; transit and car-sharing programs; or by limiting high pollution traffic, such as diesel trucks, from residential areas or places where children play outdoors, such as schools and parks. These measures may have beneficial effects in terms of reduced obesity formation in children.

Keywords: Childhood obesity, Air pollution, Traffic, California

Introduction

Childhood obesity has emerged as a major public health problem in the United States and elsewhere. Since the 1970s rates of overweight and obesity have more than doubled in the U.S. from about 15% of youth aged 2–19 years who were considered overweight or obese, to 32% in 2003–2006 [1,2]. Although the trend toward increasing obesity in the U.S. appears to have abated over the past ten years [3], the existing high prevalence remains a concern. Similar patterns of increasing childhood obesity prevalence have been reported in several other countries [4]. The increased prevalence of overweight and obesity in children has serious ramifications for future trends of metabolic disorders and disease, cardiovascular and pulmonary disease, gastrointestinal conditions, skeletal problems, cancer incidence, mortality, and psychosocial disorders [5-7]. While genetic and metabolic susceptibilities exist, the rapid rise in obesity prevalence implicates environmental factors as contributors to obesity development in children [8].

Growing evidence links the built environment to physical activity, dietary intake, and obesity [9]. Previous research has examined the impacts of land use patterns such as “urban sprawl” [10], local land use mixtures

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[11], and accessibility of neighborhood features that either promote or undermine health (e.g., exercise facilities or fast food outlets) [12,13]. Much of the existing evidence comes from cross-sectional studies [14], raising questions of reverse causality whereby individuals and families who would have otherwise stayed at a healthy weight locate in neighborhoods that support their already active lifestyles and nutritional food intake.

Recently, researchers examined longitudinally the role of traffic density around the homes of children. They found that higher levels of vehicular traffic were associated with higher attained body mass index (BMI measured as kg/m^2) in children aged 10–18 [15]. Traffic is associated with several adverse exposures including increased accident danger and air pollution [16], suggesting different explanations for the positive association between traffic and attained BMI. Heightened traffic danger may discourage children from engaging in active transport by foot or bicycle for utilitarian purposes [17], and other things being equal, this would lower overall physical activity and could contribute to a positive energy balance.

Other research indicates that air pollution exposure, with traffic as a major source in many cities, may operate through inflammatory pathways to initiate metabolic processes contributing to diabetes formation [18,19]. These findings are supported by animal research showing that mice fed a fat chow diet and exposed to air pollution develop more visceral fat and insulin resistance than mice eating the same diet, but breathing purified air [20].

At this time, there are few epidemiological studies that have investigated specifically whether air pollution contributes to obesity formation in childhood, and only one study has examined traffic density effects on BMI growth [15]. A recent study suggested that early life exposure to polyaromatic hydrocarbon markers of ambient traffic-related pollution were associated with subsequent increased BMI and obesity at age seven [21]. Here we aim to assess the impact of traffic-related air pollution and traffic density near the home on the growth of BMI in a prospective cohort of children who were followed from age 5–11 in 13 Southern California communities. This paper seeks to expand on the earlier assessment of traffic as a risk factor by examining the specific pathway of air pollution exposure. In this context, the main aim of the study is to assess whether exposure to traffic and traffic-related air pollution relate to BMI growth in children.

Methods

Conceptual framework

In Figure 1, we propose the following conceptual model to illustrate the pathways through which traffic might affect obesity and cardio-metabolic disorders. Traffic could influence perceived safety and thereby affect the amount of active travel by foot or by bike. In this instance, we hypothesize that higher traffic could reduce physical activity, and as noted above, this could positively change energy balance. Previous research on this and similar cohorts has demonstrated that traffic can negatively affect active travel [22] and that this may lead to higher levels of obesity [15]. Another pathway could operate through perceived safety, noise and vibration, which all have the potential to increase stress. Stress has been associated with higher intakes of fat and carbohydrates and with cortisol and sleep dis-regulation that can affect the diet. All of these pathways, if they lead to altered eating habits, could contribute to obesity. In recent research on the same cohort, we showed that stress in the family is linked to small increases in BMI growth [23]. Finally, there is the impact of environmental and traffic-related pollution. Here the effect could operate through systemic inflammation to increase pro-obesogenic pathways mentioned above [20] or through the formation of chronic diseases that might lessen physical activity and have themselves been associated with obesity in the case of asthma [24,25]. Some components of traffic-related air pollution may contain endocrine disruptors that could be obesogens. This pathway might be enhanced through other obesogen exposures from other environmental sources such as phthalates [26]. This framework is used to guide our statistical modeling in terms of selecting variables to test for confounding and to help interpret our results where specific variables are unavailable for analyses (e.g., biomarkers of obesogen exposures).

Ethics statement

The research protocol, including informed consent forms, was reviewed and approved by the Institutional Review Board, University of Southern California. Subsequent approval was given by the Committee on the Protection of Human Subjects, University of California, Berkeley for the geographic information exposure assignment to the homes of the study subjects.

Study design

A cohort of children attending kindergarten and first grade (age 5–7 years) were enrolled during the 2002–03 school year from classrooms in 45 schools across 13 communities in Southern California (N = 4550). Parents provided informed consent and completed a detailed baseline and yearly follow-up questionnaires with information about asthma and related symptoms, demographic characteristics, physical activity, characteristics of homes, and other relevant covariates. Height and weight were measured without shoes at study entry and annually by a trained technician at the child's school.

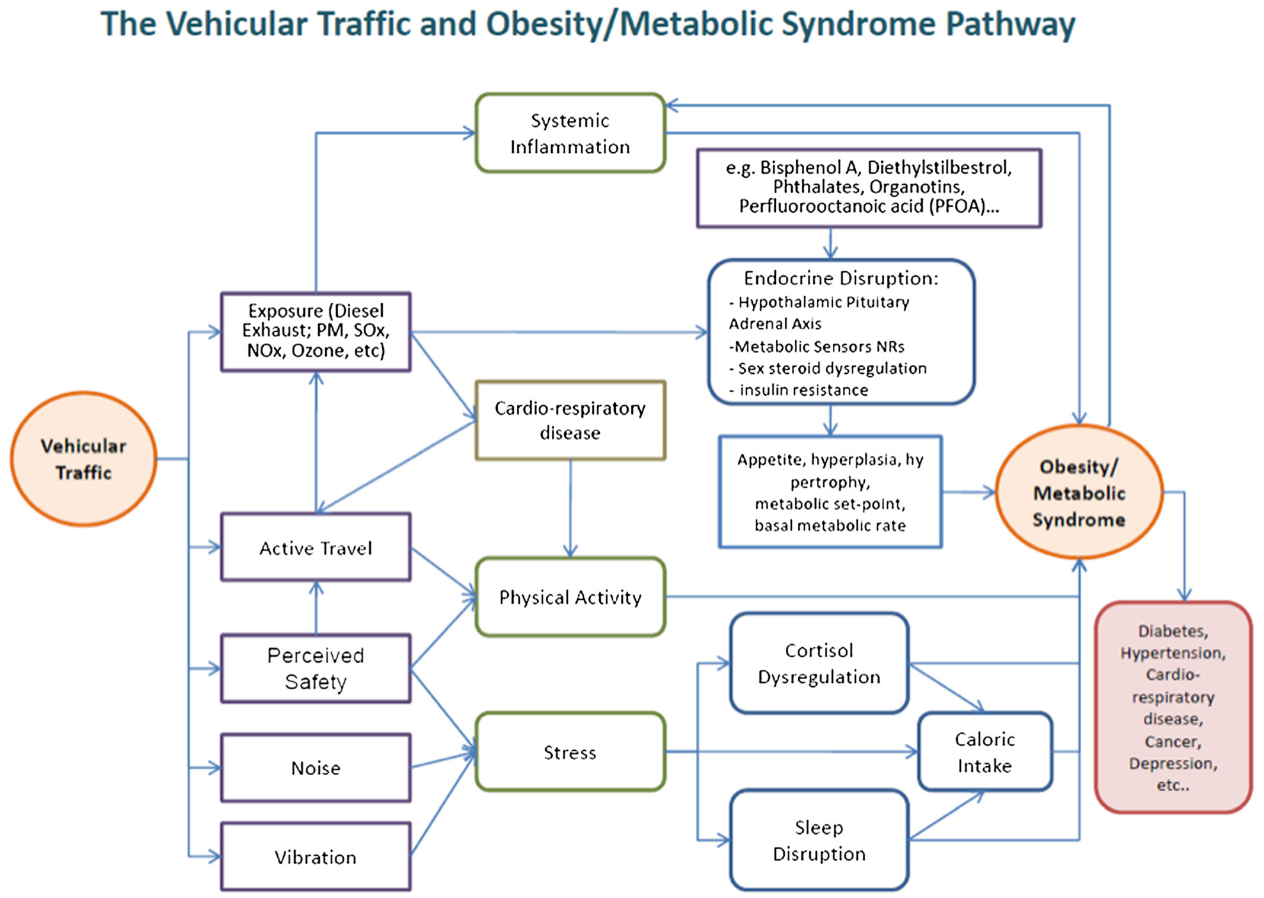

Figure 1 Conceptual framework. Conceptual framework illustrating pathways from vehicle traffic to obesity and metabolic syndromes.

Technicians followed a standardized procedure to measure height and weight using a calibrated medical scale. Measurements were recorded to the nearest 1 cm and 1 lb (0.45 kg), respectively. These objective measures of height and weight allowed for accurate calculation of BMI.

Other characteristics of this cohort have been described previously [27]. Information on demographic characteristics from questions that were asked repeatedly in yearly questionnaires was updated for this analysis. We also collected information on physical activity, mainly in the form of programmed activities and team sports (see Additional file 1 for details). The analytical data set was restricted to children who had two or more measurements of height and weight (N = 4257).

Homes of the children were geo-coded. Built-environment variables such as access to parks were calculated around the children's homes and schools and assigned to each child (see [13,15] for more detail on the built environment variable compilation). Neighborhood and community social environmental variables, such as the poverty rate available from the U.S. Census, were also assigned to the residential address for inclusion as confounders in our multilevel models.

Exposure models

Exposure to air pollution was assigned using the CALINE4 dispersion model (see Additional file 1 for details). Briefly, this model used Gaussian plume dispersion parameters with traffic data, emissions factors, and local meteorology to estimate exposure to the mixture of near-roadway pollutants at the homes of the children based on a model for the incremental increase in nitrogen oxides (NO_x) above regional background levels, as previously described [27]. Exposures for freeway and non-freeway sources were assigned to the baseline address of the children.

Traffic exposure variables were based on the California Department of Transportation Functional Class (FC) data for the year 2000. The annual average daily traffic (AADT) volumes were conflated to the TeleAtlas road network [28]. Traffic data were based on continuous measurements on freeways, highways, and some major arterials, and intermittent measurements within the previous three years on other major roads. The spatial pattern of traffic density changes slowly over time and the temporal period used here likely supplies a good representation of the longer-term traffic patterns around the subjects' homes for our study period. As described elsewhere, a kernel density function was estimated to smooth the influence of traffic around the home [15]. This function down-weighted the influence of traffic exposures as a function of Euclidian distance away from the child's home. Based on previous evidence [15], traffic density was examined within 150 m of the home.

Statistical methods

A multilevel linear model was used that allowed for examination of the effects that risk factors have on attained BMI level at age 10 and the rate of growth during the follow-up period between the ages of 5–11 years [29,30]. This modeling approach properly adjusts for age- and sex- specific effects on BMI growth in children, provides an effective mechanism for assessing effects of risk factors on BMI level and growth, and also implicitly adjusts for baseline levels of BMI. Letting c, i and j denote the study community, child and year of measurement, respectively, the following multi-level linear model was used to examine the effect of an exposure variable (e.g., NOx) at the individual level, X_{ci}, on BMI, Y_{cij}:

$$Level\ 1: \quad Y_{cij} = A_{ci} + B_{ci}t_{cij} + e_{cij} \tag{1}$$

$$Level\ 2a: \quad A_{ci} = A_c + \beta_1 X_{ci} + \delta_1 Z_{ci1} + \cdots + \delta_q Z_{ciq} + e_{ci} \tag{2}$$

$$Level\ 2b: \quad B_{ci} = \beta_0 + \beta_2 X_{ci} + f_{ci} \tag{3}$$

where t_{cij} denotes age of participants at time of BMI measurements (centered at 10 years of age), A_c denotes town specific intercepts, and $Z_1, \ldots, Z_q$ denote adjustment factors such as sex, and race/ethnicity categories. Our results were obtained by combining equations (1–3) to fit the following unified mixed effects model:

$$\begin{aligned} Y_{cij} = A_c + \beta_0 t_{cij} + \beta_1 S_{ci} + \beta_2 S_{ci} \times t_{cij} + \delta_1 Z_{ci1} \\ + \cdots + \delta_q Z_{ciq} + e_{ci} + f_{ci} t_{cij} + e_{cij} \end{aligned} \tag{4}$$

In Eqn (4), β_1 and β_2 correspond to the simultaneously estimated effects of exposure on BMI level attained at age 10 (i.e., examining the main effect between individuals) and also the yearly slope of change in BMI during the follow-up period, respectively. Random effects for community were used in models that assessed confounding by community level covariates such as poverty and crime rates, essentially leading to three-level models.

This modeling approach allowed for examination of the effects of covariates of interest at various levels: between times (within individual), between individuals, and between other levels of spatial aggregation (e.g., school or community). The base model included indicator functions for community, gender, and race or ethnicity. A final model was then developed by including all additional confounders that individually changed the effect of interest on the attained BMI level at age 10 (level) or the rate of change in BMI levels (slope) by at least 10%. All confounders were included for both "level" and "slope". Analyses were conducted using SAS (Cary, NC, U.S.) and R (Vienna, Austria) statistical software packages.

In these multilevel models, more than 50 confounding variables were screened at the individual, neighborhood, school, and community scales. As a sensitivity analysis, models with both random and fixed effects clustered on the schools of the children were also run.

Results

The mean age of children at study entry was 6.6 years (standard deviation (SD) 0.65; range 4.5-8.9). Average BMI was 16.79 at study entry (SD 2.81) (Table 1). By year 5 of the study BMI had increased approximately 2.6 units to 19.35 (SD 4.21) with boys showing a slightly greater increase. Based on Centers for Disease Control percentiles between the 85th and 95th percentile, rates of overweight were 14.4%. Obesity rates measured as BMI scores equal to or greater than the 95th percentile were 15%. The growth curves for BMI in boys and girls are shown in Figure 2. The slope of the growth curve over the follow-up period did not deviate from a linear trend.

Traffic density at 150 m radius had a positive, but borderline significant (p <0.1) association with the intercept and the slope of BMI growth curves of the children (Table 2). Further evaluation of the traffic effects revealed that they were confounded by other variables, particularly whether the questionnaire had been completed in Spanish, suggesting the child was from a family of recent immigrants from Latin America. A final model included asthma status of the child, the language used to complete the questionnaire (Spanish or English), whether the child was exposed to second-hand smoke in the home, the parental level of education, the gamma index (a measure of the connectivity of the street network around the child's home which affects walking distances), the number of fast food outlets within 500 m of the child's home, greenness around the home as measured by the normalized difference vegetation index, the number of active recreational programs for children offered within 5 km of the home, and traffic density at 150 m (Table 2). In this fully-adjusted model, the effect of traffic within 150 m remained positive on the slope, but was reduced by more than 20% by the confounders and was no longer borderline significant. Of note, we tested several variables measuring various aspects of physical activity or participation in sports, but none of these variables met our inclusion criteria for confounding.

Table 1 Participant baseline[a] characteristics, exposures and potentially confounding variables used in the analysis

Participant characteristics	No.	(%)	Mean	(SD)
Race/Ethnicity				
African American	122	(2.68)		
Asian	145	(3.19)		
Hispanic	2462	(54.11)		
Non-Hispanic White	1664	(32.18)		
Other	357	(7.85)		
Gender				
Male	2297	(50.51)		
Female	2251	(49.49)		
Individual and household characteristics				
Parental Education				
Less than High School	905	(21.75)		
High School	781	(18.77)		
Above High School	2575	(59.48)		
Second hand smoke				
No one ever smoked in the house	3962	(97.22)		
Anyone ever smoked in the house	309	(7.23)		
Ever Asthma				
No	3501	(86.13)		
Yes	564	(13.87)		
Spanish Speaker				
No	3417	(75.1)		
Yes	1133	(24.9)		
Local home or school environment				
Having no food stores within 500 m road network buffer				
No	1980	(48.09)		
Yes	2137	(51.91)		
Street connectivity (Gamma index 500 m buffer)	4117		0.4	0.06
Parks and recreation (unit: acre in 500 m buffer)	3968		4.95	10.6
NDVI green cover[b] (in 500 m buffer)	4117		0.09	0.10
Recreation programs within 5 km	4117		29.7	34.20
Community social context				
Proportion of unemployed males and females			0.076	0.02
Community level violent crime rate (Crimes per 100,000 population)	4550		511.73	268.04
Air pollution and traffic				
Total NO_X (parts per billion)	4464		49.24	104.93
Traffic density within 150 m of the home	4464		19.49	18.82
Primary outcome				
BMI at baseline	4550		16.79	2.81
Males	2297		16.87	2.81
Females	2251		16.70	2.80
BMI at the end of follow up	4550		19.35	4.21
Males	2297		19.50	4.36
Females	2251		19.19	4.15
BMI CDC percentile at baseline				
85 > BMIp	3201	(70.35)		
85 ≤ BMIp < 95	660	(14.41)		
95 ≤ BMIp	684	(15.03)		

[a] First observation of the subjects in the first year of the study is N = 4550 with restriction of non-missing BMI and with two or more observations; numbers of subjects in the table vary due to missing covariate values.
[b] Normalized difference vegetation index derived from Landsat satellite images.

In the screening of the air pollution variables, non-freeway NO_x levels were significantly and positively associated with BMI at age 10 and the rate of growth over the four year follow-up period, while the freeway-related exposures were not associated with BMI growth, consistent with other previous studies on respiratory health [27]. The association between BMI and non-freeway NO_x was reduced but remained significantly elevated in models containing the same variables as those in the fully adjusted traffic density model described above and with those chosen specifically to confound NO_x (Table 2). Again none of the physical activity variables met the inclusion criteria as confounders. Interaction by gender was tested, but no significant evidence of difference in the effects on boys and girls was found.

Confounders at the community and school levels were further tested by including the average terms for each level and the individual deviations from the mean of the level. Neither community level crime nor poverty confounded the within-community effect of air pollution. The impact of the school level was then tested by including a fixed effect for school in the model, but air pollution remained significantly and positively associated with BMI growth with little change in the coefficient. This suggests that the school level variables did not confound the air pollution effect on BMI growth.

Discussion

We hypothesized that traffic density and traffic-related air pollution would positively associate with longitudinal growth in BMI. In this cohort of children from 13 communities across Southern California, traffic-related air pollution exerted a significant effect on BMI growth and

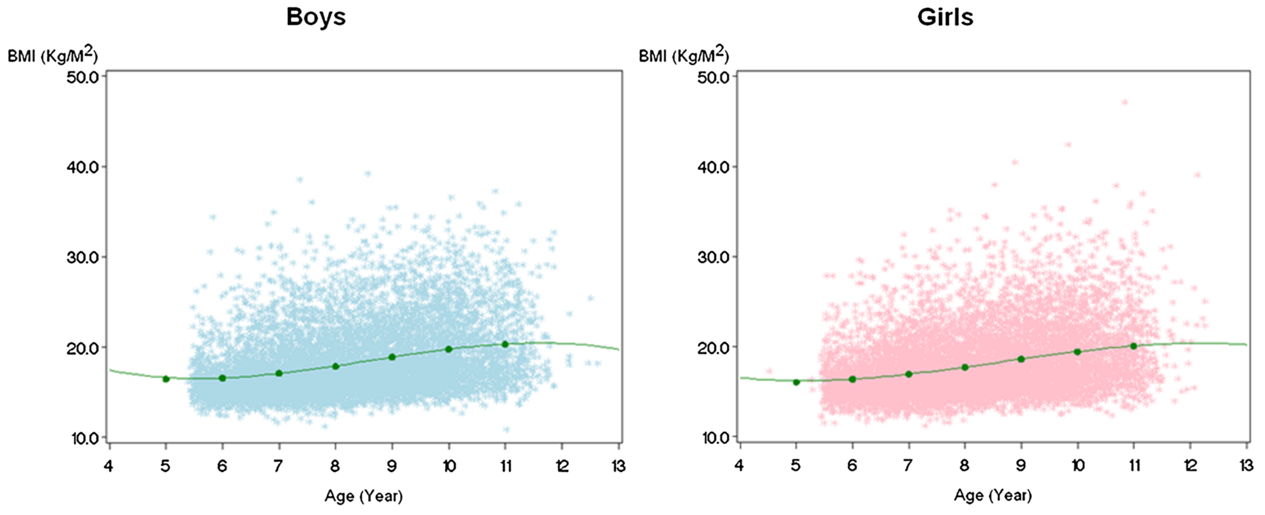

Figure 2 BMI growth curves for boys and girls over the follow-up. Points show individual BMI measures for the subjects.

BMI level attained at age 10. Evidence of effects for traffic density was found in unadjusted models. This effect was confounded in fully adjusted models, although the effects did remain elevated.

Comparing children in the highest 10% of traffic-related air pollution exposure to those in the lowest 10% of exposure yielded a 0.39 BMI unit increase in the attained BMI level at age 10. This translated into a 13.6% increase in the rate of average annual BMI growth. These effects may have large population impacts because traffic-related air pollution is a ubiquitous exposure that affects billions of people globally [31], and in many countries traffic is increasing at a higher rate than the rate of population growth [32].

Examining the effects at different times during the follow up helps to interpret the results. Figure 3 shows the BMI effects for the children in the lowest and highest deciles. The BMI range between the lowest and highest is shown as the middle line for reference. As the children get older, the effects accumulate, and the slope difference

Table 2 Effects of traffic density or traffic-related air pollution on BMI level (intercept) and growth (slope)

	Combined effect modeling	
Exposure based on 10-90th percentile contrast	Male and Female	
	Intercept β (SE)	Slope β (SE)
Traffic density[a]	0.0012* (0.0006)	0.0002* (0.0001)
Non-Freeway NO_x[a]	0.3831** (0.1552)	0.0861** (0.0255)
Traffic density[b]	0.0012* (0.0006)	0.0002 (0.0001)
Non-Freeway NO_x[b]	0.3867** (0.1552)	0.0873** (0.0255)

**$p < 0.05$.
*$p < 0.1$.
[a]Models include the same confounders: whether the child has ever had asthma, parental education as a marker for socioeconomic position, whether the questionnaire was answered in Spanish as a marker for recent immigrant status, normalized difference vegetation index within 500 m of the home as a measure of green cover, street connectivity as measured by the gamma index, recreational programming within 5 km of the home, and fast food access within 500 m of the home.
[b]Confounders selected based on modeling procedure described in the methods for each exposure. The traffic density model includes parental education as a marker for socioeconomic position, whether the questionnaire was answered in Spanish as a marker for recent immigrant status, normalized difference vegetation index within 500 m of the home as a measure of green cover, and recreational programming within 5 km of the home.
The non-freeway NO_x model includes parental education as a marker for socioeconomic position, whether the questionnaire was answered in Spanish as a marker for recent immigrant status, normalized difference vegetation index within 500 m of the home as a measure of green cover, street connectivity as measured by the gamma index, recreational programming within 5 km of the home, and fast food access within 500 m of the home.
All of the above models include indicator functions for community of residence and variables for sex and race or ethnicity.

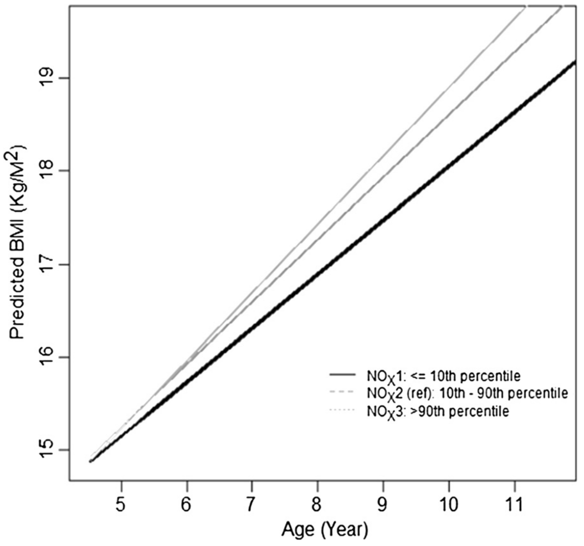

Figure 3 Predicted BMI. Plot of predicted BMI comparing children in the 10th and the 90th percentiles with the 10-90th percentile exposure contrast shown for reference.

between the lowest and highest deciles becomes more pronounced. By age 10 or 11 the difference is about 0.4 – 0.5 of a BMI unit.

Traffic density and traffic-related air pollution could not be tested in the same model because traffic density is an input variable to the dispersion models, and therefore the two variables are collinear. Traffic-related air pollution nonetheless was not confounded by other variables, suggesting that air pollution exerted a stronger effect on BMI growth than traffic density. This result was insensitive to which individual and neighborhood built environment confounding variables were used in the model. Based on the sensitivity analyses, variables at the school and community level do not confound the association between BMI and traffic-related air pollution.

The findings here differ from the only other study that examined the impacts of traffic density on BMI growth [15], which was conducted among an older cohort of children in 10 of the same study communities and used similar statistical techniques. With the same metric of traffic density within 150 m around the home, the earlier study found significant effects that were not confounded by other individual or built environment variables or community-level variables such as poverty. This difference in findings from the two cohorts may have resulted from mobility differences by age. Most of the children in the present analysis were less than 10 years old for most of the follow up, and children of this age are less likely to walk on their own than older children who were followed for the earlier research [15]. Qualitative research suggests that parents of children aged less than 10–11 perceive many barriers to allowing children to move freely in urban areas, but the same study indicates that at this age, which corresponds to the end of primary school, parents do begin to afford increased license to engage in physical activity alone or more likely in groups of peers [33]. Quantitative research using global positioning systems to track children supports the qualitative research, indicating that there is a large rise in the proportion of children allowed to range freely around the ages of 10–11 [34]. Therefore, the pathway of reduced physical activity from traffic danger in younger children may be less pronounced in older children, because fewer of the younger children exhibited independent mobility on average. The earlier study on traffic density did not test for associations with traffic-related air pollution.

Reliance on the CALINE4 dispersion model limited our ability to discern which elements of the traffic pollution mixture were most important. Although we used NOx as our indicator of traffic-related pollution, this molecular gas had strong correlations with CO, NO_2, and $PM_{2.5}$ estimates from the CALINE4 model, with correlations greater than 0.9 (see Additional file 1 for further details). We found non-freeway NOx had the association, while freeway NOx was not robust to confounders. We interpret the lack of effect from the freeway NOx as resulting from a small proportion of the total cohort who lived in proximity to freeways, rather than an attribution to a specific source from a different type of roadway. While the results indicate that traffic-related pollution likely has a stronger effect than traffic density, we are unable to identify which specific components of the traffic mixture were responsible for the effects.

Another limitation of this study related to the lack of information on food intake. Food access was controlled in the models, but dietary factors could not be directly evaluated. Given what is known about the association between lower socioeconomic position and higher traffic-related pollution exposures in California [35], some of the effects observed here may be confounded by dietary variables that are also associated with lower socioeconomic status, such as intake of sugar and fats [36]. Socioeconomic status in the home and neighborhood was controlled for, which reduces the chance of residual confounding relating to socioeconomic status, but confounding by food intake, which might be associated with air pollution through socioeconomic status, cannot be directly ruled out.

To address the concern about diet, information on dietary intake in an older cohort (ages 10–18) of nearly 2000 children in 10 of the same study communities as in the current study [37,38] was used to generate variables on macronutrients including total caloric, protein, carbohydrate, saturated fat, mono unsaturated fat, and cholesterol intake. A statistical analysis that controlled for community of residence, race, sex, and parental education as a marker of SES was performed, and for a wide array of traffic or traffic-pollution indicators there was no association between the total caloric intake and the traffic-pollution estimates or traffic density measures. A weak, borderline significant association between daily grams of carbohydrate consumption and nitrogen dioxide from non-freeway sources was observed, but the coefficient was very small. Equivalent diet information on the specific cohort used in our paper is not available, but the relationships between the traffic or pollution variables and food intake should be similar in both cohorts. Given that there was no difference in total calories or in any other macronutrient categories, the chance of confounding by unmeasured diet variables is limited.

Although we cannot rule out self selection of potentially more health-conscience families into areas with lower pollution, our mixed effects modeling framework properly controls for baseline BMI. As a result, the influence of self-selection is accounted for with subject-to-subject variability due to baseline characteristics. While self-selection could influence the trajectory, control for baseline characteristics that is inherent to our modeling framework makes it more likely that our results are from an ongoing influence of the environment and not some other factors.

The effects of pollution are significant, and the temporal pattern is consistent with the hypothesis that the inflammatory effects of air pollution predispose children to obesity in a similar way to what has been observed in laboratory experiments [20]. By analogy, this pattern is also corroborated by human epidemiological studies finding associations between metabolic disorders and air pollution [18,19]. Another explanation is possible; in areas of high traffic, children and their parents may have a heightened sense of danger that reduces activity by restricting the mobility of families [39]. In this cohort, however, traffic effects were not significantly associated with BMI growth or attained level after controlling for confounding variables. As illustrated in our conceptual framework presented in Figure 1, there are several other pathways from stress resulting from noise or from other obesogens, which could be leading to higher BMI growth in children, but we are unable to test such pathways directly. Future research may usefully address these other pathways along with traffic pollution exposures.

Conclusions

This paper provides evidence that traffic-related air pollution is associated with the development of obesity in children. Traffic pollution may be controlled via emission restrictions; changes in land use that promote jobs-housing balance and use of public transit and hence reduced vehicle miles traveled; promotion of zero emissions vehicles; transit and car-sharing programs; or by limiting high pollution traffic, such as diesel trucks, from residential areas or places where children play outdoors, such as schools and parks. These measures may have beneficial effects in terms of reduced obesity formation in children.

Additional file

Additional file 1: Additional information on physical activity and exposure assessment.

Competing interests

Dr. McConnell has received research support from an air quality violations settlement between the South Coast Air Quality Management District, a California state regulatory agency, and BP. The authors have no other conflicts of interest to disclose.

Authors' contributions

Conceived and designed the experiments: MJ RM JW KB. Performed the experiments: RM RC CL FL. Analyzed the data: MJ RM JW RC CL GD FG. Wrote the first draft of the manuscript: MJ RM JW GD FL KB. Contributed to the writing of the manuscript: MJ RM JW RC CL GD FG FL KB. ICMJE criteria for authorship read and met: MJ RM JW RC CL GD FG FL KB. Agree with manuscript results and conclusions: MJ RM JW RC CL GD FG FL KB. All authors read and approved the final manuscript.

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doi:10.1186/1476-069X-13-49
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FW:

DRP Metro Area Plan <MetroAreaPlan@planning.lacounty.gov>
Mon 9/11/2023 7:54 AM
To:Tina Fung <tfung@planning.lacounty.gov>;Leon Freeman <lfreeman@planning.lacounty.gov>

-----Original Message-----
From: Reginald Melton <reginaldbmelton91@gmail.com>
Sent: Friday, September 8, 2023 5:13 PM
To: DRP Metro Area Plan <MetroAreaPlan@planning.lacounty.gov>
Subject:

CAUTION: External Email. Proceed Responsibly.

I disagree to the idea of having our communities replaced with other structures. As this community provides shelter to many, sometimes a safe place and peace of mind. Without foundation where would people go.

Reginald Melton !

Sent from my iPhone

FW: Support of LA County Metro Area Plan

Rafael Andrade <RAndrade@planning.lacounty.gov>
Mon 9/11/2023 6:56 AM
To:Tina Fung <tfung@planning.lacounty.gov>;Leon Freeman <lfreeman@planning.lacounty.gov>;Patricia Hachiya <phachiya@planning.lacounty.gov>
Cc:Elida Luna <ELuna@planning.lacounty.gov>

FYI - Please see below regarding Metro Area Plan.

Thank you,

Rafael

-----Original Message-----
From: dejaybe@everyactioncustom.com <dejaybe@everyactioncustom.com>
Sent: Friday, September 8, 2023 9:32 PM
To: EDL-DRP BU-S Commission Services <commission@planning.lacounty.gov>
Subject: Support of LA County Metro Area Plan

CAUTION: External Email. Proceed Responsibly.

Dear LA County Planning Commission,

The Metro Area Plan before you is a well-crafted multi-pronged strategy suited to the community needs of unincorporated areas in central Los Angeles County including East Los Angeles, East Rancho Dominguez, Florence-Firestone, West Athens-Westmont, West Rancho Dominguez-Victoria, Walnut Park, and Willowbrook. If approved and fully implemented, this plan has the potential to stabilize the cost of housing in these neighborhoods, advance environmental justice, bolster local businesses, and foster more livable, walkable communities. I stand with Abundant Housing LA in supporting this plan, as well as the associated zoning updates and programs.

Totaling 310,000 diverse residents across 21 square miles, the Metro Area region is, in many ways, the geographic and cultural center of our incredible County. These communities of central LA County are home to rich history and a diverse blend of cultures that help make all of Southern California more special. The Metro Area deserves a plan that's robust—not only in its approach to building affordable, accessible and abundant housing—but also in its attention to detail about the needs and preferences of these communities.

Although the plan's programs cover a wide-ranging spectrum, several of the headline items in this plan focus on needed zoning changes. Implementing these zoning updates represents an important step forward in keeping the County's Housing Element in compliance. More than 99% of the parcels targeted for rezoning in this update are on commercial corridors that do not currently allow housing construction. For that reason, zoning changes on such properties won't trigger residential displacement, an issue of significant concern in marginalized communities.

Mixed-use development along these corridors has many benefits. A thoughtful mix of uses provides the opportunity to build vibrant, walkable, multimodal neighborhoods that will support a better quality of

life, as well local economies and goals for housing affordability. Transit-oriented development will also make residents more connected. Sustainable transportation can be a lifeline for many in the Metro Area, particularly lower-income Angelenos who can’t afford to own a car. Additionally, the Metro Area Plan has the potential to boost the production of affordable and mixed-income housing through a variety of incentives and programs.

The Metro Area Plan also provides a number of other exciting projects and opportunities, including a change to allow more stores on corner lots, a plan for safe routes to schools, and the implementation of the County’s Green Zones Ordinance, which focuses environmental justice efforts in communities disproportionately impacted by pollution.

Please support the staff recommendation and approve the Metro Area Plan, as well as the projects and zoning changes also included.

Sincerely,
David Barboza
7239 Comstock Ave Whittier, CA 90602-1353 dejaybe@gmail.com

FW: Support of LA County Metro Area Plan

Rafael Andrade <RAndrade@planning.lacounty.gov>
Mon 9/11/2023 6:57 AM
To:Tina Fung <tfung@planning.lacounty.gov>;Leon Freeman <lfreeman@planning.lacounty.gov>;Patricia Hachiya <phachiya@planning.lacounty.gov>
Cc:Elida Luna <ELuna@planning.lacounty.gov>

FYI - Please see below regarding Metro Area Plan.

Thank you,

Rafael

-----Original Message-----
From: workaholicnat100@everyactioncustom.com <workaholicnat100@everyactioncustom.com>
Sent: Sunday, September 10, 2023 7:32 AM
To: EDL-DRP BU-S Commission Services <commission@planning.lacounty.gov>
Subject: Support of LA County Metro Area Plan

CAUTION: External Email. Proceed Responsibly.

Dear LA County Planning Commission,

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Please support the staff recommendation and approve the Metro Area Plan, as well as the projects and zoning changes also included.

Sincerely,
Natasha Gascon
832 Fedora St Apt 207 Los Angeles, CA 90005-2106 workaholicnat100@gmail.com

ABUNDANT
HOUSING LA

September 11, 2023

Los Angeles Regional Planning Commission
320 W. Temple Street
Los Angeles, CA 90012

Dear Los Angeles County Regional Planning Commissioners,

The Metro Area Plan before you is a well-crafted multi-pronged strategy suited to the community needs of unincorporated areas in central Los Angeles County including East Los Angeles, East Rancho Dominguez, Florence-Firestone, West Athens-Westmont, West Rancho Dominguez-Victoria, Walnut Park, and Willowbrook. If approved and fully implemented, this plan has the potential to stabilize the cost of housing in these neighborhoods, advance environmental justice, bolster local businesses, and foster more livable, walkable communities. Please join me in supporting this plan, as well as the associated zoning updates and programs.

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Although the plan's programs cover a wide-ranging spectrum, several of the headline items in this plan focus on needed zoning changes. Implementing these zoning updates represents an important step forward in keeping the County's Housing Element in compliance. More than 99% of the parcels targeted for rezoning in this update are on commercial corridors that do not currently allow housing construction. For that reason, zoning changes on such properties won't trigger residential displacement, an issue of significant concern in marginalized communities.

Mixed-use development along these corridors has many benefits. A thoughtful mix of uses provides the opportunity to build vibrant, walkable, multimodal neighborhoods that will support a better quality of life, as well local economies and goals for housing affordability. Transit-oriented development will also make residents more connected. Sustainable transportation can be a lifeline for many in the Metro Area, particularly lower-income Angelenos who can't afford to own a car. Additionally, the Metro Area Plan has the potential to boost the production of affordable and mixed-income housing through a variety of incentives and programs.

The Metro Area Plan also provides a number of other exciting projects and opportunities, including a change to allow more stores on corner lots, a plan for safe routes to schools, and the implementation of the County’s Green Zones Ordinance, which focuses environmental justice efforts in communities disproportionately impacted by pollution.

Please support the staff recommendation and approve the Metro Area Plan, as well as the projects and zoning changes also included.

Sincerely,

Leonora Camner

Leonora Camner
Executive Director
Abundant Housing LA

Scott Eptein

Scott Epstein
Director of Policy and Research
Abundant Housing LA

FW: Support of LA County Metro Area Plan

Rafael Andrade <RAndrade@planning.lacounty.gov>
Tue 9/12/2023 7:04 AM
To:Tina Fung <tfung@planning.lacounty.gov>;Leon Freeman <lfreeman@planning.lacounty.gov>;Patricia Hachiya <phachiya@planning.lacounty.gov>
Cc:Elida Luna <ELuna@planning.lacounty.gov>

FYI - Comment regarding Metro Area Plan.

Regards,

Rafael

-----Original Message-----
From: l.a.ridings@everyactioncustom.com <l.a.ridings@everyactioncustom.com>
Sent: Monday, September 11, 2023 10:46 PM
To: EDL-DRP BU-S Commission Services <commission@planning.lacounty.gov>
Subject: Support of LA County Metro Area Plan

CAUTION: External Email. Proceed Responsibly.

Dear LA County Planning Commission,

The Metro Area Plan before you is a well-crafted multi-pronged strategy suited to the community needs of unincorporated areas in central Los Angeles County including East Los Angeles, East Rancho Dominguez, Florence-Firestone, West Athens-Westmont, West Rancho Dominguez-Victoria, Walnut Park, and Willowbrook. If approved and fully implemented, this plan has the potential to stabilize the cost of housing in these neighborhoods, advance environmental justice, bolster local businesses, and foster more livable, walkable communities. I stand with Abundant Housing LA in supporting this plan, as well as the associated zoning updates and programs.

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Sincerely,
Leslie Ridings
3030 Valle Vista Dr Apt 11 Los Angeles, CA 90065-4473 l.a.ridings@gmail.com

FW: Support of LA County Metro Area Plan

Rafael Andrade <RAndrade@planning.lacounty.gov>
Tue 9/12/2023 9:24 AM

To:Tina Fung <tfung@planning.lacounty.gov>;Leon Freeman <lfreeman@planning.lacounty.gov>;Patricia Hachiya <phachiya@planning.lacounty.gov>

Cc:Elida Luna <ELuna@planning.lacounty.gov>

FYI - Comment regarding Metro Area Plan.

-----Original Message-----
From: kevin.robert.scott@everyactioncustom.com <kevin.robert.scott@everyactioncustom.com>
Sent: Tuesday, September 12, 2023 9:22 AM
To: EDL-DRP BU-S Commission Services <commission@planning.lacounty.gov>
Subject: Support of LA County Metro Area Plan

CAUTION: External Email. Proceed Responsibly.

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Please support the staff recommendation and approve the Metro Area Plan, as well as the projects and zoning changes also included.

Sincerely,
Kevin Scott
234 S Avenue 56 Los Angeles, CA 90042-4610 kevin.robert.scott@gmail.com

FW: Regional Planning Commission Hearing - Wednesday September 13th, Agenda Item 8 Metro Area Plan and FEIR - Opposition to Metro Area Plan, reject the resolution and Reject Certification of the Final EIR

DRP Public Comment <comment@planning.lacounty.gov>
Tue 9/12/2023 11:56 AM

To:Tina Fung <tfung@planning.lacounty.gov>;Leon Freeman <lfreeman@planning.lacounty.gov>;Patricia Hachiya <phachiya@planning.lacounty.gov>

Cc:Elida Luna <ELuna@planning.lacounty.gov>

FYI – Comment regarding Metro Area Plan.

From: claramsolis@earthlink.net <claramsolis@earthlink.net>
Sent: Tuesday, September 12, 2023 11:54 AM
To: DRP Metro Area Plan <MetroAreaPlan@planning.lacounty.gov>; DRP Public Comment <comment@planning.lacounty.gov>; firstdistrict@bos.lacounty.gov
Cc: Chapa, Antonio <AChapa@bos.lacounty.gov>; FourthDistrict@bos.lacounty.gov
Subject: Regional Planning Commission Hearing - Wednesday September 13th, Agenda Item 8 Metro Area Plan and FEIR - Opposition to Metro Area Plan, reject the resolution and Reject Certification of the Final EIR

Dear Regional Planning Commissioners and Metro Area Plan Staff

Please Reject the Metro Area Plan resolution (exhibit A) and reject certification of the Final EIR. The Final EIR is deficient and should be redone to seriously study the impacts from the Metro Area Plan including Human Health Risk Assessments/ Health Impact Assessments.

The Metro Area Plan is a plan that will result in more excess deaths to residents in East Los Angeles and other Metro Plan area residents due to an increase in noise and air pollution. We have provided numerous studies which show the impacts of pollution in communities like East Los Angeles.   The Metro Area plan should be rejected and a new plan prepared that will not result in more excess deaths to residents. Any new plan's EIR should include a Health Impact Assessment and a Health Risk Assessment to ensure it will do no harm to community members who are already facing health risks due to pollution.

HEALTH IMPACT ASSESSMENT/HUMAN HEALTH RISK ASSESSMENT MUST BE REQUIRED

The draft PEIR fails to document the increased poor health outcomes, premature deaths, increased cases of asthma, heart and lung disease and other health problems currently experienced by residents facing pollution.

The draft PEIR fails to conduct a health impact risk assessment.

Because the project will cause air quality impacts in East Los Angeles, an environmental justice community and other communities within the Metro Plan Area that already suffer from health problems from poor air quality that is in non-attainment under an applicable federal or state ambient air quality standard, the PEIR should include a Health Risk Assessment and Health Impact Assessment to determine the general air quality, health risk, and greenhouse gas impacts from the Project. It should also include a summary overview of the results of the AQ/HRA/GHG analyses.

A human health risk assessment must also be prepared because the risk to life and health among East Los Angeles is endangered by this plan which will exacerbate air and noise pollution and increase heat island impacts. A human health risk assessment is a quantitative, analytic process to estimate the nature and risk of adverse human health effects associated with exposure to specific chemical contaminants or other hazards in the environment, now or in the future. For more information, see the U.S. Environmental Protection Agency.

Responses to our letter claim that it would be difficult to conduct a Health Impact Assessment (HIA), stating:

> *However, there are numerous scientific and technological complexities associated with correlating criteria air pollutant emissions from an individual project to specific health effects or potential additional nonattainment days, and there are currently no modeling tools that could provide reliable and meaningful additional information regarding health effects from criteria air pollutants generated by individual projects within the SCAQMD jurisdiction.*

Yet as of four years ago in 2019, our Los Angeles County Public Health Department found, 84 HIA's were completed 35 percent relating to Planning and Zoning, 19 percent related to transportation, 16 percent related to housing and 5 percent related to Community Development. See:

http://publichealth.lacounty.gov/chie/HIA.htm

One of the steps of the HIA is to:

> Provide strategies to manage identifies adverse health impacts and maximize benefits to health.

Communities like East Los Angeles in the Metro Area Plan which have been historically used as dumping grounds for projects no other community would accept, like five major freeways, polluting industries, and rail yards require an HIA. To approve a plan without it, knowing the impacts of pollution on community member's health would be negligent. It is unfair to once again use the poorest, most polluted communities as the counties solution to its housing element requirements. The Metro Area Plan makes it seem as if it is acknowledging the past injustices, but in adding more pollution is continuing past practices. Indeed the green zones program was supposed to remove polluting businesses yet that has been removed from consideration.

Responses to our comment letter admit:

> *even with implementation of MM-4.3-1 and MM-4.3-2, existing regulations and proposed goals and policies to reduce impacts, the Project impacts at the program level would* ***remain significant and unavoidable*** *because at this level of review, the exact location, orientation, number, and timing of individual projects and/or infrastructure improvements that could occur as a result of the Metro Area Plan are unknown.*
>
> And
>
> because future potential projects would potentially exceed the SCAQMD thresholds for VOC, NOx, CO, PM10, and PM2.5, **the potential health effects associated with criteria air pollutants are considered potentially significant.**

Current state law allows density bonuses which can increase number of units, height of buildings with increases as much as 33 feet, this also could add to the impacts of the Metro Area Plan and could mean the actual amount of pollution created is underestimated.

Further, responses to our comments state, non-discretionary projects would not necessarily be subject to CEQA review, additional environmental assessments, or mitigation measures

Additionally, responses to comments, state: the Recirculated Draft PEIR acknowledges that the buildout of the Metro Planning Area would exceed the growth projections anticipated by the Southern California Association of Governments (SCAG) RTP/SCS,

So, it is likely that the pollution and health impacts including excess deaths from pollution caused by the Metro Area Plan will be significant. It is not unreasonable for the community to ask that a Health Impact Assessment be done and that the Metro Area Plan be modified to create fewer increases in pollution.

The County cannot just assume health impacts will be significant without providing analysis. This was the holding in a California Supreme Court case, *Sierra Club v. County of Fresno* (2018) 6 Cal.5th 502.

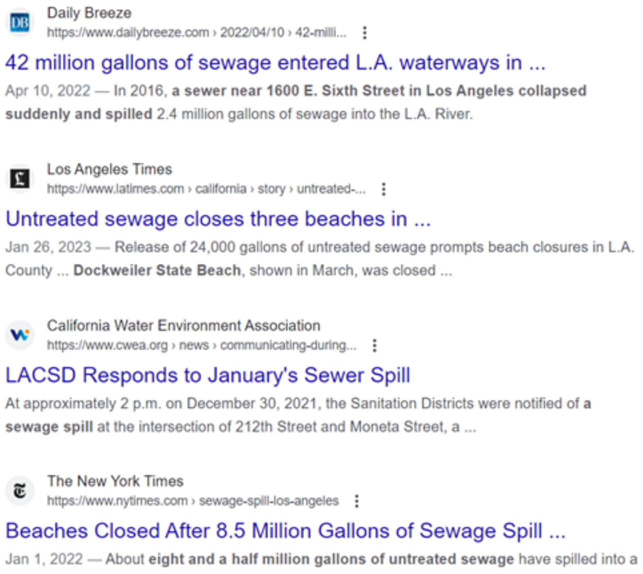
The project will create significant impacts to infrastructure/utilities.

Additionally, our aging infrastructure cannot support the amount of density proposed.

In response to Los Angeles County Sanitation District Comment

A comment response admits: the Recirculated Draft PEIR acknowledges that the buildout of the Metro Planning Area would exceed the growth projections anticipated by the Southern California Association of Governments (SCAG) RTP/SCS, and that future development projects associated with the implementation of the Project are anticipated to require the relocation or construction of new or expanded facilities. As discussed on page 4.19-40 of the Recirculated Draft PEIR, pursuant to the General Plan's Implementation Program PS/F-1, the County will prepare a Capital Improvement Plan (CIP) for each of the 11 Planning Areas, including the Metro Planning Area. Each CIP will include a comprehensive sewer capacity study which will evaluate sewer system infrastructure needs and treatment capacity to ensure adequate capacity is available to accommodate future growth, along with a Planning Area-specific Implementation Program and Financing Plan. In summary, the District's comments have been adequately incorporated into the Draft Recirculated PEIR and Final PEIR and no additional changes are required.

Yet, no system can manage unlimited growth, indeed a quick search on google shows the failure of the sewer system which is over 100 years old in many parts of Los Angeles:



Daily Breeze
https://www.dailybreeze.com › 2022/04/10 › 42-milli...

42 million gallons of sewage entered L.A. waterways in ...

Apr 10, 2022 — In 2016, **a sewer near 1600 E. Sixth Street in Los Angeles collapsed suddenly and spilled** 2.4 million gallons of sewage into the L.A. River.

Los Angeles Times
https://www.latimes.com › california › story › untreated-...

Untreated sewage closes three beaches in ...

Jan 26, 2023 — Release of 24,000 gallons of untreated sewage prompts beach closures in L.A. County ... **Dockweiler State Beach**, shown in March, was closed ...

California Water Environment Association
https://www.cwea.org › news › communicating-during...

LACSD Responds to January's Sewer Spill

At approximately 2 p.m. on December 30, 2021, the Sanitation Districts were notified of **a sewage spill** at the intersection of 212th Street and Moneta Street, a ...

The New York Times
https://www.nytimes.com › sewage-spill-los-angeles

Beaches Closed After 8.5 Million Gallons of Sewage Spill ...

Jan 1, 2022 — About **eight and a half million gallons of untreated sewage** have spilled into a

Finally, we are facing a future with less water from the Colorado river who can we support this increased density? When water runs out, how will it be allocated? By city? Will areas that are denser suffer? These are issues that were not addressed by **the FEIR.**

I am also concerned that the increased density will cause problems with the electrical grid, water main leaks and gas leaks. All of this infrastructure is old.

Public Safety:

No information is provided from the Fire Department. Yet area residents at meetings have spoke of people dying of heart attacks because people died from heart attacks when the Fire Department was unable to reach resident's homes due to traffic.

Already, responses times from police and fire are slowed by traffic from the freeways. An accident in the community can cause back-ups on local streets of hours with residents forced to leave their cars and walk home.

Problems with Process:

The entire plan should be considered as a whole. It is unfair to require residents to review the project piecemeal with some parts delayed for future inclusion. The project should include the green zones program. The FEIR should not be approved without it. The Metro Area Plan in an incomplete document without it. It was created as a whole and to remove the Green Zones part with its future inclusion uncertain is unfair to the community.

Again and again, government agencies release environmental documents in these communities when they anticipate it will be most difficult for residents to participate. This whole process was a sham, with residents told the most insignificant parts of the plan at presentations and as part of the scoping process asked to do ridiculous exercises that had no significance to what was included in the plan. Further, meetings included the Green Zones plan which has now been excised out from consideration.

Additionally, our initial comments to the Draft EIR were not responded to, so when the Recirculated Draft EIR came out, residents were put at a disadvantage. This violates the intent of CEQA.

Tall Building Can make pollution worse, open space helps

The Final EIR failed to consider studies in Los Angeles that tall building close together can make pollution worse. Isolated tall buildings dispersed can create turbulence that can aid in disbursement of pollution. Open space as well works in dispersing pollution. East Los Angeles and other Metro Area communities have some of the worse pollution. The impacts of creating tall buildings which can trap pollution should be studied.

See: https://newsroom.ucla.edu/stories/l-a-s-buildings-loom-large-in-determining-street-level-air-quality

https://pubmed.ncbi.nlm.nih.gov/26938315/

METRO AREA PLAN AND FINAL EIR FAIL TO ADDRESS THE Area Specific Development Standards - Whittier Blvd Area

https://library.municode.com/ca/los_angeles_county/codes/code_of_ordinances?nodeId=TIT22PLZO_DIV10COSTDI_CH22.316EALOANCOSTDI_22.316.080ARSPDEST

CHANGING COMMERCIAL AREAS ON WHITTIER BLVD, OLYMPIC AND ATLANTIC TO MIXED USE WILL REMOVE SHOPPING AREAS THAT THE COMMUNITY NEEDS

The plan acknowledges that many resident's shop outside the community, yet instead of trying to help, this plan will remove shopping locations requiring residents to shop outside of the community. This will create more pollution and remove the tax base. All of the mixed use buildings that have been built in East Los Angeles have little commercial area.

East LA needs more supermarkets, the Accessory Commercial Unit's will not fill this gap. Providing small locations with higher prices than big markets will not solve ELA's food desert problem. Removing the commercial district will make life harder for residents who don't have cars and depend on the commercial businesses.

Vehicle Miles Traveled

The staff report claims that the Plan will encourages reduction of vehicle miles traveled by placing services near residential uses and promoting other forms of mobility aside from single occupancy vehicles. This is false. By removing the business and replacing them with mostly mixed use, residents will be forced to shop outside the community.

Accessory Commercial units will not make up for this with the high prices normally associated with corner stores in our community.

The Final EIR is deficient and fails to address the increase in VMT from residents being forced to travel outside their community.

Parks and Library Services will be overwhelmed

The Metro Area Plan and FEIR fail to address who these highly dense communities will be impacted by a lack of park space. ELA and many of the other communities are park poor and have insufficient library services. Other than an unfunded pie in the sky freeway cap proposal there is no meaningful solution to where the new residents packed into the already dense ELA (30th densest out of 265 communities in Los Angeles) will go for open space.

Please note on the letter from the Humphreys, Eagle Sydney letter the response to our comment takes our letter as only applying to East Los Angeles, but we stated, "Most of our comments are related to impacts on the community of East Los Angeles from the Plan," many of our comments also relate to the Plan as a whole.

Thank you,

Clara Solis

FW: Support of LA County Metro Area Plan

Rafael Andrade <RAndrade@planning.lacounty.gov>
Tue 9/12/2023 1:12 PM
To:Tina Fung <tfung@planning.lacounty.gov>;Leon Freeman <lfreeman@planning.lacounty.gov>;Patricia Hachiya <phachiya@planning.lacounty.gov>
Cc:Elida Luna <ELuna@planning.lacounty.gov>

FYI

-----Original Message-----
From: yeskurtcan@everyactioncustom.com <yeskurtcan@everyactioncustom.com>
Sent: Tuesday, September 12, 2023 1:12 PM
To: EDL-DRP BU-S Commission Services <commission@planning.lacounty.gov>
Subject: Support of LA County Metro Area Plan

CAUTION: External Email. Proceed Responsibly.

Dear LA County Planning Commission,

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Sincerely,
Kurt Canfield
3924 E 4th St Long Beach, CA 90814-1656 yeskurtcan@gmail.com

FW: Support of LA County Metro Area Plan

Rafael Andrade <RAndrade@planning.lacounty.gov>
Tue 9/12/2023 1:42 PM
To:Tina Fung <tfung@planning.lacounty.gov>;Leon Freeman <lfreeman@planning.lacounty.gov>;Patricia Hachiya <phachiya@planning.lacounty.gov>
Cc:Elida Luna <ELuna@planning.lacounty.gov>

FYI

-----Original Message-----
From: briannajungegan@everyactioncustom.com <briannajungegan@everyactioncustom.com>
Sent: Tuesday, September 12, 2023 1:41 PM
To: EDL-DRP BU-S Commission Services <commission@planning.lacounty.gov>
Subject: Support of LA County Metro Area Plan

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Sincerely,
Brianna Egan
520 S Helberta Ave Redondo Beach, CA 90277-4353 briannajungegan@gmail.com

FW: Comments / Metro Area Plan

DRP Metro Area Plan <MetroAreaPlan@planning.lacounty.gov>
Tue 9/12/2023 2:05 PM
To:Tina Fung <tfung@planning.lacounty.gov>

1 attachments (250 KB)
Metro_Area_Plan_Comments_Republic 9-11-23.pdf;

From: Passantino, Susanne <SPassantino@republicservices.com>
Sent: Tuesday, September 12, 2023 2:03 PM
To: DRP Metro Area Plan <MetroAreaPlan@planning.lacounty.gov>
Cc: Lowery, Gretchen <GLowery2@republicservices.com>
Subject: Comments / Metro Area Plan

CAUTION: External Email. Proceed Responsibly.

Good afternoon,

Please see Republic's comments attached regarding the Metro Area Plan update project. We appreciate the opportunity to provide our feedback.

Please confirm receipt and let us know if you have any questions or would like any further detail.

Sincerely,

Susanne Passantino
Market Director, Government Affairs

Los Angeles, CA 91352
e spassantino@republicservices.com
o 818-974-5136
w RepublicServices.com

REPUBLIC SERVICES

Sustainability in Action

REPUBLIC SERVICES
1 9200 Glenoaks Blvd., Sun Valley, CA 91352
866-224-0985 republicservices.com

VIA EMAIL
metroareaplan@planning.lacounty.gov

September 11, 2023

Michael R. Hastings, Chair
Pam O'Connor, Vice Chair
Yolanda Duarte-White, Commissioner
David W. Louie, Commissioner
Elvin W. Moon, Commissioner
Los Angeles County Regional Planning
320 West Temple Street
Los Angeles, CA 90012

Dear Commissioners:

On behalf of Consolidated Disposal Service, LLC ("Consolidated") dba Republic Services, we are the owner and operator of the East Los Angeles Recycling and Transfer Station ("ELARTS") located at 1512 North Bonnie Beach Place, East Los Angeles, California, 90063.

ELARTS is critical to our ability to provide safe and ongoing collection and processing of waste and recycling throughout Los Angeles County.

Regarding the Metro Area Plan update project, we are pleased with recommendations set forth in the Staff Report indicating the area where ELARTS is located shall remain zoned as Heavy Industrial. Heavy Industrial zoning is consistent with the continued operation of ELARTS as a solid waste transfer station.

Any other zoning designation for ELARTS would remove a critical piece of infrastructure from the region's overall collections and processing network, and severely impact our ability provide your residents waste and collections services.

We would like to thank staff for their hard work in updating the Metro Area Plan and are available to answer questions.

Sincerely,

DocuSigned by:
Gretchen Lowery
E8A2AE9E0A464F5...

Gretchen Lowery
Area Vice President

FW: Opposition to LA County's Metro Area Plan to Rezone

DRP Metro Area Plan <MetroAreaPlan@planning.lacounty.gov>

Tue 9/12/2023 2:05 PM

To:Tina Fung <tfung@planning.lacounty.gov>;Leon Freeman <lfreeman@planning.lacounty.gov>

1 attachments (5 MB)

Robert Arsenian to LA Planning.pdf;

From: Enrique Vazquez <enrique@southlanddisposal.com>
Sent: Tuesday, September 12, 2023 12:45 PM
To: DRP Metro Area Plan <MetroAreaPlan@planning.lacounty.gov>
Cc: Southland <southlanddisposal@aol.com>
Subject: Opposition to LA County's Metro Area Plan to Rezone

CAUTION: External Email. Proceed Responsibly.

Mr. Leon Freeman,

Attached you will find Robert Arsenian's written comments to the Regional Planning Commission for inclusion in the public record in regards to the public hearing scheduled for September 13, 2023 at 9:00 a.m. to consider the Metro Planning Area project.

Please acknowledge receipt of this email and attached document.

Best regards,

Enrique Vazquez
Southland Disposal
Office: 323-780-7150
Cell: 626-347-3226

SOUTHLAND
DISPOSAL
Waste Collection
Recycling
Transfer
Disposal

September 11, 2023

VIA ELECTRONIC MAIL

Leon Freeman
LA County Planning
320 W. Temple Street
Los Angeles, CA 90012

RE: Opposition to LA County's Metro Area Plan to Rezone Properties APN:5224011001; APN 5224009014

Dear Mr. Leon Freeman:

In February 2023, I received a letter dated February 2, 2023 from LA County Planning notifying me that my properties located at 1523 and 1533 Fishburn Avenue, Los Angeles, CA 90063 were being rezoned from M-2 to LSP-GZ and that a Public Hearing was scheduled for May 23, 2023.

While I appreciate the need to find ways to improve the area, I am very disturbed by LA County Planning's inadequate process.

The above notification was the first time we ever heard of the County's effort to rezone the area, although apparently this has been in the planning for several years. And although your materials indicate that the County completed community outreach, no one had reached out to me or apparently to any business in the area.

At LA County Planning's invitation, we scheduled a virtual meeting for June 6, 2023 at 1:00 p.m. On the day of the meeting, no one from LA County Planning showed up. We received no notification that the meeting had been cancelled, postponed, or otherwise rescheduled. We sent an email to MetroAreaPlan@planning.lacounty.gov explaining that LA County Planning staff did not show up at our scheduled meeting and inquiring as to how to reschedule the meeting. On June 15, 2023, we received a response stating that Rich Marshalian had recently departed, and that the County had no replacement for him and were now fielding general information through their email address. The feedback session never occurred. We were directed to check the website for updates.

We have since been informed that the Public Hearing was rescheduled to September 13, 2023 and we have received emails with links to additional information. Although LA County Planning has published numerous documents, it has been extremely difficult to determine where matters stand in regard to my properties. It appears that LA County Planning has decided to pause the rezoning to LSP-GZ and will now rezone to M-2-GZ.

While LA County Planning's actions today may not be downzoning the City Terrace area where my properties are located, it is clear that LA County Planning intends to downzone sometime within the next five years. LA County Planning has already expressed its desire to rezone the area to LSP:GZ: Life Science

Park and redesignated IO: Industrial Office. I understand that that goal has not changed – only the timeframe has been delayed.

It appears that LA County Planning does not fully understand the destructive impact their policy action has already had and will continue to have on the communities they serve. This is not an empty, undeveloped space under consideration for rezoning, it's a fully developed space with mature manufacturing and industrial businesses that rely on the current M-2 zoning designation.

In 2004, I developed City Terrace Recycling, a Materials Recovery and Transfer Station Facility and since then, I operate both City Terrace Recycling and Southland Disposal Company, a solid waste collection operation from said properties. City Terrace Recycling operates under a conditional use permit and is also permitted and inspected by the LEA to ensure all standards for solid waste facilities are enforced.

City Terrace Recycling serves a unique purpose in the area. Solid Waste collection vehicles which are not designed for long hauling must have a nearby location to deposit their loads. City Terrace is able to handle the waste shed from the North Central Los Angeles County area. Solid waste collected by Southland Disposal Company including refuse, recycling materials, and organics, are taken to City Terrace Recycling where they are processed and transferred to landfills, organic processing facilities, and / or commodity markets. Several other solid waste and recycling collection companies that operate in Los Angeles and in surrounding communities also depend on City Terrace Recycling for transfer and disposal of their solid waste, recycling, and organics, including the Cities of Glendale, Burbank, Pasadena, and unincorporated County areas.

Additionally, Southland Disposal Company is the largest hauler of Los Angeles Internal Services Department Service Zones' wastes. Those locations include LACUSC Medical Center, Men's Central Jail, Twin Towers Correctional Facility, Rancho Los Amigos Hospital, the Hollywood Bowl, Ford Theatre, all fire stations, libraries, and other county facilities. All of the waste from these locations comes to City Terrace Recycling for processing and recovery of recyclables with the residue transported to landfills in North Los Angeles County. Since 2004, over 20,000 tons per month or 4.3 million tons of waste have been processed at City Terrace Recycling resulting in 1.3 million tons of recovered recyclables diverted from landfill disposal.

Material recovery facilities require millions in investment and it take decades to recover the initial investment before being able to receive a return on the investment. And because the industry continues to change, ongoing reinvestment is always required to continue conforming with laws and regulations such as SB 1383. I bought these properties with the specific intent of developing a materials recovery facility and to continue the operation of my family business in solid waste and recycling collection. The location was a strategic choice, and the zoning designation was crucial in the decision to purchase the properties.

The action already taken by LA County Planning has already had a devastating economic impact on the value of my business by introducing uncertainty to the ongoing viability of the operation. With the possibility of downzoning, the future viability of my business is bleak. The initial draft published by LA County Planning indicated that material recovery facilities, transfer stations, and recycling centers would no longer be permitted to be sited in this zone. Pausing this action does not remove the uncertainty.

The value of my business is significantly based on its strategic location and its ability to remain there. An exit strategy for me would include selling my business. But based on LA County Planning's action, this option has been eliminated. In addition, financing any effort to modernize the plant with superior technology and more efficient equipment has become impossible.

My family has been in the business of solid waste and recycling for over 50 years. Any rezoning that would not allow my current business to continue operations will destroy all the value that my family and I have worked for all our lives. Besides destroying my business, any downzoning action taken by LA County Planning will result in a decrease in the value of my property without due compensation.

I oppose any action by LA County Planning that will not allow my current business to continue operating at its current location.

Respectfully,

Robert M Arsenian

Robert Arsenian

FW: LA METRO AREA PLAN

DRP Metro Area Plan <MetroAreaPlan@planning.lacounty.gov>
Tue 9/12/2023 2:06 PM
To:Tina Fung <tfung@planning.lacounty.gov>;Leon Freeman <lfreeman@planning.lacounty.gov>

-----Original Message-----
From: Sofia Quinones <sofiaquinones@sbcglobal.net>
Sent: Tuesday, September 12, 2023 12:07 PM
To: DRP Metro Area Plan <MetroAreaPlan@planning.lacounty.gov>
Subject: LA METRO AREA PLAN

The LA METRO AREA PLAN fails to address the forecast ed climate changes that disproportionately are experienced by those of us who face discrimination, segregation and exclusion under the current systemic racist Los Angeles County structure. These inequality are a result of our ethnicity and national origin. We who suffer the most from the climate change crises and are now being subjected to draconian measures that will accelerate are death and the comorbidity of illnesses we have been diagnosed with. The Los Angeles County has failed to provide proper health care services, and adequate health services such as body scanning machines and other health related procedures that health care providers need in order properly diagnose us and treat us. Without the proper equipment and medical procedures we will not be able to gather the information or measure the long term levels of contamination our bodies have been exposed to for years. We have a multitude of toxic exposures that surround us. The Center For Disease Control has mapped the cancer clusters and a variety of other disease and illnesses all across the county. We who suffered the loss off family members, animals, and other life forms due to the environmental racism and redlining are not responsible for the crisis. The Los County Board of Supervisors are to blame for these conditions and they are guilty of genocide and premeditated murder if they approve the LA METRO PLAN. Between 1850 and 2022 the Global North is largely to blame for these harmful conditions. The industrialized states produced three times the carbon-dioxide emissions produced by the entire Global South. The United States is responsible for 20 percent of the total cumulative carbon dioxide emissions. There are 90 multinational corporations that are headquartered in the Global North that are responsible for 63 percent of cumulative industrial emissions from 1971 to 2010.
Our historical environmental oppression persists along with the ecological disasters. The political and social effects are “acts that ‘remain unrepaired in the present. These wrongs continue to disfigure generations, and which, in consequence, we call out now for a just response.

Therefore we call on the LACBOS to reject the LA METRO PLAN and extend the comment period in order to properly address the climate crises.

Por Mi Raza Habla Mi Espritu!

Sofia G. Quinones

East Los Angeles Boyle Heights Coalition