

Near Roadway Air Pollution and Mitigation Strategies webinar transcript

Speaker: Lisa Matthews

Let me introduce our presenters. We are pleased to have Dr. Jan Dye and Dr. Richard Baldauf with us today. Both are in EPA, Jan is in EPA's Office of Research and Development's National Health and Environmental Effects Research Laboratory in Research Triangle Park, North Carolina. She is going to be talking to us about the health effects of near roadway air pollution. Rich, who is also with EPA ORD's National Risk Management Research Laboratory also out of RTP, NC who will be focusing on some of the mitigation strategies that community and transportation planners can consider to protect the public health from air pollution.

So without further ado, I'm going to turn this over to Jan to start this presentation.

Speaker: Jan Dye

Thank you very much Lisa, can everyone hear me? [Yes] Welcome everyone. Today we're going to talk about different types of roadways. Certainly they have many things in common, but they can have nuances that are different. Look at this pictures for a second. You can see not all major roadways are identical. This top one is an evening commute here in Raleigh, NC. What do you notice? I see 5 lines of traffic, more or less mostly cars, and an occasional truck. I don't really see a bus or anything indicative of public transportation. They all seem to be going in one direction at the exact same time, and most [cars] have one driver in them. This is typical of an urban commute, and it would involve a lot of gasoline type, tail-pipe emissions.

Look now at the lower slide on the left. You'll see that the automobile traffic is interspersed between trucks, this type of traffic would be more like that of a goods movement and it would have more diesel exhaust in its' emissions. Finally the last, and this is a bit of an extreme example, but this is just to remind us that there are many roads that involve a lot of stop and go, so we have breaking, idling and revving up to race to the next red light. And of course, there's more brake and tire wear in these types. Most roadways represent a mixtures of these three, but they can generate somewhat different types of traffic pollutants and may require somewhat different types of mitigation strategies.

In the US, how many people do you think live near a roadway if we define it as a freeway or interstate? Well based on this CDC report from 2013, about 4% on average or nearly 11 million people. But there clearly not evenly distributed across the US. There are dark blue states that not surprisingly have both a lot of people and a lot of highways, for example California or Texas or New York, and they're shown here in darker blue. Those states its closer to 6% of their population and the report also notices, which I think is important, is that such individuals are more likely to be in minority communities or lower socioeconomic groups.

But if we ask the broader questions, like who lives, works or goes to school or even plays near a major road or a major transportation facility, including airports and railroads then we're talking about 40 to 50 million people in the US – that's a lot of people. So amongst those is approximately 2 million children whose schools are sited within 200 meters of a large roadway. That's doesn't even take into account the

traffic exposure you receive going back and forth to your school or your work. Here in Raleigh, this could be an hour commute easily, and most of that is riding alone in your car as shown here in this purple pod.

So let's ask this question one more time – who lives, works or plays in the near roadway environment? A lot of people. This is a picture you've probably seen on various EPA websites, but I used it easily shows, if I highlight the football field which should be 100 yards which is close to 100 meters, and I draw a pink rectangle around it, and I overlap it with the school building, you can easily see that it falls well within that 200 meter zone. Now this is not the only exposure children can get because they have to go back and forth. Sometimes being in traffic for a long time can also constitute a lot of exposure. When they get to school they may be in a bus lane with idling buses or some sort of carpool lane. Together, this can be a lot of exposure.

We can think of the near-road environment as a highly concentrated mobile sources, and it makes sense that there would be some sort of gradient between roadways and nearby communities. The rate or the extent of that drop off is going to depend on a variety of factors – wind, temperature, elevation, but there's likely to be hot spots, especially where 2 major roads meet or intersect or cross.

So how do we begin to define health effects in this highly dynamic and variable near-road environment? We tend to use a combination of approaches, a big part of which is epi-studies. But we supplement them with experimental studies, whether it be panel or animal toxicology as well as mechanistic studies. I've included a link here where you can get more resources through EPA, but one of the critical tools that has been used to define near roadway air pollution has been this multi-stage high volume ambient air sampler. Say that 12 times fast – it's a mouthful. It's shown here next to some guy who looks very interested in this device and it – the device, not the guy – can sample and collect from the ambient air across a wide-range of sizes because it passes through a variety of filters. So we can collect very small ultrafine particles PM 2.5 or even the larger coarse particles, PM 2.5 up to 10 microns. You can take this device and put it near a road or you can put it at variable distances away from a road. When you combine it with the trailer, which can contain a lot of other monitoring devices, it can be mobile. It can go to different cities under different seasons. It has been used to characterize the PM in these areas and to learn more about the near-road environment.

So far the rest of my talk, I've broken it down into these three broad questions. We're going to have a few examples [that are] obviously brief and very high level. What is in that near-road environment, who is at risk and perhaps why? This is graph showing across multiple states the consistency of how those very fine, ultrafine particles fall off from one, the center of the road to a tenth of that amount as you get anywhere from between 100 and 200 meters away. So two take home messages from this slide, it was produced by Gayle Hagler and colleagues here at EPA – one is that consistency of that drop off and the other is to point out just how high that concentration of particles can be in that near-road environment, up to ten fold higher compared to that farther outer background of that urban fixture.

Now this is a follow-up study by Karner and colleagues, and I've labeled this relatively complex graph into three panels. The first panel I just want you to look to see how certain things in this environment fall off fairly quickly. Again, we can see ultra-fine particles and I've highlighted with the blue arrow the "CO" [for] carbon monoxide. These things tend to fall off 50% as you get 150 meters away. But in the second panel I've highlighted the nitrogen dioxide or NO₂ and the fine particles or PM 2.5 because they tend to show only gradual decay. Finally in the third panel, there are some studies show that the fine and the coarse particles don't necessarily change in mass as they get farther out, but that's not to say they don't change in their characteristics or subcomponents. The three that I've highlighted the CO, NO₂

and fine PM, PM 2.5, these are the pollutants often considered markers for traffic. Sometimes they refer to that as traffic related air pollutants or TRAPS, and they are the key characteristics pollutants that can be derived largely from mobile sources.

So now that you have a little better handle on the pollutants and the concentration gradients that we're taking about in this near-road emissions, the question becomes should we be concerned? A number of reviews such as this meta-analysis special report by the Health Effects Institute a few years ago in 2010 indicate that yes we should [be concerned]. This report showed a significant association and quite a number of suggested associations with a variety of health outcomes.

So this leads us to our second health question, understanding who is at risk from these emissions and very importantly who is most at risk. Not surprisingly, people with respiratory conditions are clearly effected. These individuals may have rhinitis as well as a variety of lung and inflammatory conditions such as asthma, COPD, bronchitis, and it especially includes children with these conditions. A wide number of studies have shown exposure to traffic emissions may increase your symptoms, they may increase the severity of those symptoms requiring an emergency department or even a hospitalization. Another good body of evidence shows that the lung function that should increase as you grow, especially as your height grows is less than it should be, [so] there's a reduced lung growth.

So I like this graph by Frank Gilliland and colleagues in the School of Medicine in California because it shows simply and elegantly how your odds ratio of asthma can increase as the distance of your home to a major roadway is 150 meters or less.

So since the 2010 HEI report, there have been a large number of additional epi-studies and tox-studies. They continue to report suggested positive associations across a variety of health effects. Yesterday I inquired [about] traffic and health effects and I got more than 4,000 hits. Many of those related to noise, quite a few related to car crashes, but the bulk were truly health related. Respiratory, cardiovascular outcomes like linkage to coronary artery disease and hypertension, adverse birth outcomes and even cancer - possibly lung, bladder or leukemia related. The adverse birth outcomes, we'll talk about a little more in a moment and then there's just this general category of premature mortality. On this slide, I want you to realize that the majority of these publications use some sort of traffic marker be it CO, NO₂ or PM 2.5. A very small subset uses distance to a roadway as their traffic proxy, and an even smaller subset has both metrics. But because we regulate air pollutions based on concentrations of these select criteria pollutants and not distance to roads, this type of study is especially useful to our understanding of near-road emissions.

The next two slides I'm going to highlight recent findings from the EPA STAR Grants. This is referred to as the Clean Air Research Centers, sometimes we call them CARC. I just have 6 studies here that focus on respiratory effects. Two of them, one from Emory – you can see with the “E” here and Harvard with the “H” actually have a metric of near-roadway distance. Report by Brown in 2012, they followed school-aged children and they showed that those who lived closer to the roadway tended to have poorer asthma control. A follow-up study by this group showed that poverty further increased the traffic air pollutants or TRAP effects in the asthmatics. In the 2015 Rice report, they compared people that lived 400 meters away, now that's fairly far, compared to those 100 meters away from a major road. The ones living closer to the road actually showed decreased FEV1 measurements. FEV1 is an index of how much air you can readily exhale [and] it's often reduced in asthmatics, especially when they're symptomatic. Reduction in FEV1 is also tracked with PM 2.5 concentrations. This is one of those rare but useful studies that has both a distance and a criteria pollutant concentration linked to the health effects.

The other reports shown here show things like emergency department visit and the risk of developing asthma or wheeze with pollutants like PM 2.5 or NO₂. So here's a link, you can go to this link look at NCER grants, it'll provide you a connection to the CARC and then individual parks have highlighted their findings and posted their individual publications so you can read as much as you want.

This slide is just to capture and remind us that it's not just respiratory diseases that have been associated with near-road air pollutants, but it's also cardiac disease. Rather than show specific examples, I've included this very recent overview by the Southern California Group. I really liked it because in it shows as they're tackling their near-road and traffic related emissions, that because since those same transportation sources contribute to greenhouse gases like CO₂, and of course because tail-pipe emissions with hydrocarbons react with NO_x species in sunlight to form ozone, that as they're tackling their traffic issues they're improving their ambient air standards and reducing their carbon footprint. We call that a win, win, win.

Last of all the CARC slides we have prenatal exposure, and perhaps that is the most susceptible of all populations. The three studies shown here highlight, again from Emory and Harvard, where higher TRAP exposure was associated with either preterm birth, lower preterm birth and reduced fetal growth with more rapid post-natal weight gain. Poverty again was associated with increased susceptibility to the TRAP effects. Here they used lower education attained by the mothers as that metric. The last study by Strickland is especially interesting because these folks again found significant associations for emergency department visits for asthma or wheeze with air pollution. Ok, we've heard that about 6 times already, but they further showed that the strongest association were kids who had themselves be premies, in other words born preterm. Can you can kind of see this vicious cycle beginning to develop?

Our last question is – ok, I believe the literature, but why would traffic emissions be causing all these health effects? Here I'm going to just show some of our TOX and in-vitro data to sort of tie in some of these effects.

Let's circle back to the PM samples that were obtained from the Highball Sampler. In a report by Cho and colleagues, they reported – and I'm referring to this cute little pink and yellow chart – they reported that the near-road particle content was enriched with certain elements especially metals, for example copper or zinc, especially in the coarse and fine particle sizes. Notably, copper and zinc are markers of brake and tire-wear respectively, and the metal content of PM has been shown to be directly linked [to] induction of airway inflammation and airway changes. Similarly, Olson showed that the semi-volatile components were 2 or 3 or so times higher in that near-roadway environment. These compounds can act as irritants and they would tend to exacerbate airway or respiratory disease. Some other clever individuals modified the Highball Sampler so that it only collected particles depending on certain wind directions. With that, they were able to enrich samples coming downwind from the roadway or up way from the urban area. Marie and Calvin and colleagues showed that the downwind from the roadway samples resulted in almost twice as much mass as the upwind samples collected from the same period. So I hope you're appreciating there are many things changing in this group, the particle amount may be changing, the volatiles is higher within the [near] roads, and the content within the substances on those particles can be quite different.

We're going to switch gears here for just a second. We know that diesel exhaust particles comprise a significant amount of the fine PM associated with traffic especially on movement and truck routes. So in the next series of in-vitro study, we wanted to examine the direct effects of those diesel particles in cell culture. So here, we created a wound straight through the center of a sheet of epithelial cells. Then we

exposed the cells to either no particles or simple carbon black particles – the kind you can find in cartridge toner, or to diesel exhaust particles but at the same mass and proximate number. We looked three days later and we could see that the unexposed or carbon block exposed cells were pretty much healed, but the diesel cells showed no repair, and the cells seemingly could not were not able to migrate into the area and cause healing. These results we showed were largely due to the organic carbon fraction of the diesel particles and this was seemingly more important than just the mass per say. Now cell migration is critical to epithelial healing, and these findings may have relevance to the increased symptoms in asthmatics for example after an insult such as a viral infection, and they may also relate to lung growth which requires effective cell migration.

So here's another in-vitro study and we looked to see how healthy airway cells responded to diesel particles and we compared them to cells that were cultured along with a variety of inflammatory cytokins, referred to as a cytomix. This would be similar to those that were commonly increased within the airways of asthmatics. I'm showing you two pictures on the left, these were just the cells that the healthy cells but the top one you see little blue dots, these were the nuclei – the cells that were exposed to a salt solution. But if you look below them, you can notice that the cells exposed to diesel particles had increased green staining of a fluorescent marker and that was used to indicate intercellular oxidative stress. The top graph shows that although the diesel particles exposure alone caused oxidative stress, the amount of stress was nearly doubled that in the inflamed or asthma like culture. The bottom graph shows that increased oxidative stress seemingly led to significantly greater injury in the inflamed cells but not the healthy cells. Although I'm not going to go into details, we were able to show that there was an interaction between radical oxygen species and radical nitrogen species creating more stable radicals, which overcame the antioxidant capacity of the cells themselves.

So collectively our animal-TOX findings suggest that the coarse particles possibly owing to their increased metal content caused greater respiratory effects than the smaller sized particles. On the other hand, the really small ultrafine particles appeared to cause more cardiovascular effects, at least based on studies using a perfused heart model. Overall these effects observed in our sensitized mice, which were an allergy or asthma-like model were significantly greater than the effects of healthy mice that were exposed to the same particles or the same dose of particles, whether the size seemed to matter as much. In the in-vitro studies as I've just described, it seems as though certain components of the particles like organic carbon are key to inducing other oxidative injury, oxidative stress and delayed epithelial healing.

So this is going to be my last slide and I want to make two final points. One is that I want to point you in the direction of this really good review article by Chen Z and colleagues last year. They highlight nearly two decades of results from the Southern California Children's Study, and importantly they conclude that traffic related air pollution not only exacerbates disease in individuals with existing issues like asthma and airway inflammation, but it also appears to be associated with new onset asthma. The second point is that their conclusions to these associations appear to be involved in E-Genes involved in oxidative and nitrostrative stress, so this is an excellent coherence with our TOX findings. So what can we do for that – let's turn to Rich Baldauf.

Speaker: Richard Baldauf

Thanks Jan. So Jan gave us a great overview of what some of the health effects and what the public health concerns are with near-road exposures. I'm going to really address that last question – what can we do about it? How can we at least reduce if not eliminate some of these increased risks from near road exposures. So for this last half of the presentation, I'll just give a really brief overview of some of the mitigation options. They vary from ways to reduce emissions, how can we also reduce vehicle activity and then also get into urban and transportation planning on how those can be used to reduce exposures, whether it be how we design the road itself or how we design developments around the road. So again just one of the main missions of EPA is our emission reduction programs. We have regulatory and voluntary responsibility to reduce emissions. We also do a lot of the research that leads to our understanding on what control technologies help to reduce emissions [and] how much they help to reduce emissions. As an Agency, we have standards for heavy-duty diesel vehicles and light-duty vehicles as well, mostly passenger cars and trucks that run off of gasoline. We actually have standards for what we call non-road vehicles as well so these can be like ships and trains but also like construction equipment and agricultural equipment as well. In addition to the regulatory programs, we do have quite a few voluntary programs that are also aimed at reducing emissions and programs that can also reduce the impacts to ambient air quality as well. These include the National Clean Diesel Campaign, anti-idling programs and Smart Way and things like that. So we really use all these different programs, both regulatory and voluntary to aim at reducing overall emissions on the road. In addition, we do try to promote activities that reduce vehicle activity itself. This can include public transit also ways to promote active transit, you know walking and biking. This is related to urban planning called Smart Growth where we try to do more dense inside development (i.e.) try to bring people's residence closer to where they work or go to school in a way to try to eliminate more vehicle trips. Finally, there have also been a number of programs implemented in the US and probably more in other parts of the world including Europe, including things like auto-restricted zones, areas where vehicles aren't allowed, or congestion pricing, so tolls and other costs of driving increase at certain times when there tends to be more [driving] activity. Again, all of these are ways that we can bring down emissions. Some, especially on the emission standards side can be used and effective for reducing near road concentrations, some are a little more regional like public transit so obviously have local and regional air quality benefits.

What I'm going to focus a little more on is an area of more current research where we're really looking at how land use and transportation planning can be used to help reduce near-road exposures. This slide here just gives an example of some of the land development type options that can be available to help reduce exposures and hopefully reduce these adverse health effects. One method that's been used especially out west in California and Washington has been the use of Buffer/Exclusion Zones. For example, California has a restriction on siting new schools in less than 500 feet of what they call a major road, so that's like a highway of 100,000 vehicles or more a day or an arterial road of 50,000 vehicles or more a day. Other methods though also since again land can be difficult, especially in urban areas, it can be difficult to find site locations that are suitable that are that far from major roads. Also, EPA has been working on providing some guidance to planners and developers on how they can do more efficient and effective site layouts to reduce exposures. So that's an example here given at the bottom. On the left you see a situation that would be considered a high exposure layout, you can see the school right next to the road even residences where people are going to spend a lot of time near a road with retail being farther away even parking farther away. So really thinking how can we move locations where again people are going to be spending more time – can we keep those farther from the road? As Jan

mentioned, there can be fairly sharp gradients of pollutant concentrations with distance from the road so can we move these more sensitive locations, like school athletic fields [and] residences further from the road. I'll talk about this a little bit but can we also design the structures or can we put in roadway features that can also reduce concentrations like a noise wall being cited for the more improved layout to the right.

So that leads to this again more emerging area of research, I'll spend a little bit of time because it is a bit newer, whereas other work has been ongoing for a while. One of the things is looking at roadway design itself – how can we design the road in order to minimize exposures to the extent possible. One way is rerouting traffic, and that has been done. Usually it's been on a temporary basis, but there have been places where there have been sensitive receptors or there's high density of residences where they've not allowed traffic on a nearby road. Other examples like in China during the Beijing Olympics and Atlanta during the Olympics there where they actually restricted use on certain roadways, partly for pollution reduction both for athletes and fans. Another option though is roadway features themselves, things like noise walls, road-side vegetation and even combinations of those have been shown to reduce near road pollution as well. These are of interest because really existing situations where roadway pollution is of concern there are really few options to help, so things like the emissions standards, doing activity reduction like rerouting and things like that - they take a long time to implement. As I've mentioned buffer exclusion zones are often either not feasible or just very difficult to implement. So that's one of the reasons we've been looking at this. In addition, these features have other benefits. Obviously noise reduction with noise walls, but there can be aesthetics, water runoff control and things like that, so ways that we can kind of effectively and efficiently bring these to integrate these into air quality benefit is an area of interest.

This just gives an example of one of the first studies that we've started looking at, road design and road configuration. There's a wind tunnel facility down here in North Carolina at EPA, that's shown at the bottom left there they were able to simulate roadway designs and features to estimate what different pollutant concentrations would be, what the gradients are away from the road. A summary of that is shown on the graph to the right. Essentially, what it shows is that the highest concentrations and the sharpest gradients can occur with at-grade roads, so there's no obstructions to airflow off the road or even elevated roads, especially with fill underneath the road. But then once we start adding complexity to roads, whether it be adding a solid noise barrier or putting what we call a cut-section where the road bed is actually below grade with either vertical or sloped walls leading up to the surrounding terrain. When we start adding that complexity, it actually increases mixing and can reduce down-wind pollutant concentrations. This is really useful in both identifying this potential as well as allowing us to work on developing models to try to quantify this.

The next slide also just shows an example. We actually collaborated with the National Oceanic and Atmospheric Association (NOAA) on a study in Idaho Falls, Idaho. Out there they actually simulated a noise barrier out in the field and released tracer gases around that noise barrier, so they looked at the downwind with the tracer gas, with the barrier in place, and then right next to the barrier where there was no obstruction and that is shown in the picture there in the top left. There you really get a direct comparison of what the tracer gas concentrations are with and without the barrier. Some of the results are shown to the right and you can see very significant decreases of pollutant concentrations downwind with the noise barrier. Those are under different meteorological conditions as well. The unstable is more like higher winds [and] a lot of mixing, stable is in the morning when it's very calm, low winds –what we

call very stable conditions. So again, very significant reductions with this barrier under all these conditions.

So we also took a look at roadside vegetation, with all the extra benefits that come into play with roadside vegetation. This is just an example of a study that was done in North Carolina. You see in the top left we have a section of road with roadside vegetation there and the other section without. There's another picture below, you kind of get an idea of the vegetation. It's fairly thick, there's coverage from the ground to the top of the canopy, which is the type of characteristics that we'd look for to potential have a reduction in near-road concentration. The graph to the right gives some of the results, and what we see is that solid top line those the concentration in this case of those ultrafine particles. Like Jan mentioned earlier, these are very good tracers for directly combustion emissions from vehicles, so it's something we use a lot when we do these types of studies. We can see that top solid line concentration is much higher in the clearing [and] the dotted lines represent concentrations at two different heights behind the vegetation. We see in the morning when we do have stable winds, they're generally from the road, we see very significant decreases in particulate concentrations behind vegetation. Later on in the afternoon the winds become more variable, they pick up, there's a lot more mixing so we don't see as much of an effect, but we also see overall the concentrations are much lower. So really during these time periods when the concentrations can be at their highest, the vegetation has this potential for removing a higher amount of particles. Again the reductions tend to be as the vegetation has the potential to remove some particles, but they also can cause some increased mixing so we have seen reductions in some gaseous pollutants as well.

Last on these roadside features, I wanted to mention, we also did a study here in the Raleigh area looking at a combination, and how a combination of noise barrier and vegetation might effect. Again in this case we were looking at how they effected the ultrafine particle concentrations. The picture to the top left shows the study area, and the graph shows some of the results again for the particles. Again we see the highest concentrations are occurring in a clearing at grade so there's no obstruction to airflow. Actually we have a section here that was just noise barrier and that's the solid data points are, that's where the data points are, but then when we added vegetation to the noise barrier as shown in that bottom right picture we saw an even further decrease in concentration. This combination has the potential to be the most effective at reducing concentrations because of both the potential for removal and also increasing mixing.

So I talked about a number of potential mitigation options, one thing I do want to highlight is that some studies show that as we implement these mitigation strategies and can reduce the pollutant concentrations, we can actually see health benefits occurring. This graph shows some results from the Southern California Children's Health Study that Jan had mentioned earlier. Essentially, you can see overtime that pollutant concentrations decreased as the area in this case the city of Los Angeles implemented a number of mitigation strategies. Now this would be all mitigation strategies not just traffic, although in Los Angeles traffic is a very major contributor to the air pollution issues, so a lot of these reductions were from their traffic mitigation strategies. So again we see these developmental effects and improvements in lung function and growth for these kids in the southern California area.

The next slide too I just wanted to show real quick that also indicates direct traffic benefits – this is actually though a study from Japan. Again, they implemented some nitrogen oxide, NPM emission standards, and they looked overtime as the concentrations were reduced. A lot of this was some near

road populations, and as these concentrations went down as exposures went down we saw some health benefits overtime.

The last thing then I wanted to do was present quickly some of the resources that are available that both highlight the near road issue with some of the concerns are, but also how mitigation strategies can be implemented and give some guidance and recommendations towards implementing mitigation. This slide just shows an example from a webpage that EPA has, it's actually housed under our transportation and air quality. It's set up as a question and answer website, so it lays out in a frequently asked question format. A number of things that have come up, questions that have been asked overtime, some of that research, how that research has been implemented into mitigation strategy. Again it deals with things across from emissions, air quality, exposures and the adverse health effects. There's a link at the bottom so if anyone is interested in seeing that and getting more information that is a good place to get it.

The next one is just a couple years, Congress asked EPA to put together some school siting guidelines. This was actually meant to address multimedia issues, so not just air but also water, land contamination issues and give guidance to schools on how to pick an appropriate site to reduce environmental risks. Near road was a big issue that was raised in these guidelines. Really provide some useful information on how to consider near road exposures, siting issues, development type of options that I mentioned earlier, as well as even a discussion about buffer and exclusion zones - so this can be useful information, especially for this broad area of information and impacts from multiple media. One thing that did arise from this siting guidance is what [do] existing schools do, especially around this near road issue. What are opportunities and options for helping to reduce exposures in schools? Studies estimate that over 2 million school children live very close to these major roads. So it's a large population [and] many schools are in this situation. These guidelines or these best practices and recommendations on ways that existing schools can mitigate. So again it comes to both indoor and ambient air are mentioned. It talks about ventilation, filtration, but also site locations, where air intakes are, anti-idling programs for school bus loading and unloading as well as personal cars, and those roadside features like I discussed earlier.

Lastly I just wanted to mention some recommendations that are actually just coming out again on these roadside features. There are some questions about what are the characteristics that are important in the design of these roadside features to make sure we get the most air quality benefit [and] don't get any unintended consequences around. We've recently developed some guidance on roadside vegetation as well as the combination of vegetation and solid noise barriers, and we're actually working the US Department of Transportation for similar types of guidance for solid noise barriers as well to improve both noise and air quality benefits.

Lastly a quick summary, again as Jan mentioned many people live, work and go to school nears these large roads with things like Smart Growth becoming more and more popular, there's compact development - that population could potentially be increasing. Again, there are environmental justice, susceptibility type issues so again there are a lot of reasons both to be concerned but also to be optimistic that there are mitigation options potentially out there. Again, EPA has a number of programs [and] we've been doing a lot of research in this area to develop these recommendations and guidance. Again, one thing at the state and local level especially trying to not just look at these federal implementation programs, but also ways that through urban planning and transportation planning how that could potentially be used to improve that near road air quality and reduce exposures, and again hopefully improve public health.

So the last slide is just our contact information, but we'd be happy to answer any questions.