Current research in NRMRL on the mitigation of near-road air pollution by vegetative and structural barriers

Background

Numerous research studies published in scientific literature have shown that people living, working, and going to school near large roads experience increased adverse health effects. In addition, studies show that air pollution is worse in close proximity to major roadways (e.g., Hagler et al., 2009). In order to understand the effects of traffic emissions on near-road air quality, EPA's Office of Research and Development has conducted a number of field measurement and modeling studies (e.g., http://www.epa.gov/nrmrl/news/082009/news082009.html). EPA is also interested in identifying ways to mitigate the traffic emissions that may pollute populated areas nearby. One option being investigated by EPA researchers is the use of roadside structures, such as vegetative buffers or solid noise barriers, to alter the transport and dispersion of traffic emissions. The hypothesis is that roadside obstacles to air flow causes the polluted air over the roadways to lift and vertically mix, leading to lower concentrations on the ground-level in areas nearby major roads. The surfaces of leaves or structural walls may also serve to remove pollution from the air.

Recent modeling and field measurements conducted by EPA researchers in the National Risk Management Research Laboratory (NRMRL) and National Exposure Research Laboratory (NERL) determined that this idea has merit and that roadside barriers may indeed improve air quality in areas next to major roads. Some key results from these studies include:

- Field measurements showing reductions of carbon monoxide and particle counts by 15-50% when behind a 6 m noise barrier in comparison to in a clearing, when downwind of a major roadway in Raleigh, NC (Baldauf et al., 2008).
- Model simulations of the Raleigh, NC noise barrier site using the Quick Urban Industrial Complex (QUIC) model, predicting lower air pollutant concentrations in barrier-protected areas compared to flat terrain areas, in agreement with field data (Bowker et al., 2007).
- Wind tunnel studies finding consistent reductions in near-road pollutant levels for multiple roadside barrier configurations in comparison to a flat terrain scenario, when winds are perpendicular to the road (Heist et al., 2009).

These previous findings are motivating current research at EPA into the effects of roadside barriers on near-road air quality. Current research is expanding into several topics, including the impact of vegetative buffers on traffic emissions dispersion, whether certain site conditions may lead to adverse barrier effects on near-road air quality, and how the barrier effect may vary with wind direction.

Research Objectives

In order to understand how roadside structures alter near-road air quality, EPA research scientists are conducting further field and modeling studies aimed at answering the following questions:

1. Do roadside vegetative and structural barriers reduce near-road air pollution?
2. How do vegetative and structural barriers alter the transport of traffic emissions?
3. What meteorological or barrier site conditions lead to the greatest improvement in near-road air quality?

Research Methods

Field Measurement Campaigns

Multiple field studies have been conducted to measure how traffic emissions disperse with and without barriers present. The locations of the completed studies, conducted during 2008-2009, include Raleigh, North Carolina (structural barrier), Mebane, North Carolina (deciduous tree stand), Chapel Hill, North Carolina (evergreen tree stand), and Las Vegas, Nevada (no barriers). In addition, field measurements will be conducted in Detroit, Michigan in 2010. The air pollution data is collected using an innovative mobile monitoring technique, using air monitoring equipment mounted onboard vehicles and collecting data either while parked at selected locations or mapping data while driving. Air pollutants measured included carbon monoxide, black carbon, ultrafine particles, and fine and coarse particulate matter. In addition, a portable meteorological tower measured wind direction and speed, as well as temperature and humidity. Barrier properties were also documented, including leaf air index for vegetative buffers and barrier physical dimensions.

Figure 1. Air monitoring data collection onboard one of the mobile monitoring vehicles

Figure 2. EPA’s Geospatial Monitoring of Air Pollution (GMAP) vehicle.

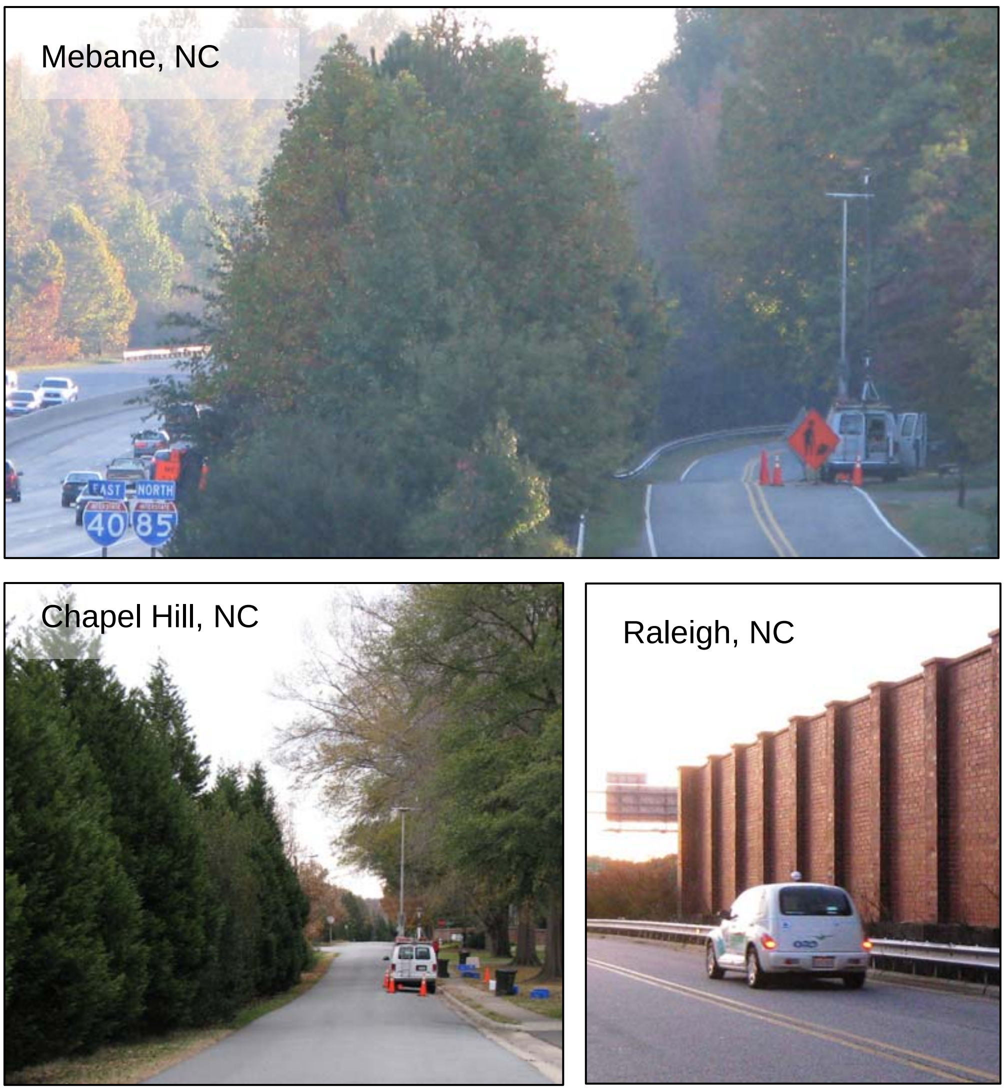

Figure 3. Roadside barrier field sites in North Carolina.

__Modeling Studies:__
A benefit of physical or computational models is the capability to control a number of variables that you are unable to do in the field, such as the wind speed and traffic emissions rate. In order to observe how barriers affect the transport of traffic emissions under a variety of scenarios, a computational fluid dynamics (CFD) model was designed by expert modelers in EPA's Environmental Modeling and Visualization Laboratory (EMVL). The base road model was based upon experimental wind tunnel data collected by NERL researchers (Heist et al., 2009). Simulations of traffic emissions dispersion was conducted for multiple barrier heights, wind directions, and barrier types (vegetation and structural). The model outputs concentration and flow fields that show how the structural barrier would alter flow patterns and near-road concentrations. In addition, to specifically determine whether vegetation collects particulate air pollution, a wind tunnel study was conducted dispersing fine and coarse particles through a vegetative buffer using EPA's Aerosol Wind Tunnel in Research Triangle Park, North Carolina.

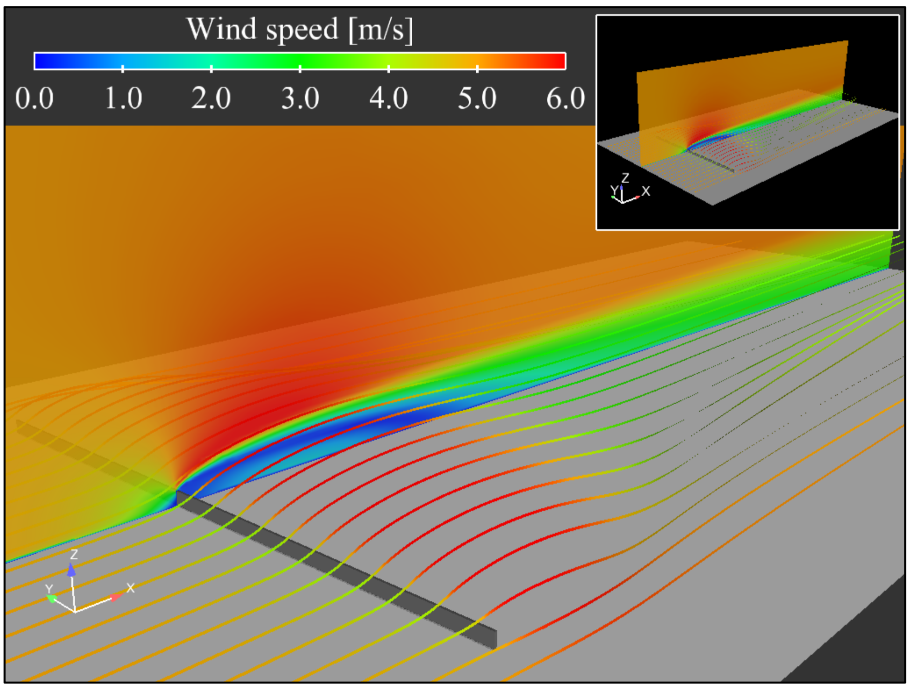

Figure 3. Roadside barrier computational fluid dynamics model.

Application and Impact
Results from this research will improve our knowledge of how traffic emissions disperse in the presence of roadside structures, which will improve the accuracy of air quality and exposure models and support future transportation planning. This research will integrate into the overall EPA Near-Road Research Program, which focuses on near-road air pollution from the point of tailpipe emission to human health outcomes.

Workshop:
EPA is hosting a workshop, titled "The Role of Vegetation in Mitigating Air Quality Impacts from Traffic Emissions", that will occur in April, 2010 in Research Triangle Park, NC. This workshop will bring together planning, research, and policy stakeholders

to review the current science and identify future applications in evaluating the potential role of vegetation in mitigating near-road air pollutant concentrations.
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Presentations:

Poster Presentation at the Air & Waste Management Annual Conference in Calgary, Canada, June 2010, titled "A field and modeling study to assess the potential mitigation of near-road air pollution by vegetative and structural barriers"

Platform Presentation at the Fifth International Symposium on Computational Wind Engineering in Chapel Hill, North Carolina, May 2010, titled "Computational fluid dynamics modeling to assess the impact of roadside barriers on near-road air quality"

Platform Presentation at the Air & Waste Management Information Exchange in Research Triangle Park, NC, December 2009, titled "Mitigation of near-road impact by vegetative and structural barriers"

Platform Presentation at GREENBUILD International Conference and Expo in Phoenix, Arizona, November 2009, titled "Can roadside vegetation improve near-road air quality?"

Contributing Organizations

EPA National Risk Management Research Laboratory
EPA Advanced Monitoring Initiative
EPA National Exposure Research Laboratory
EPA Environmental Modeling and Visualization Laboratory
EPA Office of Transportation and Air Quality
ARCADIS
Alion Science and Technology
Duke University
Lockheed Martin Corporation, Information Systems & Global Services

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Bowker, G.E., Baldauf, R., Isakov, V., Khlystov, A., Petersen, W., 2007. The effects of roadside structures on the transport and dispersion of ultrafine particles from highways. Atmospheric Environment 41, 8128–8139.

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