Best Practices for Reducing Exposures to Traffic Emissions Near Larger Roadways

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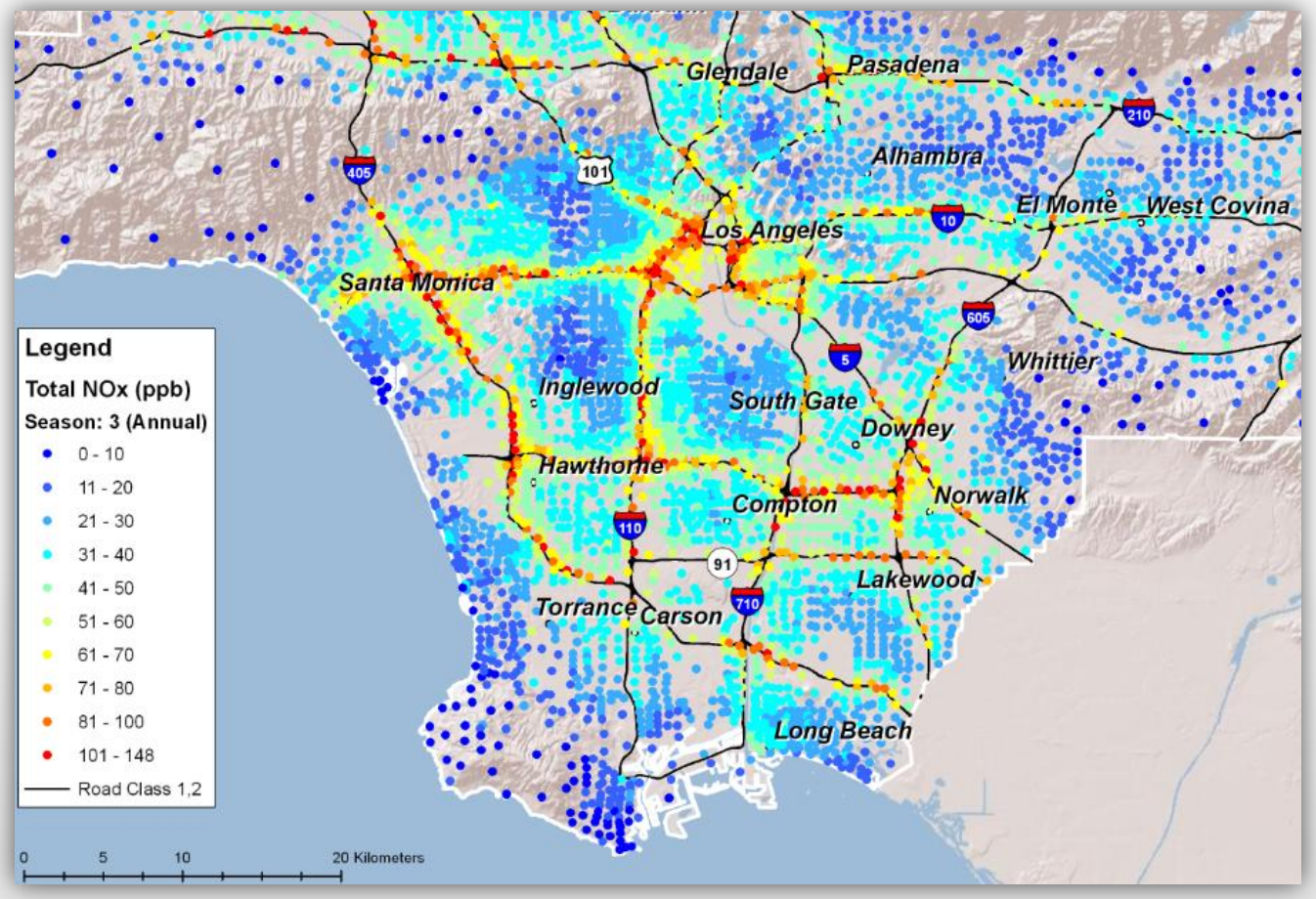
Sonoma Technology, Inc.

Reducing Pollution Exposure

1. Problem illustration: modeled and measured
2. Core concepts for reducing near-road pollutant emissions, concentrations, and exposure
3. Six strategies to mitigate near-road air pollution exposure
4. Case study: HVAC filtration in schools
5. Summary
6. Acknowledgments

Modeled: Los Angeles NO_x



STI modeling to support multi-university health effects research collaborative. *Near-Roadway Pollution and Childhood Asthma,* Perez et al., 2012.

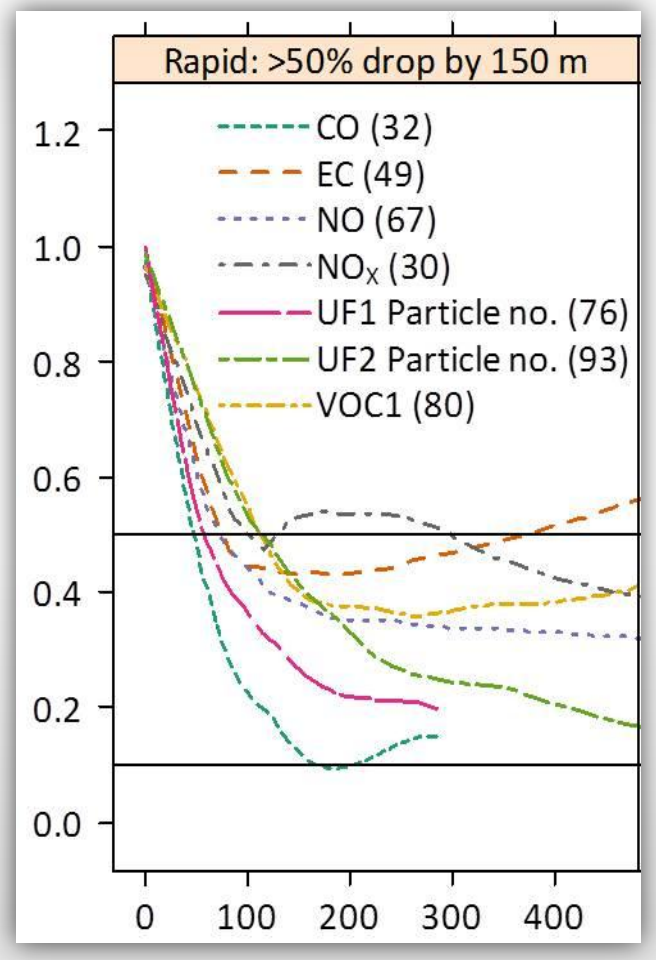
Measured: Worldwide Synthesis

Measured near-road concentrations
41 studies, 13 countries, 30 years

Key findings, by distance from road:

- 150 m – rapid (50%) decline
- 400 m – most at background
- 600 m – nearly all at background

(nighttime exceptions)



Source: Karner, Eisinger, Niemeier (2010) *ES&T*, 44, 5334-5344.

Core Concepts

To mitigate traffic-related air pollution exposure near high-volume roadways, planners can target:

Emissions

Image: noaa.gov

Concentrations

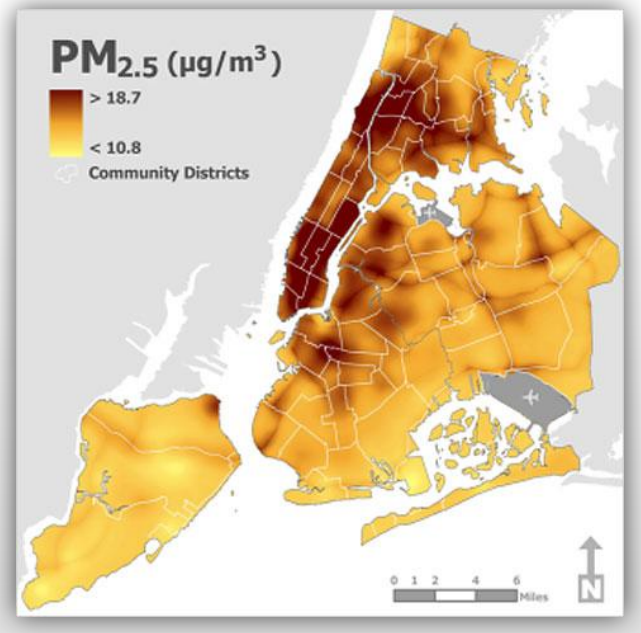


Image: nytimes.com

Exposure

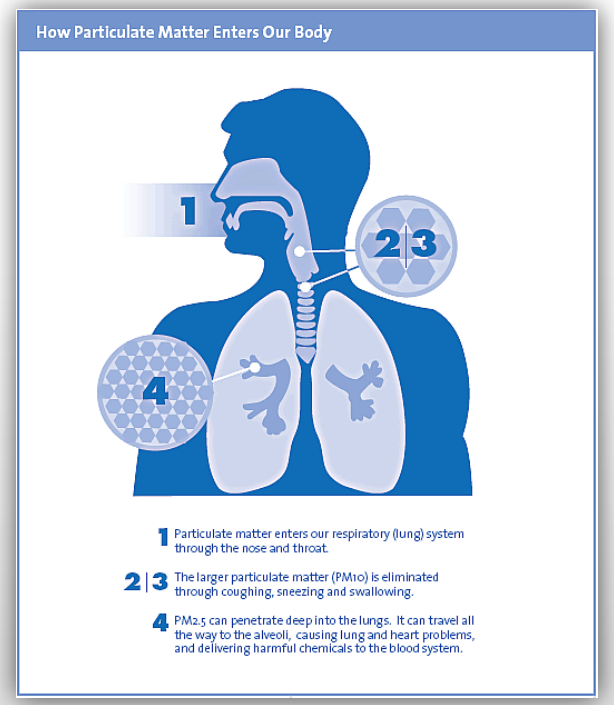


Image: bcairquality.ca

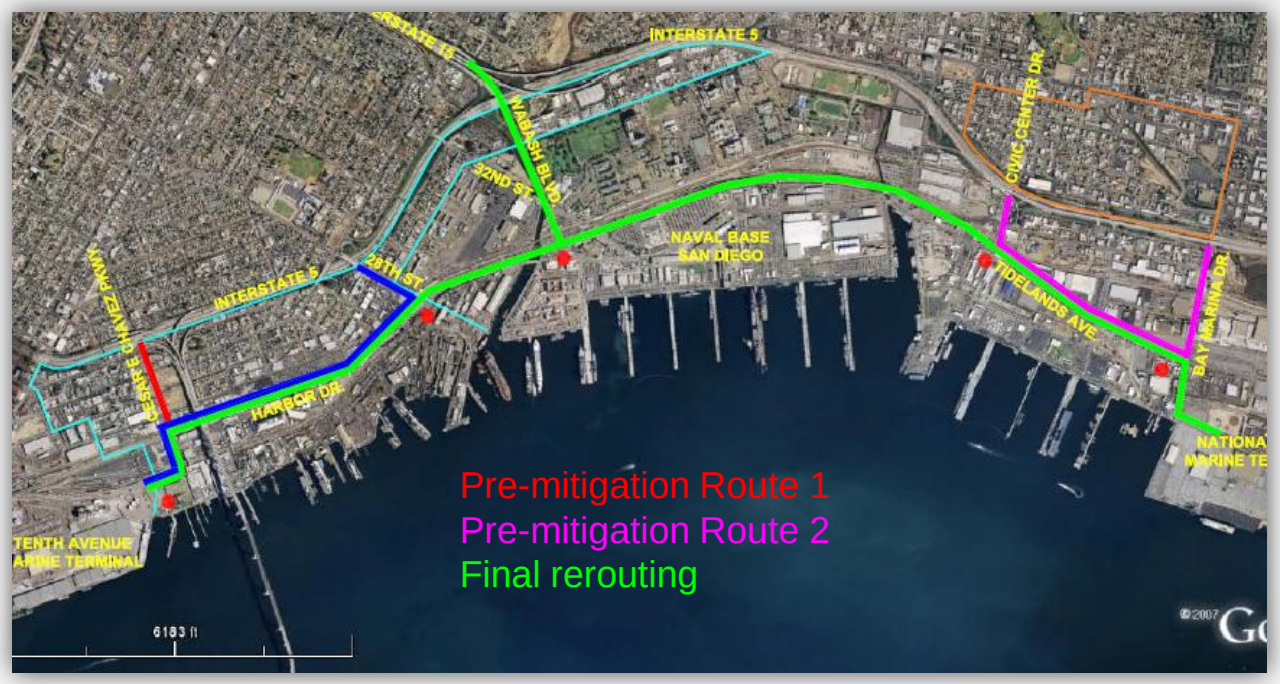
Six Strategies to Mitigate Near-Road Air Pollution Exposure

Emissions Concentrations Exposure

Transportation Infrastructure	Roadside Features	Site Planning	Building Design, Ops.
1. Corridor Mgt. • Improve traffic flow • Reroute trucks • Increase trips by foot, bike, or transit	3. Barrier Use • Install walls • Add vegetation	4. Design • Locate sensitive uses farther from roads • Phase parcels closest to road later in build out	5. Design • Optimize occupant placement 6. Operations • Use/improve HVAC filtration
2. Street Design • Lower volumes • Buffer people from roads			

1. Corridor Management

Truck rerouting reduced diesel PM in San Diego residential areas.
Image: Karner et al., 2009.



Reduce Emissions

- Improve traffic flow
- Reroute, restrict truck traffic away from sensitive land uses
- Promote land use strategies that encourage the accessibility and use of transit and active transportation

2. Street Design

Reduce Emissions

- Design complete streets
- Improve traffic flow

"Complete streets" support multi-modal travel (ULI image, 2012).

Reduce Exposure

- Create landscape and parking zones to buffer people from roads

Wider sidewalks and landscaping create buffers.

3. Barriers: Sound Walls/Vegetation

Image credit: Missouri DOT.

Image excerpt: Baldauf et al., 2013.

Reduce Concentrations

- Walls: 15-50% reduction
- Walls plus vegetation: 60% reduction
- Vegetation can filter, block
- But… gaps can allow pollutants to pass through and accumulate

Fine Print:

"Effects are still uncertain and depend on factors such as roadway configuration, height, barrier design, and meteorology. Models for quantifying impacts are still under development."

3a. Sound Walls

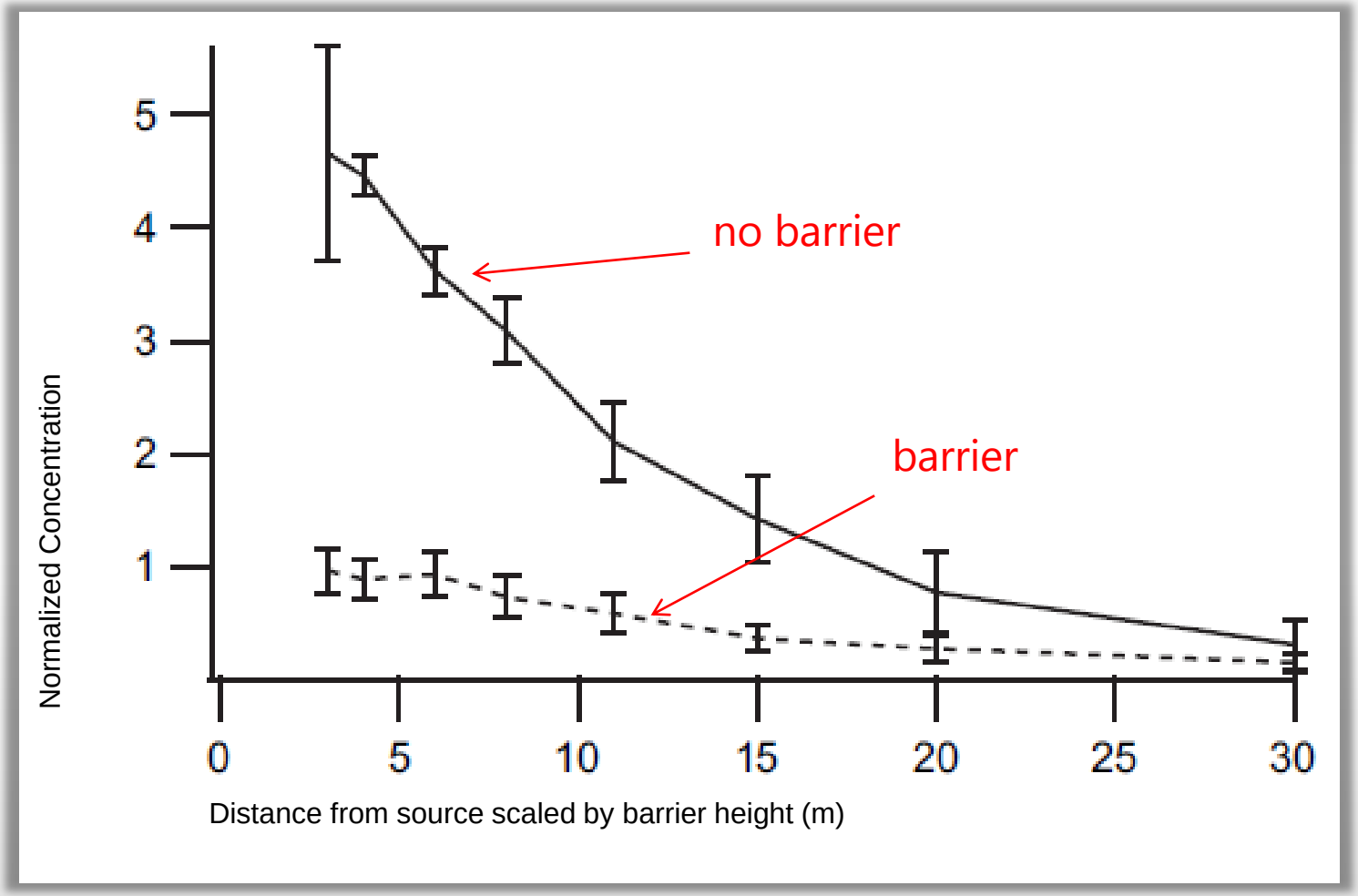
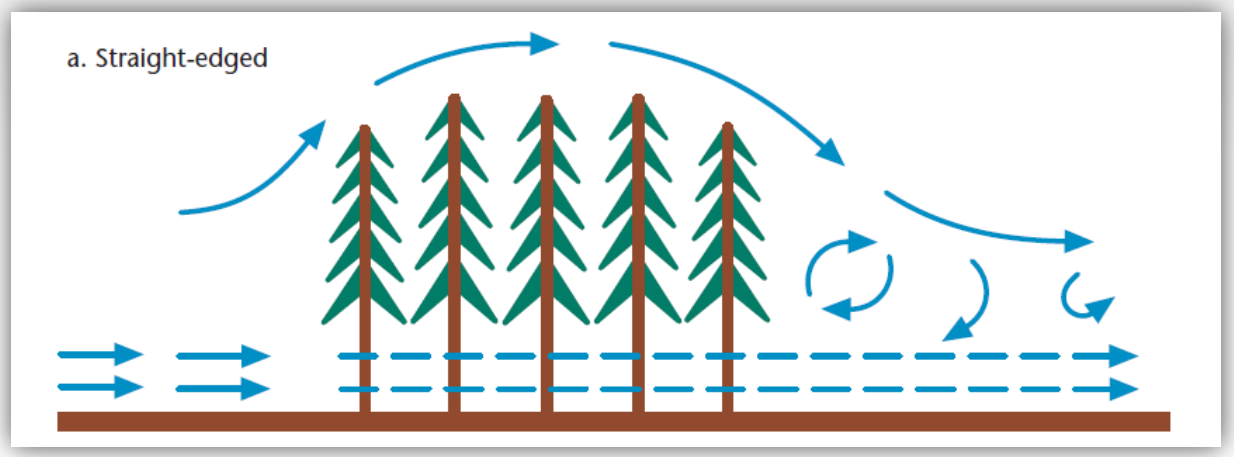
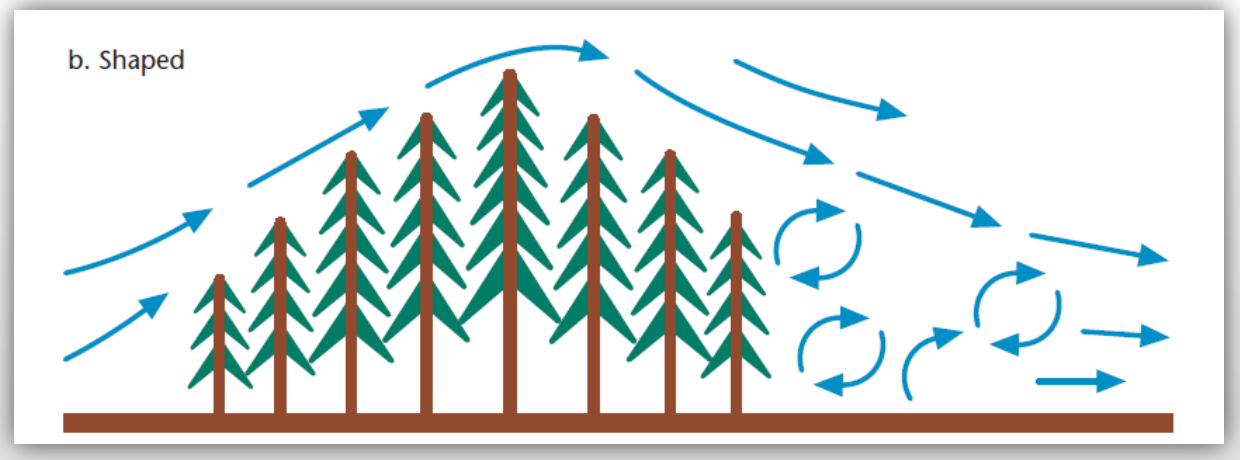


Image: Finn et al., 2010.

3b. Vegetation





Barrier shape can affect wind flow

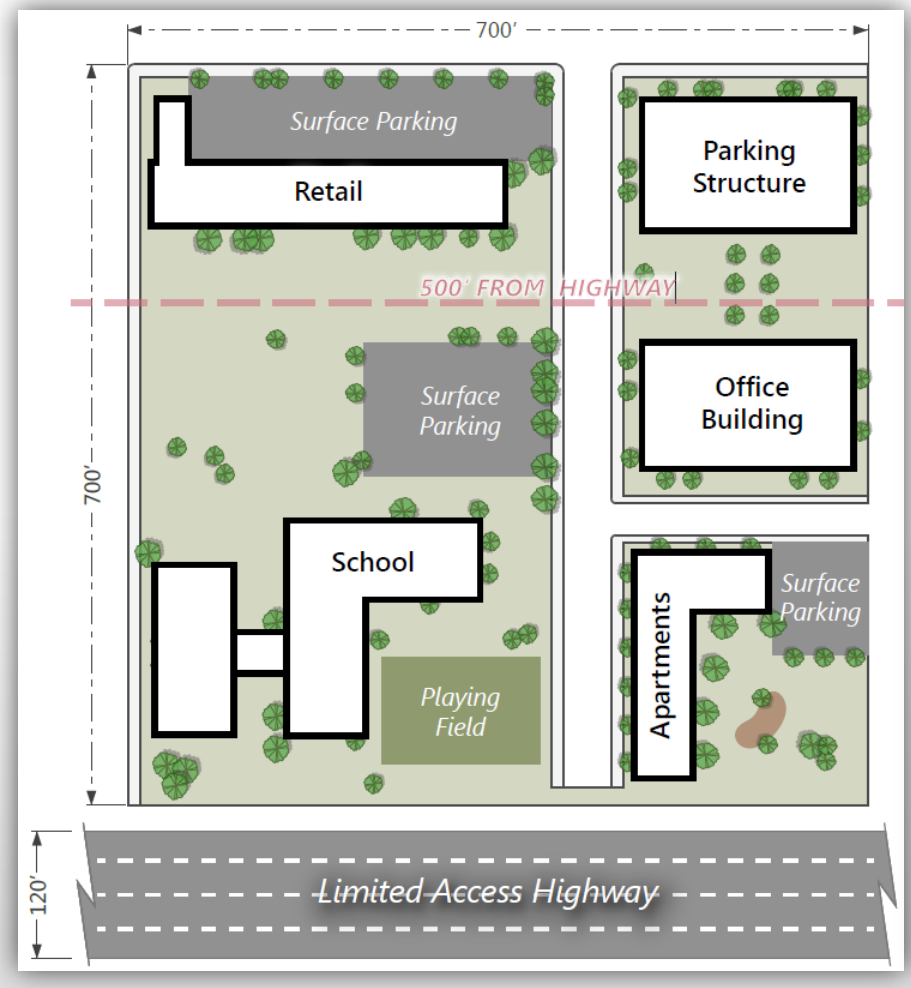
Image source:

"Principles of Using Woods for Shelter," Gardiner et al., 2006

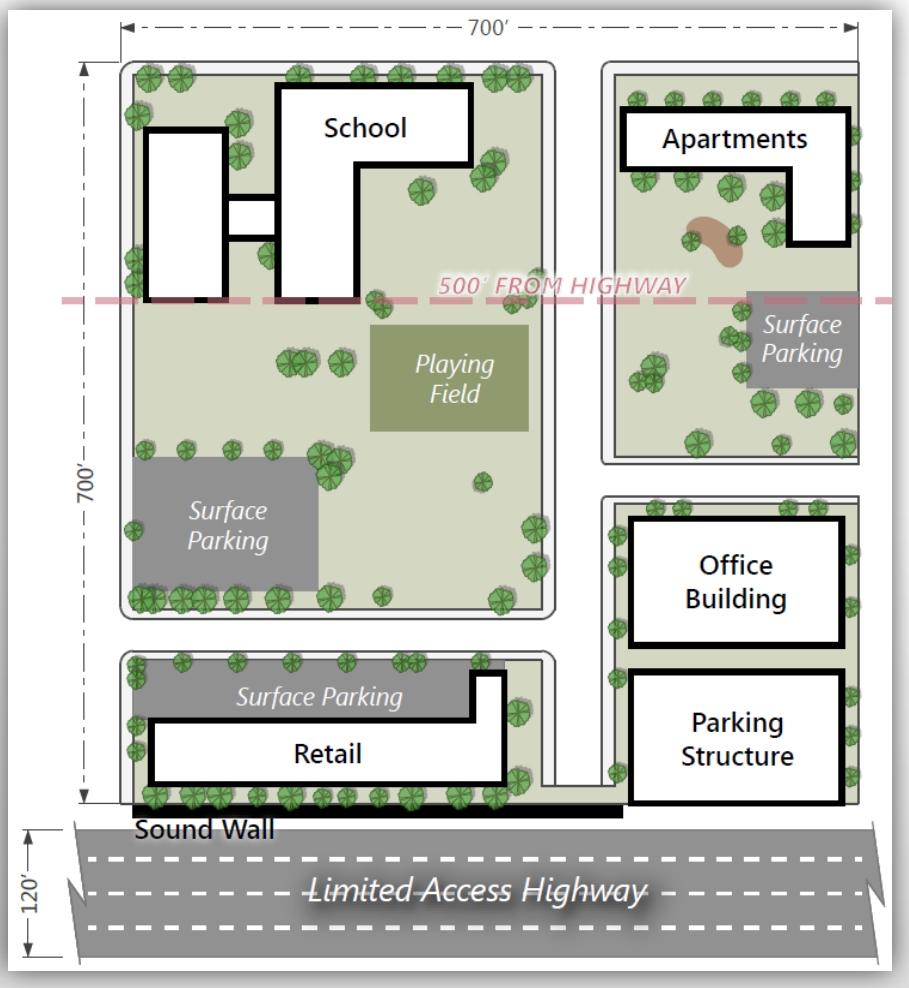
www.forestry.gov.uk

4. Site Design

Less desirable



Improved



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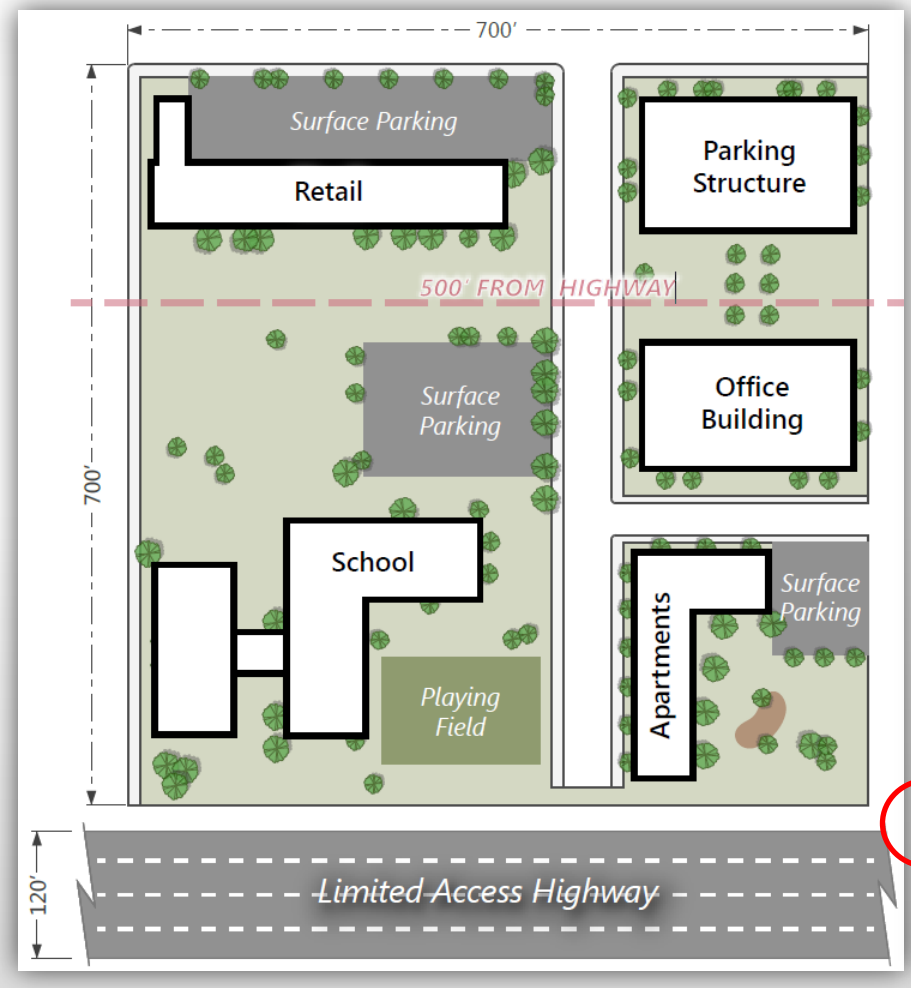

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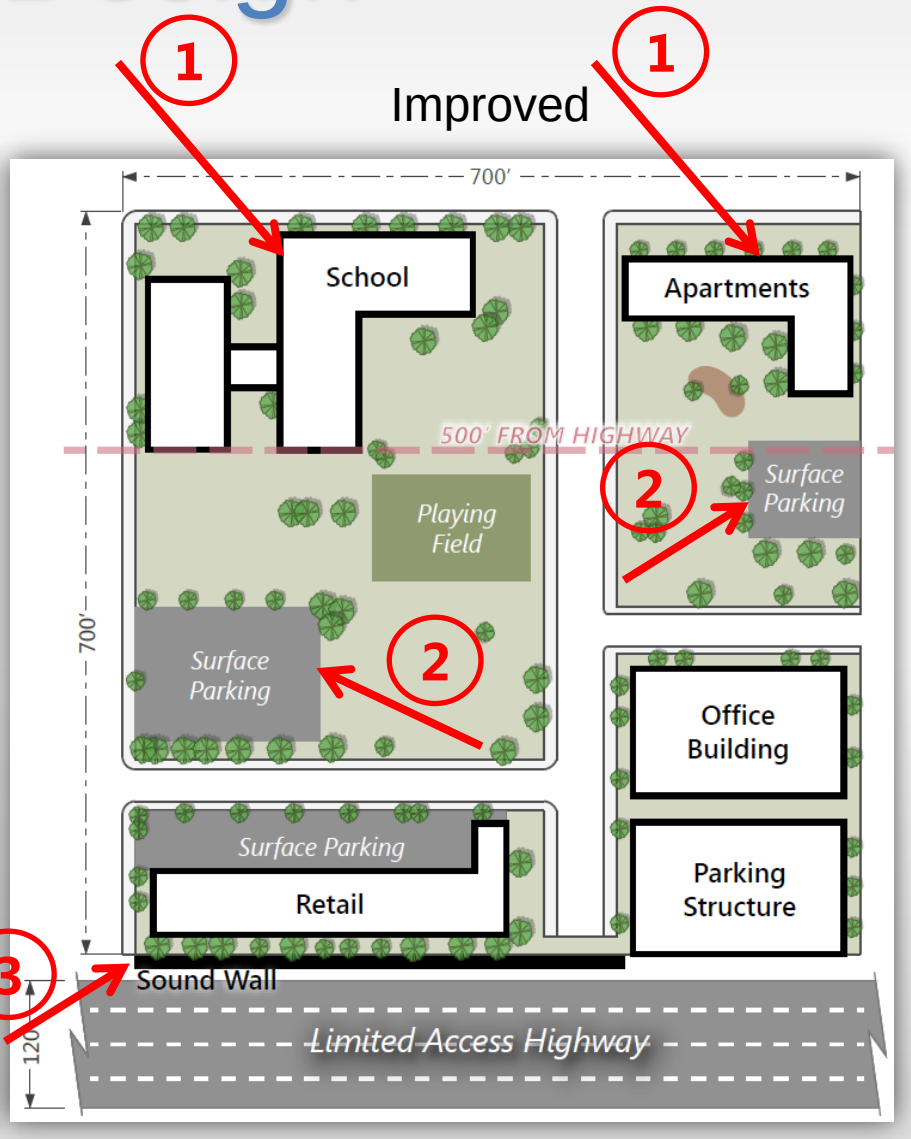

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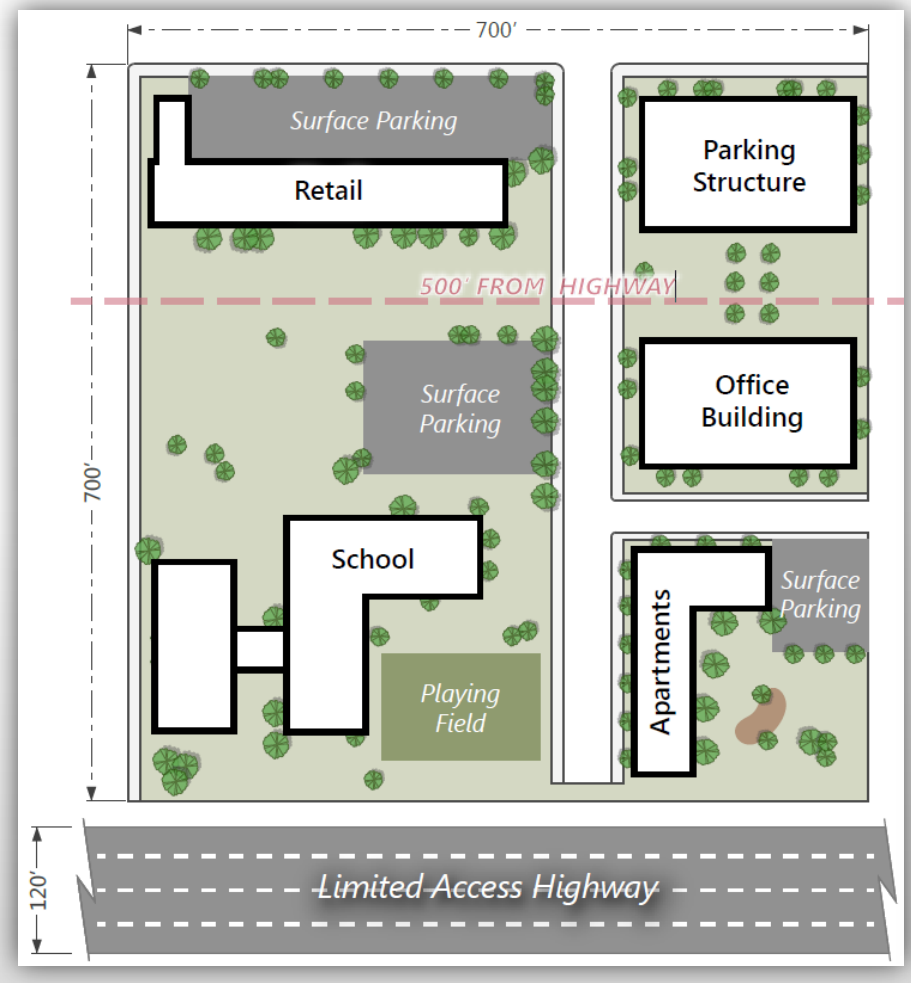
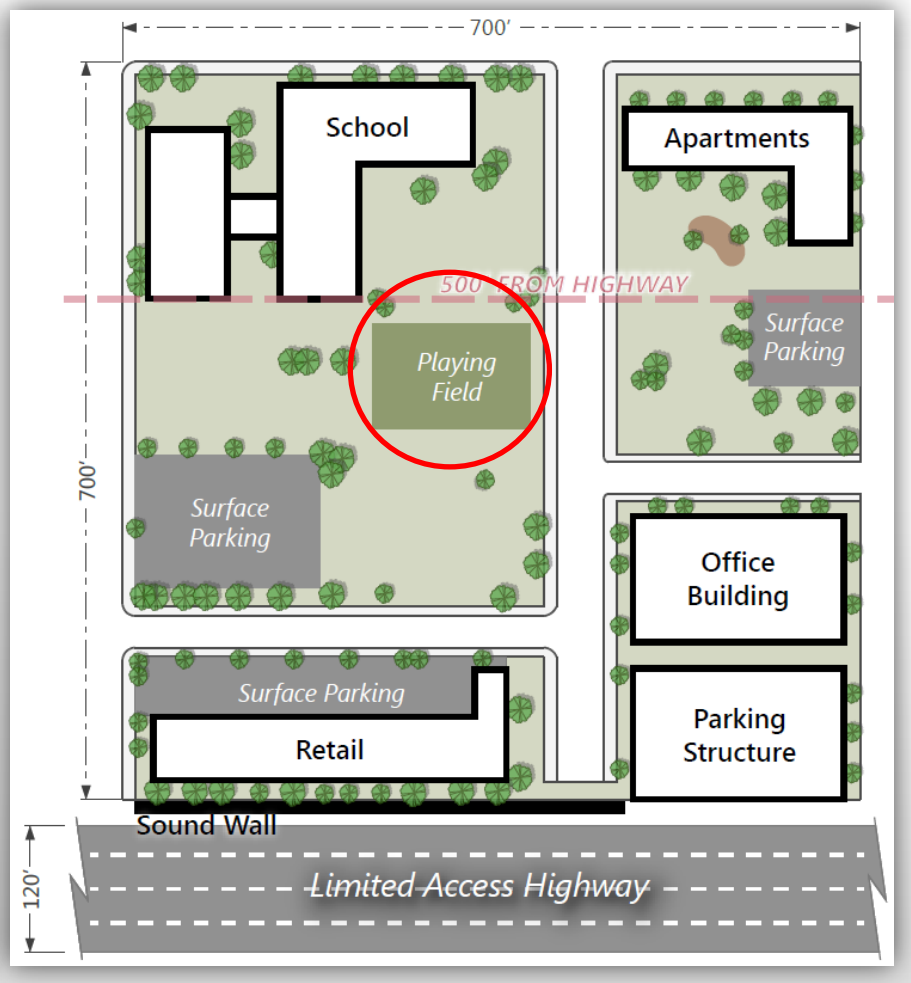


Improved



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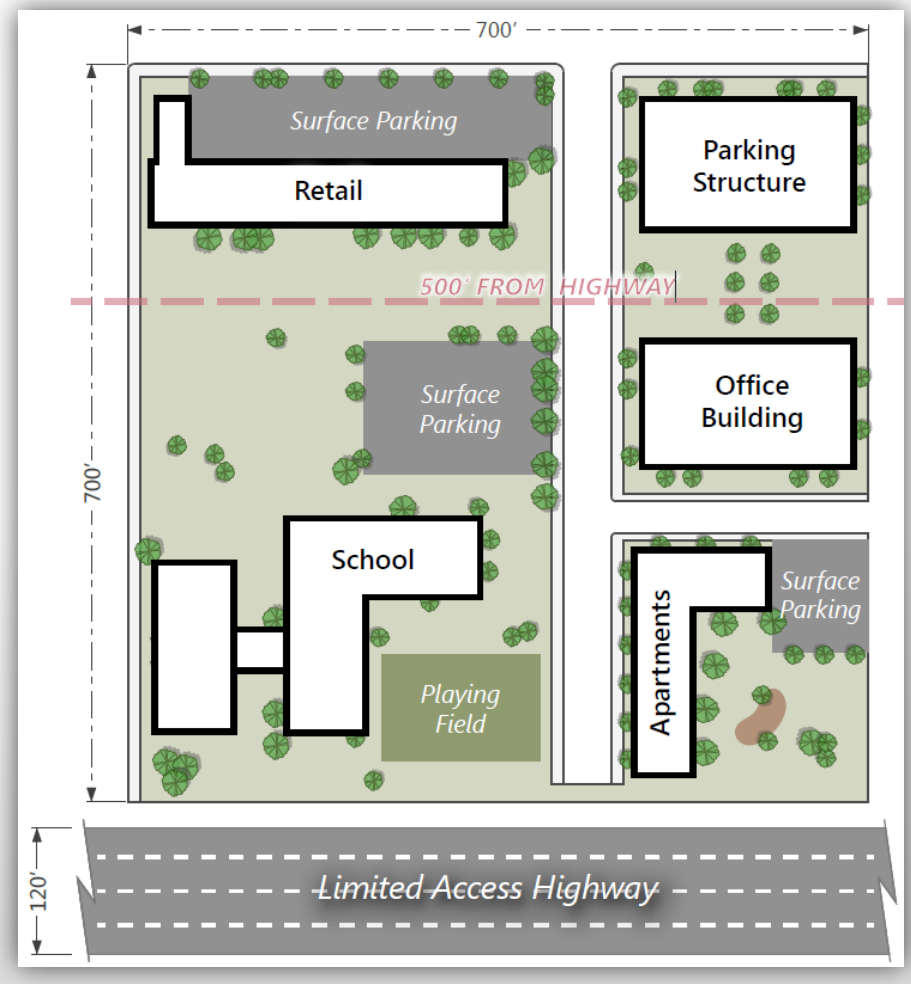
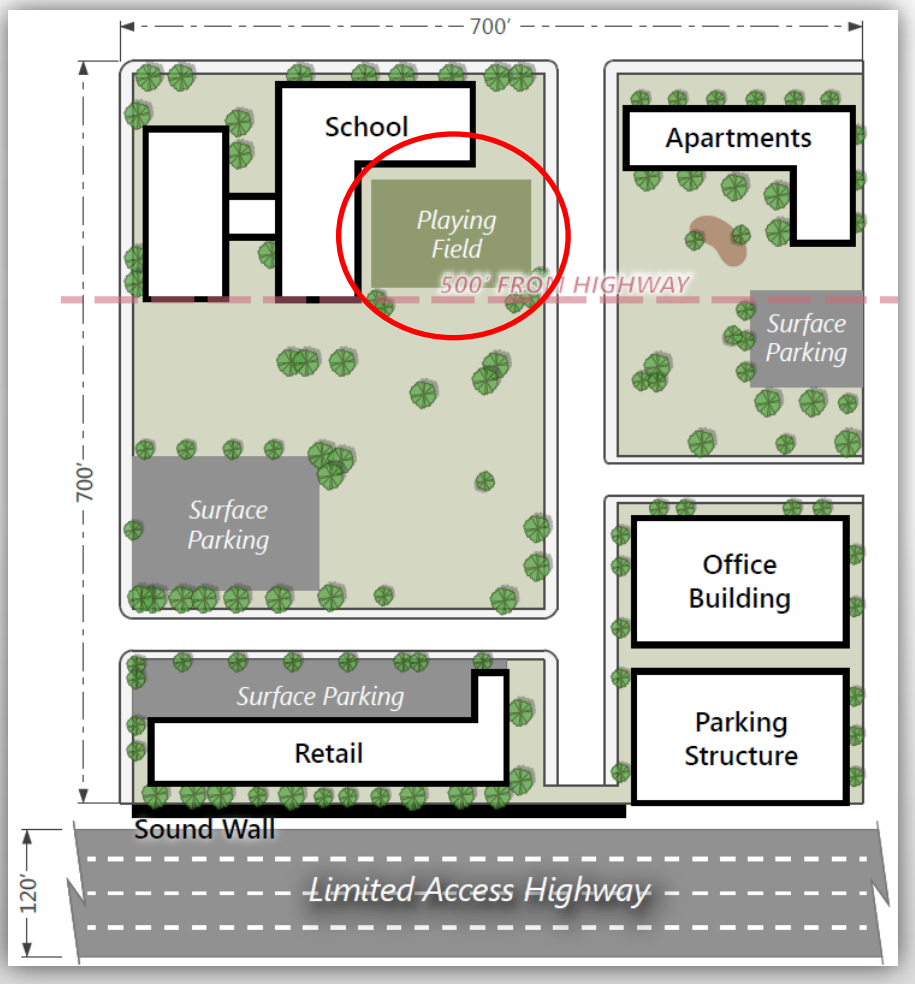


Even better



5. Building Design & 6. Operations

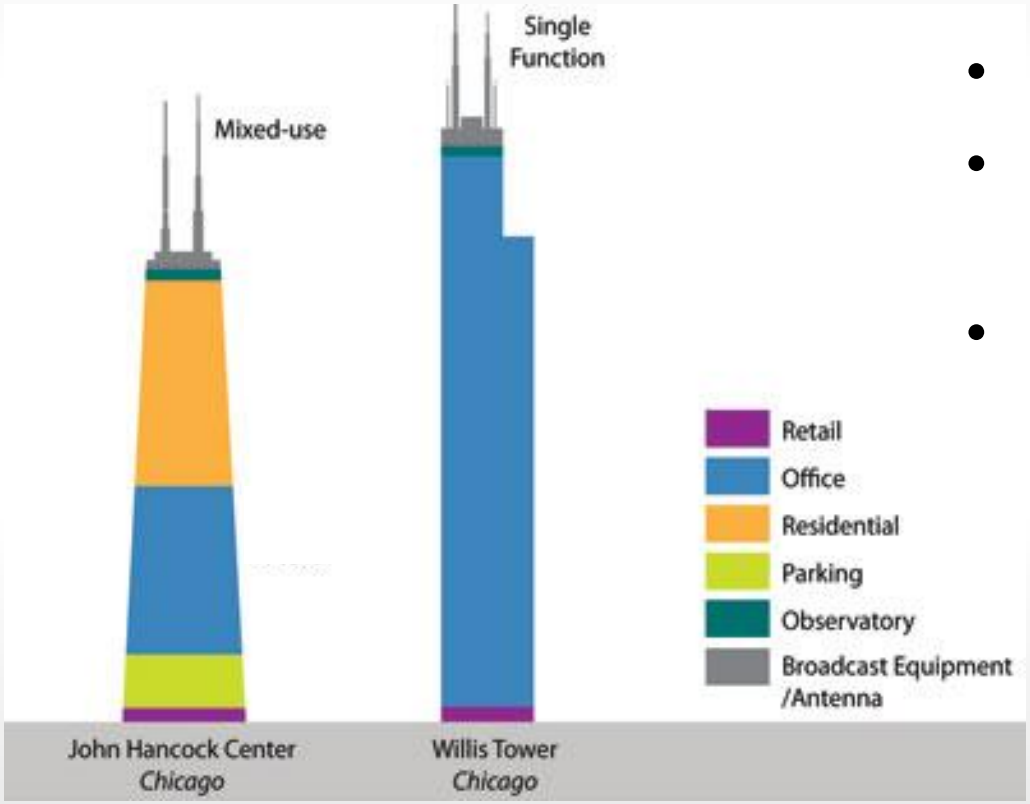


Image: ctbuh.org

Reduce Exposure

- Optimize occupant location
- Place air intakes away from pollutant source
- Improve filtration (next slides)

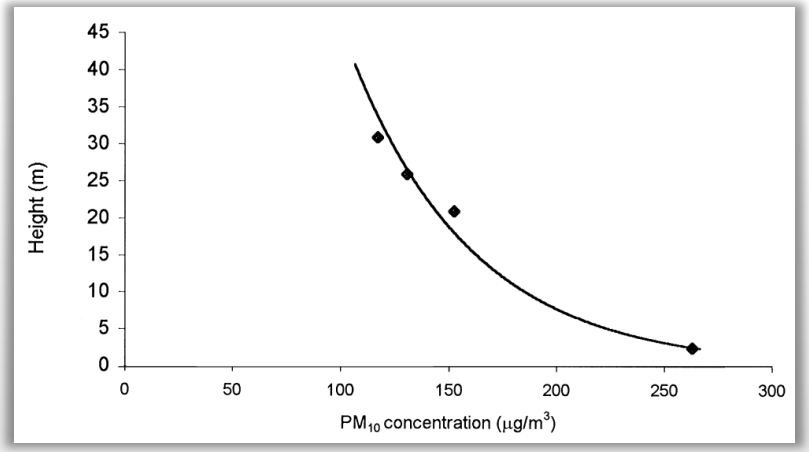


Image: Chan et al., 2000. Vertical dispersion of PM, Hong Kong street canyon.

Building Operations Case Study

Fyfe Elementary, near US 95, Las Vegas (one of several schools studied)

Before widening

After widening

Roberts et al., 2010; McCarthy et al., 2013

Building Operations Case Study

HVAC Filtration Efficiency for Black Carbon

School	Original Efficiency (old filters)	Upgraded Efficiency (2008, new filters installed)	2013 Efficiency (5 Years later)
Adcock Elem.	66%	97%	91%
Fyfe Elem.	50%	72%	50%

Roberts et al., 2013

Note: Original filter rating of MERV 6 was used in all three schools.
MERV = Minimum Efficiency Reporting Value, per ASHRAE. This is the typical efficiency of particle removal in the size range of 0.3 to 10 microns in diameter.

Mitigation: Consider as a Package

Emissions Concentrations Exposure

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Acknowledgments

Best practice work was supported by several U.S. EPA offices

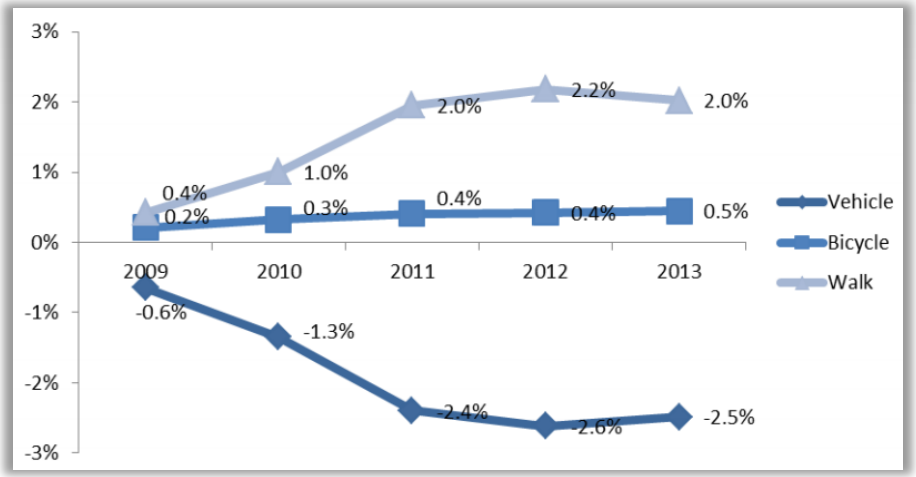
- Office of Sustainable Communities
- Office of Research and Development
- Office of Transportation and Air Quality
- Region 9 Office
- Office of Children's Health Protection

School filtration pilot testing work was supported by

- Nevada Department of Transportation
- Clark County School District

Supplemental Slides for Questions and Answers

Supporting Active Transport Can Reduce Vehicle Use

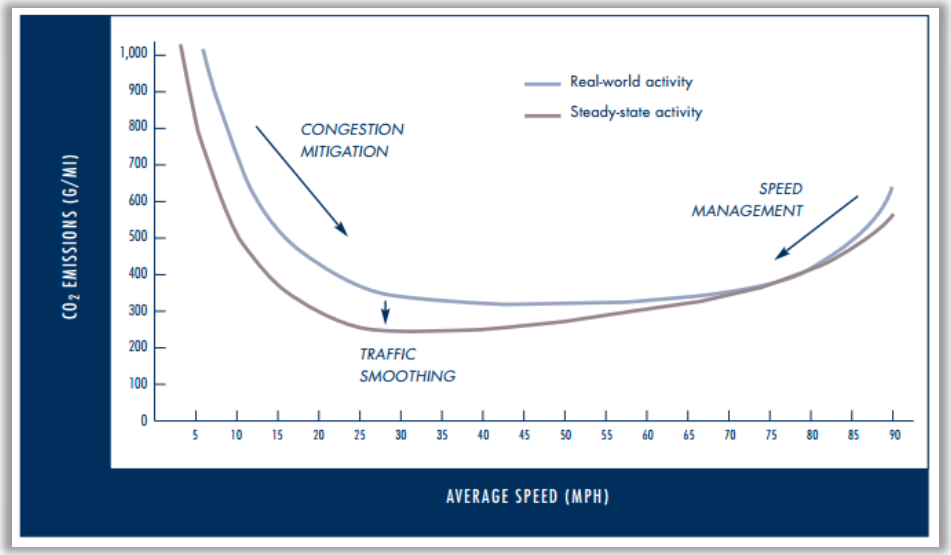


Changes in vehicle, bicycle, and pedestrian travel compared to 2007 baseline for four communities receiving ~$25M each in a pilot program to support walking and biking infrastructure and other non-motorized programs. Data presented are three-year moving averages. Image from Federal Highway Administration (2014).

Additional Resources

- U.S. Environmental Protection Agency (2001) Improving Air Quality Through Land Use Activities. Available at www.epa.gov/otaq/stateresources/policy/transp/landuse/r01001.pdf.
- National Research Council (2009) Driving and the built environment: The effects of compact development on motorized travel, energy use, and CO_2 emissions. Available at http://www.nap.edu/openbook.php?record_id=12747.
- Federal Highway Administration (2014) Nonmotorized Transportation Pilot Program. Available at http://www.fhwa.dot.gov/environment/bicycle_pedestrian/ntpp/2014_report/hep14035.pdf.

Smoothing Flow Can Reduce Emissions

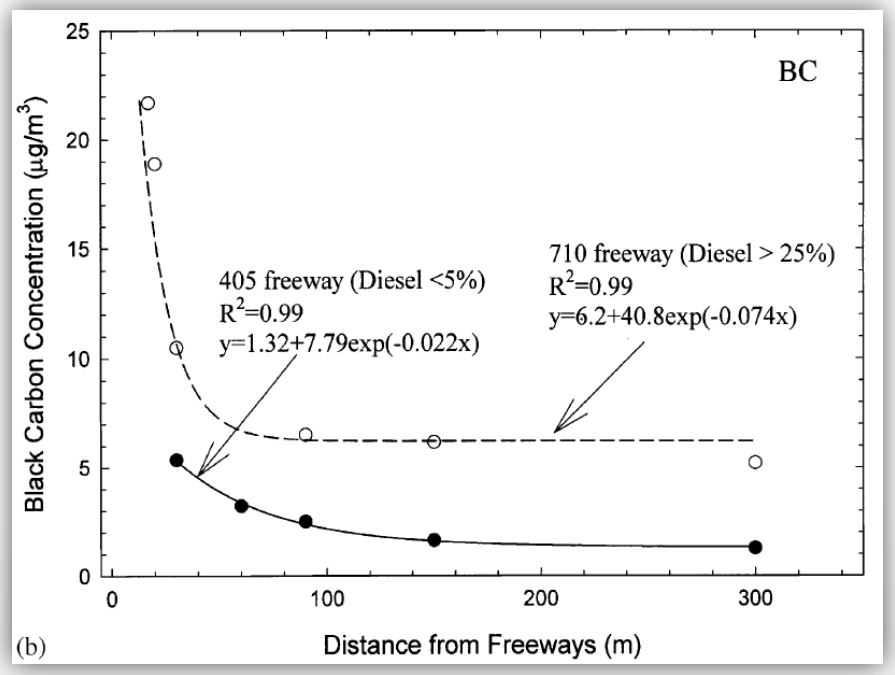


CO_2 emissions versus average vehicle speed, and possible use of traffic operation strategies. Image from Barth and Boriboonsomsin (2009).

Additional Resources

- Timoshek et al. (2010) Mobile source air toxic emissions: sensitivity to traffic volume, fleet composition, and average speed. *Journal of the Transportation Research Board*, 2158, 77-85.
- Keuken et al. (2010) Reduced NO_x and PM_{10} emissions on urban motorways in The Netherlands by 80 km/h speed management. *Science of the Total Environment*, 408(12), 2517-2526.
- Dowling et al. (2005) Predicting air quality effects of traffic-flow improvements. Available at http://trb.org/publications/nchrp/nchrp_rpt_535.pdf.

Rerouting, Restricting Trucks Targets Priority Emissions

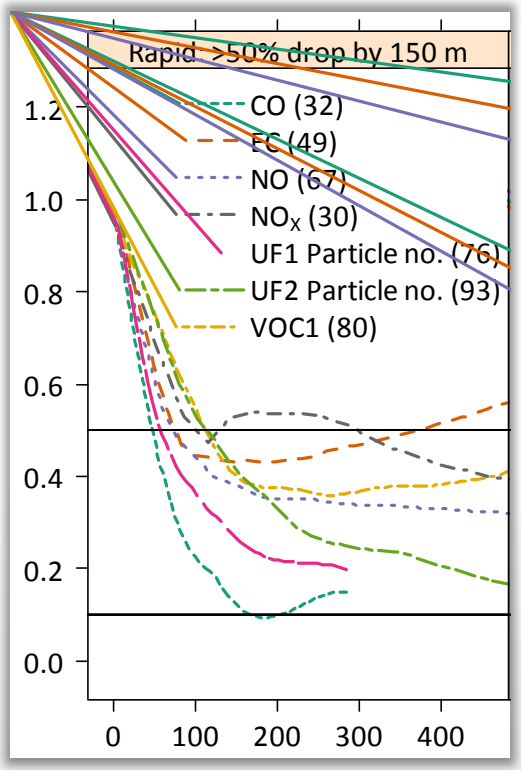


Pollutant concentrations as a function of distance from the roadway for roadways with <5% and >25% diesel traffic. Image from Zhu et al. (2002).

Additional Resources

- Karner et al. (2009) Mitigating diesel truck impacts in environmental justice communities: transportation planning and air quality in Barrio Logan, San Diego. *Journal of the Transportation Research Board*, 2125, 1-8.
- Burr et al. (2004) Effects on respiratory health of a reduction in pollution from vehicle exhaust emissions. *Occup. Environ. Med.*, 61(3), 212-218.
- Zhu et al. (2002) Study of ultrafine particles near a major highway with heavy-duty diesel traffic. *Atmos. Environ.*, 36(27), 4323-4335.

Concentrations Generally Decrease by at Least 50% Within 150 m (~500 ft) of a Roadway

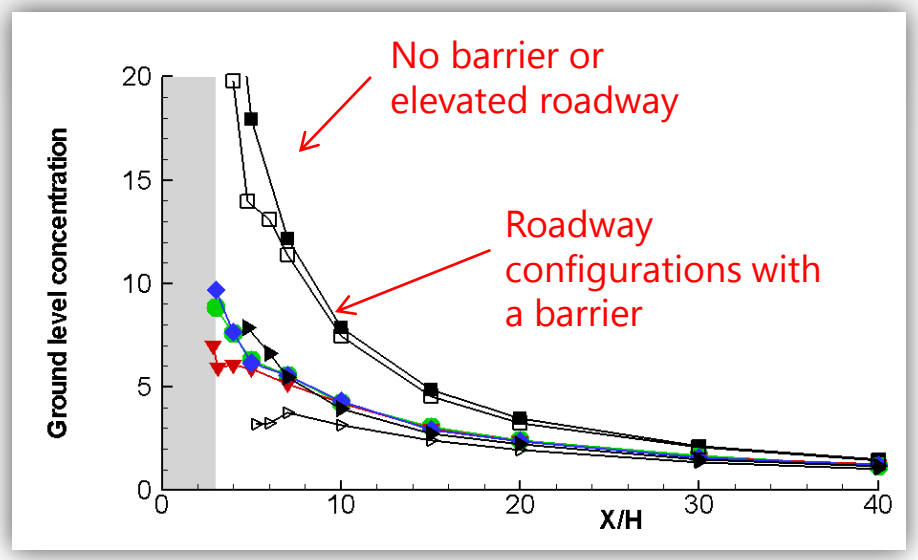


Normalized pollutant concentration as a function of distance in meters from the roadway. Image from Karner et al. (2010).

Additional Resources

- Karner et al. (2010) Near-roadway air quality: synthesizing the findings from real-world data. *Environ. Sci. Technol.*, 44, 5334-5344.
- HEI Panel on the Health Effects of Traffic-Related Pollution (2010) Traffic-related air pollution: a critical review of the literature on emissions, exposure, and health effects. Special Report 17 by the HEI, Boston, MA.
- Zhu et al. (2002) Study of ultrafine particles near a major highway with heavy-duty diesel traffic. *Atmos. Environ.*, 36(27), 4323-4335.

Barriers Can Reduce Concentrations ~15–60%



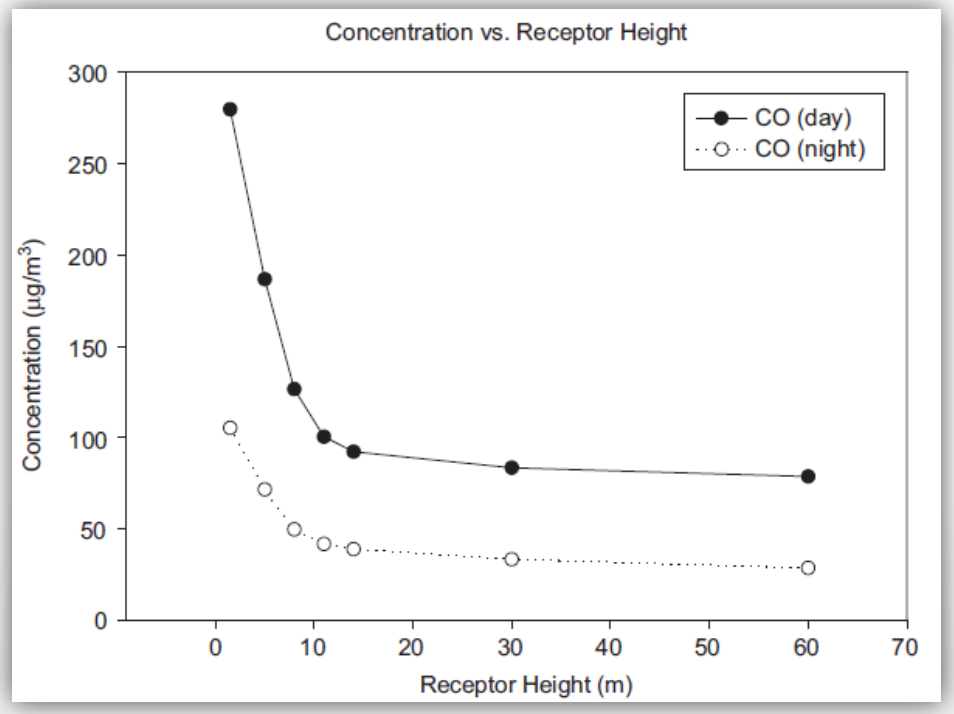
Normalized pollutant concentrations, normalized distance from road, and presence of a barrier. Data from

- Baldauf et al., 2009 (*Near-road air quality monitoring: factors affecting network design and interpretation of data*)
- Heist et al., 2009 (*Wind tunnel study on the effect of roadway configurations on the dispersion of traffic-related pollution*)

Additional Resources

- Hagler et al. (2012) Field investigation of roadside vegetative and structural barrier impact on near-road ultrafine particle concentrations under a variety of wind conditions. *Science of the Total Environment*, 419, 7-15.
- Finn et al. (2010) Tracer studies to characterize the effects of roadside noise barriers on near-road pollutant dispersion under varying atmospheric stability conditions. *Atmos. Environ.*, 44, 204-214.
- Baldauf et al. (2008) Impacts of noise barriers on near-road air quality. *Atmos. Environ.*, 42, 7502-7507.

Site, Building Design, and Use Can Reduce Exposure (Consider Concentration Changes with Height)

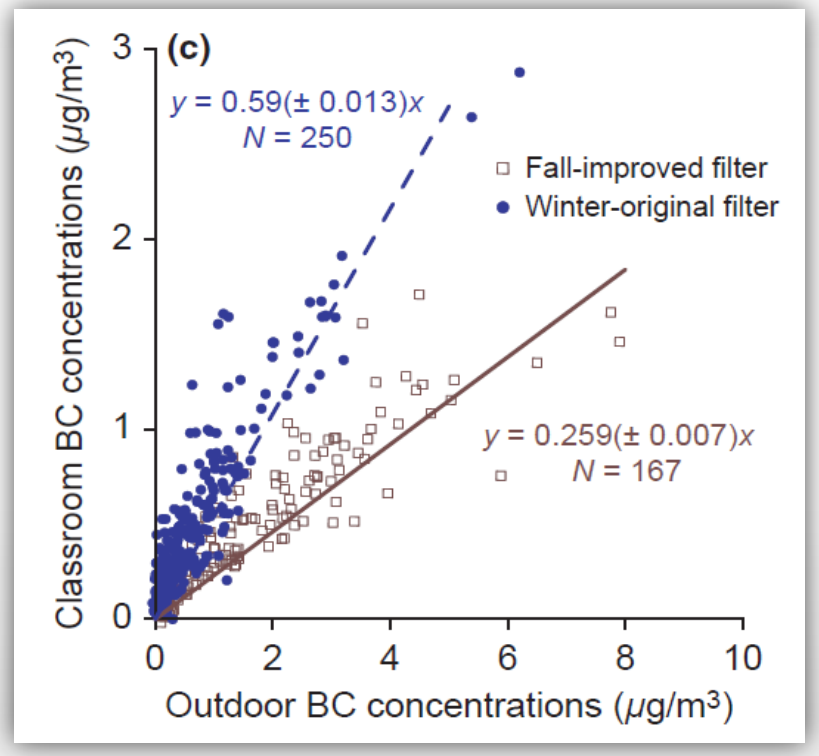


Modeled vertical profiles of CO in a New York City street canyon. Concentration in the graph refers to the contribution from traffic. Image from Zhou and Levy (2008).

Additional Resources

- Jung et al. (2011) Effects of floor level and building type on residential levels of outdoor and indoor polycyclic aromatic hydrocarbons, black carbon, and particulate matter in New York City. *Atmosphere*, 2, 96-109.
- Zhou and Levy (2008) The impact of urban street canyons on population exposure to traffic-related primary pollutants. *Atmos. Environ.*, 42(13), 2087-3098.

Filtration Can Reduce Indoor Particle Exposure by as Much as 97%



Indoor versus outdoor black carbon concentrations for classrooms using low- (purple) and high-efficiency (brown) filters. Image from McCarthy et al. (2013).

Additional Resources

- McCarthy et al. (2013) Filtration effectiveness of HVAC systems at near-roadway schools. *Indoor Air,* 23(3) 196-207.
- Polidori et al. (2012) Pilot study of high-performance air filtration for classroom applications. *Indoor Air,* 23(3) 185-195.
- Jamriska et al. (2003) Control strategies for sub-micrometer particles indoors: model study of air filtration and ventilation. *Indoor Air*, 13(2), 96-105.