

Sent via email

November 17, 2006

CABOL

RE: Expected Air Quality and Health Related Impacts
Proposed Knoxville Parkway Orange Route

The purpose of this letter report is to provide CABOL with information regarding potential impacts to public health that will be caused by the proposed Knoxville Parkway "Orange" route. This report was prepared by Timothy Quarles[1] of Quarles Environmental LLC (QE) in Billings, Montana at the request of CABOL.

This report contains the following sections. Section 1.0 provides a brief introduction to the Knoxville Parkway project. Section 2.0 discusses the Knoxville area's current air quality, and the mobile source's contribution to Knoxville's currently degraded air quality. Section 3.0 provides a discussion of the significant and negative human health effects which occur from exposure to elevated levels of the toxic air pollutant emitted from mobile sources.

East Tennessee's weather and topography are known to negatively affect the region's atmosphere's ability to disperse air pollutants. Further, the Orange Route's location in a series of valleys is also a significant cause for concern. These special effects on air pollutant dispersion are significant and are described in Section 4.0. Finally, Sections 5.0 and 6.0 provides a summary and conclusions of our investigation, and notes that a significant and unavoidable negative impact to the health of individuals living along the Orange Route can be expected if this Route is chosen.

QE recommends that TDOT accurately quantify population health risks for each alternative route by conducting a detailed health risk study that includes a full dispersion modeling study using meteorological data collected from sites along each alternative route and an EPA-approved complex terrain model. Further, we recommend that TDOT fully comply with the FHWA Section 109 public interest analysis by conducting a full benefits and costs review, fully identifying health risks associated with the project, and providing cost estimates to mitigate these adverse impacts.

1.0 Introduction

The Knoxville Parkway is touted by the Tennessee Department of Transportation (TDOT) as a high capacity bypass for I-75 through traffic that if constructed would re-

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1 Mr. Quarles is an air quality consultant with 30 years experience. He earned his Bachelors of Science in Environmental Science from Vanderbilt University, and a Masters in Chemical Engineering (Atmospheric Chemistry emphasis) from Washington State University. Mr. Quarles is familiar with the Knoxville area and surrounding terrain.

route through I-75 traffic, much of it heavy diesel truck traffic, away from a congested I-40/I-75 segment through downtown Knoxville. The Parkway Orange route would generally traverse Hardin Valley, Bull Run Valley, Raccoon Valley and Wolf Valley, all of which are located in what is now a rural, somewhat undeveloped area to the west of downtown between Knoxville and Oak Ridge.

The Orange route was recently selected by the Tennessee Department of Transportation (TDOT) as the preferred route for the new Parkway or bypass. The location of the Orange route is shown in Figure 1.

According to the Tennessee Department of Transportation (TDOT) Knoxville Parkway website[2], the purpose of the Knoxville Parkway is to provide an alternative route for I-75 traffic desiring to bypass both Knoxville and the I-40/I-75 corridor. The Parkway, TDOT says, would also improve access to and circulation among communities within the area. TDOT feels that an alternative route for I-75 is needed because I-40 and I-75 are major through-truck routes that are funneled together for the combined I-40/I-75 segment that is also a major commuting route in and out of Knoxville. TDOT believes that allowing through-traffic to bypass the combined section would reduce travel times and improve safety for the through-traffic, and would provide some relief to commuters and local traffic on the existing combined I-40/I-75 segment. And according to TDOT, the Parkway would also provide a high capacity alternative route should I-40/I-75 be closed due to an accident or other emergency.

Therefore, if TDOT's assumptions and basis for design of the Parkway are correct, initially a significant portion of traffic transiting the Parkway will be trucks wishing to bypass the I-40/I-75 corridor through downtown Knoxville, and to a lesser extent local traffic accessing the communities along the corridor.

TDOT's name for the highway project has been known variously as a beltway, a bypass, and now a parkway. Since TDOT selected the location of the highway through the Orange Route, use of the term "bypass" is a misnomer. The Orange Route is in close proximity to downtown Knoxville (less than 4-8 miles to the I-640 loop), and also nearby to Oak Ridge. The Orange route can be expected to immediately begin to promote intense in-fill development not only along the Orange route, but also along all routes leading into downtown Knoxville and areas surrounding the other communities in the area, including Oak Ridge.

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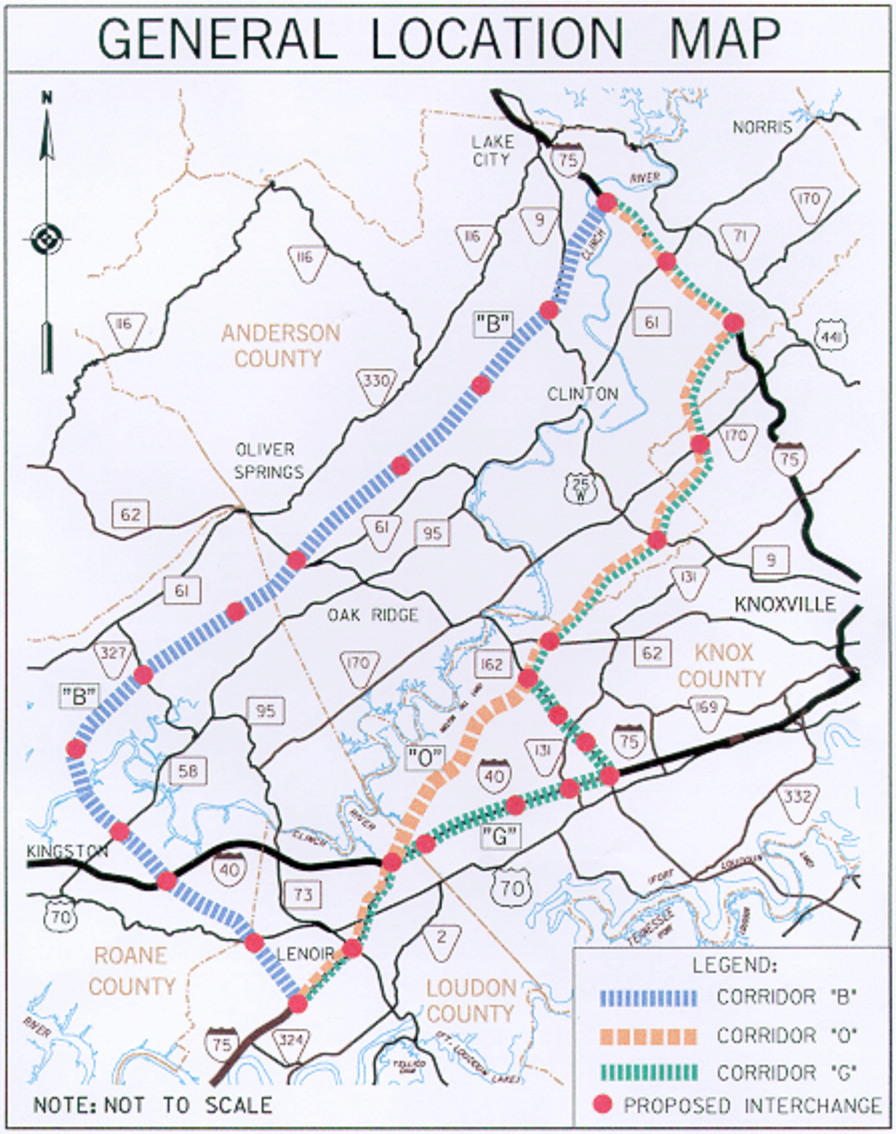
2 (http://www.knoxvilleparkway.com/faq.php)

Figure 1 – Location of Knoxville Parkway "Orange" Route



According to the Draft Environmental Impact Statement (DEIS)[3], approximately 16,800 to 31,500 vehicles per day would be diverted from various segments of I-40/I-75 onto the Orange route in 2025. Presumably this would be in addition to local area traffic.

2.0 Knoxville Air Quality and Mobile Source's Contribution

2.1 Knoxville Air Quality

The US Environmental Protection Agency (EPA) regulates both criteria pollutant emissions – the most well known of which are ozone, oxides of nitrogen (NO_x), sulfur dioxide (SO_2), volatile organic compounds (VOC), particulate matter less than 10 micrometers in diameter (PM_{10}), and particulate matter less than 2.5 micrometers ($PM_{2.5}$ or fine particulate matter) – and hazardous air pollutants, also referred to as toxic air pollutants or air toxics. EPA currently regulates 188 different hazardous air pollutants.

EPA has established National Ambient Air Quality Standards (NAAQS) for criteria pollutants. These are ambient concentrations of each pollutant that are safe even for the most sensitive portion of the population. EPA has not established national standards for hazardous air pollutants. Note that as time has passed since these NAAQS were first established decades ago, and more studies have been conducted on the health effects of air pollutant exposure, these NAAQS have been continually modified andgenerally lowered in an attempt to be fully protective of public health. For instance, the focus of managing exposure to particulate matter (PM) is now focused on only the fine fraction of PM that is less than 2.5 micrometers in aerodynamic diameter.

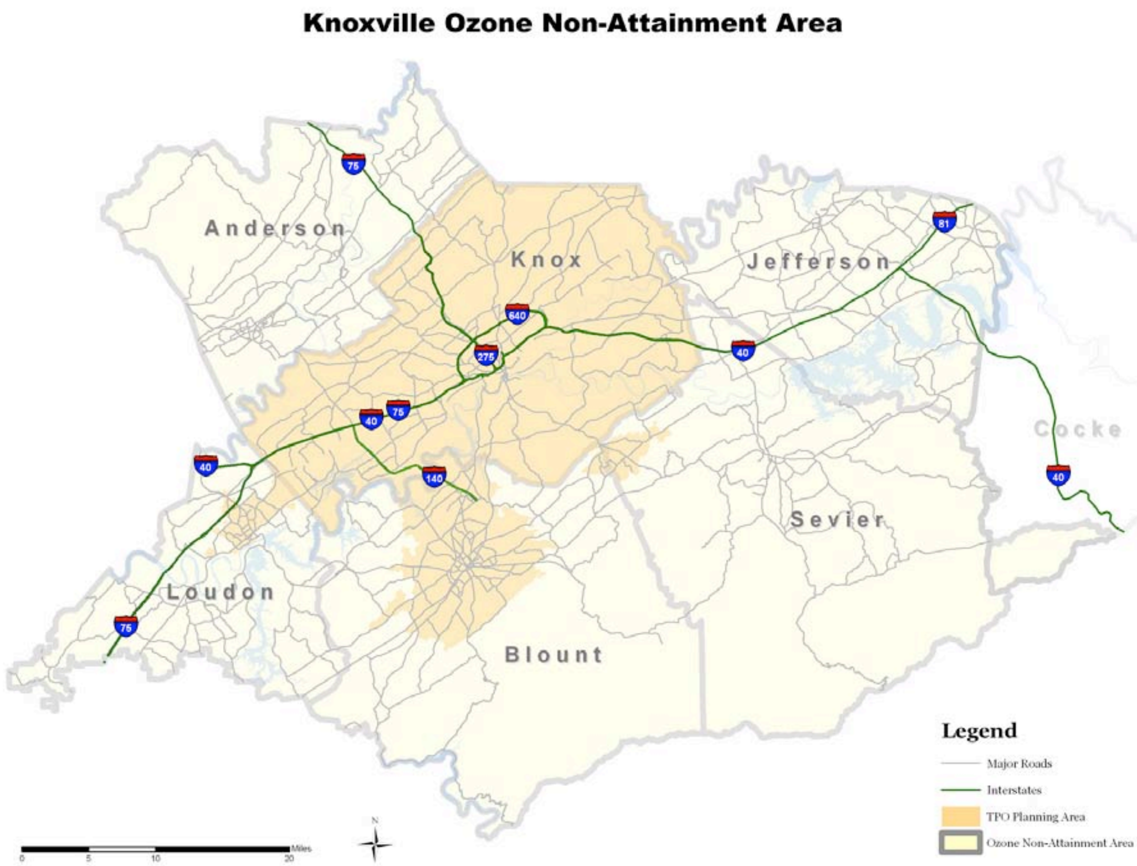
The Knoxville area is currently suffering from significant negative air quality impacts and their serious health effects, as measured by compliance with the current criteria pollutant NAAQS. EPA has formally designated the Knoxville area as one which has measured air pollution in excess of the NAAQS. These NAAQS are established by EPA at levels which would be protective of public health of the most sensitive portion of the population if attained.

A "nonattainment area" designation for a location is a formal indication by the EPA that these NAAQSs are not being achieved at that location, and public health is therefore being jeopardized. On April 15, 2004, the USEPA designated the counties of Anderson, Blount, Jefferson, Knox, Loudon, Sevier, and a portion of Cocke within the Great Smoky Mountains National Park in "basic" non-attainment of the 8-hour standard for ozone. This area must meet air quality standards for ozone by June 2009. A map showing the boundaries of the ozone nonattainment area is provided in Figure 2. On December 17,

[3] Proposed Route 475 (Knoxville Beltway) from Interstate 75 South of Knoxville to Interstate 75 North of Knoxville in Loudon, Roane, Anderson, and Knox Counties, Tennessee. FHWA-TN-EIS-01-02-D, Federal Highway Administration, Tennessee Division, Page 1-7.

2004, EPA designated Anderson, Blount, Knox, Loudon, and a portion of Roane County in non-attainment of the fine particulate matter ($PM_{2.5}$) standard. The area must meet

Figure 2 – Map of Knoxville 8-hour Ozone Nonattainment Area Boundary



quality standards for $PM_{2.5}$ by April 2010. A map showing the boundary of the $PM_{2.5}$ fine particulate matter nonattainment area is also provided in Figure 3.

The proposed Orange route of the Parkway is located in both nonattainment areas, and will significantly affect the region's future air quality, and its ability to attain and maintain compliance with the NAAQS. According to Knox County, highway vehicle emissions account for a significant percentage of regional emissions of ozone precursor (VOC and NO_x) emissions. Highway vehicles also likely account for a high percentage of the region's $PM_{2.5}$ emissions as well, and will certainly be a source of localized high concentrations of $PM_{2.5}$.

A strong indication that Knoxville residents' health is being negatively affected by these unhealthy levels of air pollution can be found in the incidences of asthma cases in the region and the number of premature deaths. Recently, Knoxville was ranked as one of the 50 worst cities in the United States according to where dirty air affects the most number of children, based on a review of 3 years of air quality data[4]. And the American Lung Association notes that Knoxville is the 14th smoggiest city in the United States, ranking worse than such places like Cleveland, Pittsburgh, Cincinnati and St. Louis[5]. Only 6 cities outside the state of California had smog levels worse than Knoxville's.

According to the Allergy and Asthma Foundation of America, Knoxville was rated as the worst city in the United States for asthma sufferers in 2005, and only marginally better in 2006[6]. These rankings considered a number of factors, including prevalence of asthma and risk factors for asthma attacks, including air pollution levels. These incredibly negative findings are not a recent phenomenon for Knoxville. A report from 1996 identified the Knoxville Metropolitan Statistical Area (MSA) as ranking 48th out of 239 United States MSAs for the number of premature deaths attributable to particulate air pollution per 100,000 population.[7]

2.2 Mobile Source Contribution to Knoxville Area Air Pollution

2.2.1 Criteria Pollutants

Emissions of criteria air pollutants from on-road mobile sources are a very significant portion of Knoxville's criteria pollutant emissions inventory and are therefore a very significant part of Knoxville's difficulties in attaining and maintaining compliance with the ozone NAAQS.

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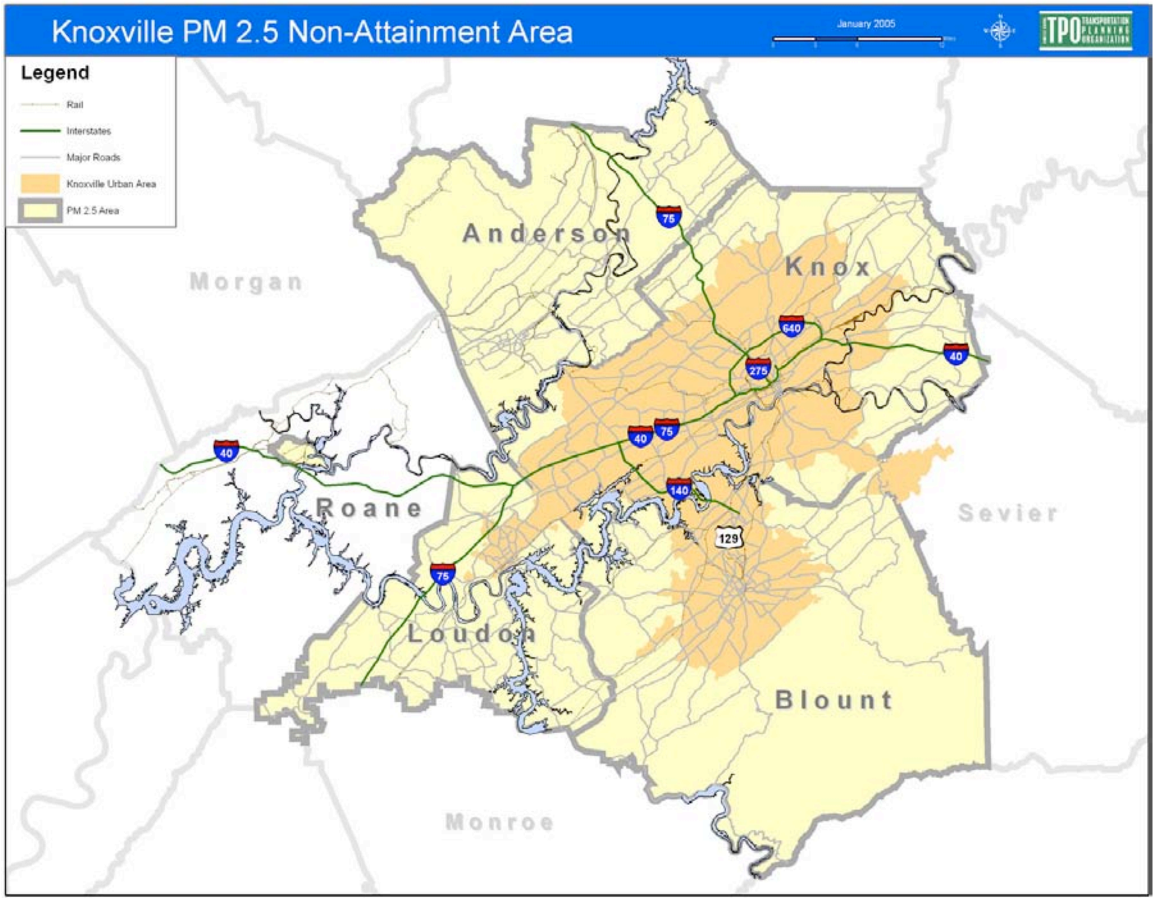
4 Environmental Defense. Dangerous Days of Summer. 2006.
http://www.environmentaldefense.org/cleanairforlife.cfm?subnav=aiyc_50cities

5 American Lung Association. State of the Air - 2006. http://lungaction.org/reports/sota06_cities.html

6 Allergy and Asthma foundation of America website. http://www.aafa.org/display.cfm?id=7&sub=92&cont=538.

7 Shrprentz, Deborah Sheiman. "Breathtaking - Premature Mortality from Particulate Air Pollution in 239 American Cities". Natural Resources Defense Council. 1996.

Figure 3 – Map of Knoxville $PM_{2.5}$ Nonattainment Area Boundary



In 2004, emissions of VOC and NO_x, the primary ozone precursor emissions, from automobiles and trucks represented 20 % and 55 %, respectively, of the region's total emissions of these pollutants, according to Knoxville's ozone maintenance plan[8].

Mobile sources contribution to the region's $PM_{2.5}$ emission inventory is less well understood as an accurate inventory is still to be developed. This issue is further complicated by the fact that $PM_{2.5}$ ambient concentrations are the result of both direct emissions of the pollutant and the secondary formation in the atmosphere of the pollutant through atmospheric chemical conversion processes associated primarily with sulfates and nitrates from fuel combustion. However, data exists to suggest that mobile source emissions are an overall significant fraction of the ambient concentration of $PM_{2.5}$, exceeding at least 50 % in some areas.[9] And EPA addressed this issue in their notice of final rulemaking requiring hot spots analyses for $PM_{2.5}$ conformity determinations for listed projects[10]. EPA noted that they reviewed over 70 technical studies in concluding that elevated concentrations of $PM_{2.5}$ did occur near roadways with heavy diesel truck traffic – 8 to 60 % increases over background concentrations near high traffic highways, and almost 300 % increases over background concentrations near congested areas including truck stops[11]. EPA attributes diesel mobile sources as the primary contributor to these elevated concentrations.

2.2.2 Toxic Air Pollutants

EPA has identified as mobile source air toxics (MSATs) pollutants that cause chronic adverse health effects, such as cancer, and acute effects from short-term exposures (hours or days) such as asthma attacks. Congress listed benzene, 1,3, butadiene, and formaldehyde as mobile source-related air toxics in the 1990 Clean Air Act Amendments when it required EPA to set vehicle emission standards for these pollutants. EPA included these three statutory MSAs and ten other mobile source-related pollutants on a list of 33 priority pollutants targeted for control under EPA's Integrated National Urban Air Toxics Strategy. Six MSATs were ultimately identified as priority, based on their significant health effects. These include acetaldehyde, acrolein, benzene, 1,3, butadiene, diesel particulate matter, and formaldehyde.

EPA noted that vehicle emissions are an important contributor to the urban air toxics problem, accounting for over half the excess human cancer risk from outdoor sources of

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8 Federal Register Volume 69 No. 21, Monday, February 2, 2004. Page 4854.

9 Gillies, JA and AW Gertler. Comparison and Evaluation of Chemically Speciated Mobile Source PM2.5 particulate matter profiles. J Air Waste Management Association. 2000; 50(8); 1459-80. Division of Atmospheric Sciences, Desert Research Institute, Reno, Nevada, USA.

10 Federal Register: March 10, 2006 (Volume 71, Number 47), [Page 12467-12511] PM2.5 and PM10 Hot-Spot Analyses in Project-Level Transportation Conformity Determinations for the New PM2.5 and Existing PM10 National Ambient Air Quality Standards

11 Ibid. page 12472.

air pollution.[12] And in likely the most comprehensive study of its kind, the South Coast Air Quality Management District's MATES II study determined the percentage of excess human cancer risk from outdoor sources to be much higher – 90% or greater.[13] A University of Tennessee study indicated that mobile source emissions of the 33 urban air toxics accounted for over 56 % of Tennessee's total emissions of these pollutants.[14]

Some toxic compounds are present in gasoline and are emitted to the air when gasoline evaporates or passes through the engine as unburned fuel. Benzene, for example, is a component of gasoline. Cars emit small quantities of benzene in unburned fuel, or as vapor when gasoline evaporates.

A significant amount of automotive benzene comes from the incomplete combustion of compounds in gasoline such as toluene and xylene that are chemically very similar to benzene. Like benzene itself, these compounds occur naturally in petroleum and become more concentrated when petroleum is refined to produce high octane gasoline. Formaldehyde, acetaldehyde, diesel particulate matter, and 1,3-butadiene are not present in fuel but are by-products of incomplete combustion. Formaldehyde and acetaldehyde are also formed through a secondary process when other mobile source pollutants undergo chemical reactions in the atmosphere.

Diesel exhaust (DE) has been characterized by the EPA when examining the health effects of this complex pollutant.[15] Diesel exhaust (DE) is a significant source of many toxic air contaminants. DE is a complex mixture of hundreds of constituents in either a gas or particle form. Gaseous components of DE include carbon dioxide, oxygen, nitrogen, water vapor, carbon monoxide, nitrogen compounds, sulfur compounds, and numerous low-molecular-weight hydrocarbons. Among the gaseous hydrocarbon components of DE that are individually known to be of toxicologic relevance are the aldehydes (e.g., formaldehyde, acetaldehyde, acrolein), benzene, 1,3-butadiene, and polycyclic aromatic hydrocarbons (PAHs) and nitro-PAHs.

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12 http://www.epa.gov/otaq/f02004.pdf

13 The Multiple Air Toxics Exposure Study (MATES-II) for the South Coast Air Basin. South Coast Air Quality Management District. 2000. (http://www.aqmd.gov/matesiidf/es.pdf)

14 Fu, Joshua S., LA Diaz, and G. Reed. "Seasonal Distribution and Modeling of Diesel Particulate Matter in the Southeast US." Department of Civil and Environmental Engineering, University of Tennessee – Knoxville. East Tennessee Ozone Study, 2006 Science Workshop. May.

15 Health Assessment Document for Diesel Engine Exhaust. USEPA. EPA/600/8-90/057F. May 2002. Prepared by the National Center for Environmental Assessment, Washington, DC, for the Office of Transportation and Air Quality; EPA/600/8-90/057F. Available from: National Technical Information Service, Springfield, VA; PB2002-107661, and <http://www.epa.gov/ncea>.

The particles present in DE (i.e., diesel particulate matter [DPM]) are composed of a center core of elemental carbon and adsorbed organic compounds, as well as small amounts of sulfate, nitrate, metals, and other trace elements. DPM consists of fine particles (fine particles have a diameter <2.5 :m), including a subgroup with a large number of ultrafine particles (ultrafine particles have a diameter <0.1 micrometer). Collectively, these particles have a large surface area which makes them an excellent medium for adsorbing organics. Also, their small size makes them highly respirable and able to reach the deep lung.

A number of potentially toxicologically relevant organic compounds are on the particles. The organics, in general, range from about 20% to 40 % of the particle weight, though higher and lower percentages are also reported. Many of the organic compounds present on the particle and in the gases are individually known to have mutagenic and carcinogenic properties. For example, PAHs, nitro-PAHs, and oxidized PAH derivatives are present on the diesel particles, with the PAHs and their derivatives comprising about 1% or less of the DPM mass.

DE emissions vary significantly in chemical composition and particle sizes between different engine types (heavy-duty, light-duty), engine operating conditions (idle, accelerate, decelerate), and fuel formulations (high/low sulfur fuel). Also, there are emission differences between on-road and nonroad engines simply because the nonroad engines to date are generally of older technology. The mass of particles emitted and the organic components on the particles from on-road diesel engines have been reduced over the years. Available data for on-road engines indicate that toxicologically relevant organic components of DE (e.g., PAHs, nitro-PAHs) emitted from older vehicle engines are still present in emissions from newer engines, though relative amounts have decreased. There is currently insufficient information to characterize the changes in the composition of DE from nonroad diesel engines over time.

DE is emitted from “on-road” diesel engines (vehicle engines) or “nonroad” diesel engines (e.g., locomotives, marine vessels, heavy-duty equipment, etc.). Nationwide, data in 1998 indicated that DE as measured by DPM made up about 6% of the total ambient $PM_{2.5}$ inventory and about 23% of the inventory, if natural and miscellaneous sources of $PM_{2.5}$ are excluded. Estimates of the DPM percentage of the total inventory in urban centers are higher. For example, estimates range from 10% to 36% in some urban areas in California, Colorado, and Arizona.

3.0 Discussion of Mobile Source Toxic Air Pollutant Health Effects Summary

Human health effects from exposure to the priority toxic air pollutants are significant, and include both acute and chronic effects. These effects are summarized in the Table below.

PMSAT Summary of Significant Health Effects

Compound	Cancer Effects	Non-Cancer Effects
Acetaldehyde & Formaldehyde	Nasal and Nasopharangeal tumors	Upper respiratory track irritation
Acrolein	No effects	Asthma, Chronic Obstructive Pulmonary Disease (COPD), respiratory track irritation.
Benzene	Acute myeloid leukemia	Hematological effects, effects on red and white blood cells and platelets, bone marrow damage leading to aplastic anemia.
1,3, Butadiene	Leukemia, lymph sarcoma, reticular cell sarcoma	Cardiovascular, hematopoietic reproductive and developmental effects, respiratory diseases such as asthma and COPD.
Diesel Particulate Matter	Lung cancer	Cardiovascular disease, premature deaths, asthma, COPD.

A number of studies have provided more detailed information on the cause and effect relationship between exposure to mobile source emissions and toxic health impacts. In 2004, the Sierra Club published a list of 24 peer reviewed published studies documenting this relationship.[16] Results of these and many other studies, including EPA's recent diesel particulate matter Health Assessment Document for Diesel Engine Exhaust (HAD) (footnote 15) which reference literally hundreds of health effects studies, provide clear evidence that living near major highways, especially those carrying significant diesel traffic, is very hazardous to your health. EPA also noted in their diesel

16 Sierra Club. Highway Health Hazards. 2004.
http://www.sierraclub.org/sprawl/report04_highwayhealth/report.pdf

exhaust HAD that persons working or playing outdoors near freeways or other significant sources of diesel exhaust pollution are especially susceptible to exposure to unhealthy levels of diesel emissions. Children are especially susceptible as their lungs are still developing and lung capacity is small.

Some of the more important studies and conclusions, noted by the Sierra Club report, and their relevance to the Orange Route, are the following:

- **People Who Live Near Freeways Exposed to 25 Times More Soot Particulate Pollution.**[17] Studies conducted in the vicinity of Interstates 405 and 710 in Southern California found that the number of ultra-fine soot particles in the air was approximately 25 times more concentrated near the highways and that pollution levels gradually decrease back to normal (background) levels around 300 meters, or nearly 330 yards, downwind from the highway. The researchers note that motor vehicles are the most significant source of ultra-fine particles, which have been linked to increases in mortality and morbidity. Recent research concludes that ultra-fine soot particles are more toxic than larger particles with the same chemical composition. Moreover, the researchers found considerably higher concentrations of carbon monoxide pollution near the highways.

Elevated levels of fine particulate matter causes a number of significant adverse health effects, as discussed above. This Southern California study demonstrates clearly that persons living near highways are exposed to very high concentrations of fine particulate matter. The Knoxville area atmosphere's ability to disperse pollutants effectively is one of the worst in the country. Therefore, the results of this study are a good indicator of what can be expected along the Orange Route.

- **National Center for Environmental Health, Center for Disease Control and Prevention. Increasing Public Transportation and Cutting Traffic Reduces Asthma Attacks.**[18] This 2001 Center for Disease Control and Prevention study published in the Journal of the American Medical Association found that increasing public transportation along with other traffic control measures during the 1996 Atlanta Olympics reduced acute asthma attacks by up to 44 percent in children, reduced ozone concentrations by 28 percent, and morning peak traffic by 22.5 percent. These data provide support for efforts to reduce air pollution and improve health via reductions in motor vehicle traffic.

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17 Zhu, Yifang; William C. Hinds; Kim Seongheon; Si Shen; Constantinos Sioutas. Concentration and size distribution of ultrafine particles near a major highway. Journal of the Air and Waste Management Association. September 2002. And, Study of ultrafine particles near a major highway with heavy-duty diesel traffic. Atmospheric Environment. 36(2002), 4323-4335.

18 Friedman, Michael; Kenneth Powell MD; Lori Hutwagner; Leroy Graham; Gerald Teague. Impact of Changes in Transportation and Commuting Behaviors During the 1996 Summer Olympic Games in Atlanta on Air Quality and Childhood Asthma, Journal of the American Medical Association, 2001; 285:897-905.

- **Erie County, New York. Truck Traffic Linked to Childhood Asthma Hospitalizations.**[19] A study in Erie County, New York (excluding the city of Buffalo) found that children living in neighborhoods with heavy truck traffic within 220 yards of their homes had increased risks of asthma hospitalization. The study examined hospital admission for asthma amongst children ages 0-14, and residential proximity to roads with heavy traffic.
- **Asthma More Common for Children Living Near Highways.**[20] **A** study of early 10,000 children in England found that wheezing illness, including asthma, was more likely with increasing proximity of a child's home to main roads. The risk was greatest for children living within 90 yards of the road.
- **A School's Proximity to Highways Associated with Asthma Prevalence.**[21] A study of 1,498 children in 13 schools in the Province of South Holland found a positive relationship between school proximity to highways and asthma occurrence. Truck traffic intensity and the concentration of pollutants measured in schools were found to be significantly associated with chronic respiratory symptoms.
- **Diesel lExhaust Linked to Asthma.**[22] This study found that particulate matter from diesel trucks can act as an irritant in the airway causing asthma. The authors show that diesel exhaust can trigger asthma attacks in individuals with no pre-existing asthmatic history. When a natural allergen, such as pollen, was added to the situation, the reaction was even more dramatic.
- **Lung Function Reduced Among Children Living Near Truck Traffic.**[23] **A** European study determined that exposure to traffic-related air pollution, "'in particular diesel exhaust particles," may lead to reduced lung function in children living near major motorways.
- **Low Levels of Air Pollution Cause Asthma Attacks.**[24] Exposure to miniscule amounts of ozone and soot particulate matter 2.5 µm or less ($PM_{2.5}$) in air at levels above current U.S. Environmental Protection Agency (EPA) standards is a

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19 Lin, Shao; Jean Pierre Munsie; Syni-An Hwang; Edward Fitzgerald; and Michael R. Cayo; (2002). Childhood Asthma Hospitalization and Residential Exposure to State Route Traffic. Environmental Research, Section A,Vol. 88, pp. 73-81.

20 Venn et al. (2001). Living Near A Main Road and the Risk of Wheezing Illness in Children. American Journal of Respiratory and Critical Care Medicine. Vol. 164, pp 2177-2180.

21 Van Vliet, P., M. Knape, et al. (1997).Motor vehicle exhaust and chronic respiratory symptoms in children living near freeways. Environmental Research. 74(2): 122-32.

22 Pandya, Robert, et al. "Diesel Exhaust and Asthma: Hypothesis and Molecular Mechanisms of Action." Environmental Health Perspectives Supplements Volume 110, Number 1, February 2002.

23 Brunekreef, B; N.A. Janssen ; J. DeHartog; H. Harssema ;M. Knape; P. Van Vliet (1997). "Air pollution from truck traffic and lung function in children living near motorways." Epidemiology. 8(3):298-303.

24 Gent, Janneane PhD; Elizabeth W.Triche, PhD; Theodore R. Holford, PhD; Kathleen Belanger, PhD; Michael B. Bracken, PhD; William S. Beckett,MD;Brian P. Leaderer,PhD,Association of Low-Level Ozone and Fine Particles With Respiratory Symptoms in Children With Asthma, Journal of the American Medical Association. 2003; 290:1859-1867. http://jama.amaassn.org/cgi/content/abstract/290/14/1859.

risk factor for respiratory symptoms in children with asthma. Daily respiratory symptoms and medication use were examined prospectively for 271 children younger than 12 years with physician-diagnosed, active asthma residing in southern New England. Exposure to ambient concentrations of ozone and $PM_{2.5}$ from April 1 through September 30, 2001, was assessed using ozone (peak 1-hour and 8-hour) and 24-hour $PM_{2.5}$. Logistic regression analyses using generalized estimating equations were performed separately for maintenance medication users (n = 130) and nonusers (n = 141). Associations between pollutants (adjusted for temperature, controlling for same- and previous-day levels) and respiratory symptoms and use of rescue medication were evaluated. Mean (SD) levels were 59 (19) ppb (one-hour average) and 51 (16) ppb (8-hour average) for ozone and 13 (8) µg/m3 for $PM_{2.5}$. In co-pollutant models, ozone level but not $PM_{2.5}$ was significantly associated with respiratory symptoms and rescue medication use among children using maintenance medication; a 50-ppb increase in one-hour ozone was associated with increased likelihood of wheeze (by 35 percent) and chest tightness (by 47 percent). The highest levels of ozone (one-hour or eight-hour averages) were associated with increased shortness of breath and rescue medication use. No significant, exposure-dependent associations were observed for any outcome by any pollutant among children who did not use maintenance medication. Asthmatic children using maintenance medication are particularly vulnerable to ozone, controlling for exposure to fine particles, at levels below EPA standards.

As mentioned earlier in this report, Knoxville already has a very high rate of childhood asthma, and is already considered one of the worst places for an asthmatic to live. Those living along the proposed Orange Route can expect to see a rise in the incidences of asthma. High levels of pollutants near the Orange Route are to be expected due to the number of vehicles, especially heavy duty trucks, that the Orange Route is designed to attract.

- **University of Colorado Study. Children Living Near Busy Roads More Likely to Develop Leukemia, Cancer.**[25] This 2000 Denver study showed that children living within 250 yards of streets or highways with 20,000 vehicles per day are six times more likely to develop all types of cancer and eight times more likely to get leukemia. The study looked at associations between traffic density, power lines, and all childhood cancers with measurements obtained in 1979 and 1990. It found a weak association from power lines, but a strong association with highways. It suggested that Volatile Organic Compound pollution from traffic may be the cancer promoter causing the problem.

The Orange Route will pass nearby four (4) existing or planned elementary schools, high schools, and colleges with a student population of over 11,000 students. In addition, the

25 Pearson, Wachtel; Robert L. Pearson, and Kristie Ebie. (2000). Distance-weighted traffic density in proximity to a home is a risk factor for leukemia and other childhood cancers. Journal of Air and Waste Management Association 50:175-180.

Orange Route will be located near many existing neighborhoods and will certainly attract new ones. Total population exposed to this increased risk of cancer and leukemia is unknown but will be significant.

- **Brigham Young University. Soot Particulate Matter Linked to Lung Cancer, Cardiopulmonary Mortality.**[26] A recent study appearing in the Journal of the American Medical Association showed that day-today exposure to soot or fine particulate matter, a major component of tailpipe pollution increased the risk of various adverse health effects. More specifically the study shows that each 10 microgram/cubic meter elevation in fine particulate air pollution leads to an 8 percent increased risk of lung cancer deaths, a 6 percent increased risk of cardiopulmonary mortality (heart attacks) and 4 percent increased risk of death from general causes.
- **Johns Hopkins School of Public Health. Traffic Increased Cancer-Causing Pollution Levels at Tollbooth.**[27] A A 2003 study published in the Journal of Air & Waste Management shows that there is a "significant association between vehicle traffic and curbside concentrations of the carcinogens benzene, 1,3-butadiene, and particle-bound polycyclic aromatic hydrocarbons (PAH)." The measurements, which were taken at the Baltimore Harbor Tunnel tollbooth, show that much of the daily pollutant variability was explained by traffic volume, class and meteorology. The study provides a model for estimating curbside pollution levels associated with traffic that may be relevant to exposures in the urban environment.
- **South Coast Air Quality Management District. MATES II Study. Motor Vehicle Pollution Dominates Cancer Risk.**[28] The most comprehensive study of urban toxic air pollution ever undertaken shows that motor vehicles and other mobile sources of air pollution are the predominant source of cancer-causing air pollutants in Southern California. Overall, the study showed that motor vehicles and other mobile sources accounted for about 90 percent of the cancer risk from toxic air pollution, most of which is from diesel soot (70 percent of the cancer risk). Industries and other stationary sources accounted for the remaining 10 percent. The study showed that the highest risk is in urban areas where there is heavy traffic and high concentrations of population and industry.
- **Cancer Risk Higher Near Major Sources of Air Pollution, Including Highways.**[29] A 1997 English study found a cancer corridor within three miles of

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26 Pope, Clive Arden III; Richard P. Burnett, et al. Lung Cancer, Cardiopulmonary Mortality, and Long-term Exposure to Fine Particulate Air Pollution. Journal of the American Medical Association, March 6 2002— Vol. 287, No. 92.

27 Sapkota, Amir and Buckley,Timothy J. The Mobile Source Effect on Curbside 1,3-Butadiene, Benzene, and Particle-Bound Polycyclic Aromatic Hydrocarbons Assessed at a Tollbooth. Journal of Air & Waste Management. 53:7400748.

28 South Coast Air Quality Management District. Multiple Air Toxics Exposure Study-II.March 2000.

29 Knox and Gilman (1997). Hazard proximities of childhood cancers in Great Britain from 1953-1980. Journal of Epidemiology and Community Health. 51: 151-159.

highways, airports, power plants, and other major polluters. The study examined children who died of leukemia or other cancers from the years 1953-1980, where they were born and where they died. It found that the greatest danger lies a few hundred yards from a highway or polluting facility and decreases as you get further away from the facility.

- **UCLA School of Public Health Study. Pregnant Women who Live Near High Traffic Areas More Likely to Have Premature and Low Birth Weight Babies.**[30] Researchers observed an approximately 10-20 percent increase in the risk of premature birth and low birth weight for infants born to women living near high traffic areas in Los Angeles County. In particular, the researchers found that for each one part-per-million increase in annual average carbon monoxide concentrations where the women lived, there was a 19 percent and 11 percent increase in risk for low-birth weight and premature births, respectively.

The evidence is therefore very clear – a significant increase in childhood asthma, cancers, and other health problems is associated with living close to a major freeway designed to attract heavy diesel trucks and significant overall levels of traffic.

It is also clears from the evidence above, and from the region's known meteorological and topographical conditions which act to severely limit the region's atmosphere to disperse pollutants, that a new corridor of increased cancer, asthma, and other adverse health effects risk will be created along the Orange Route. These special conditions are discussed next.

4.0 Poor Atmospheric Dispersion Characteristics in Region and Valleys

The Knoxville/Oak Ridge area, between which the Orange Route will traverse, has one of the poorest levels of atmospheric dispersion in the country due to three primary reasons. First, it has one of the lowest mean wind speeds in the country[31], resulting in minimizing lateral dispersion of pollutant emissions. Second, it has one the highest rates of low level temperature inversions and isothermal conditions in the country – the highest east of the Mississippi River – as shown in Figure 4 [32]. Inversion essentially put a lid on air pollution and limit dispersion vertically, causing an increase in concentration by limiting the amount of atmosphere available for dilution. Note that in the summer, inversions or isothermal conditions below 500 feet occur in greater than 45% of all hours in the summer and winter. And finally, a significant portion of the Orange Route corridor is located in valleys, whose dispersion characteristics are poor to begin with. Combined with the region's

30 Wilhelm,Michelle and Beate Ritz. (2002). Residential Proximity to Traffic and Adverse Birth Outcomes in Los Angeles County, California, 1994-1996. Environmental Health Perspectives. doi: 10.1289/ehp.5688.

31 http://www.worldfactsandfigures.com/weatherfacts/average_wind_speed.php

32 Slade, David H., editor. Meteorology and Atomic Energy 1968. Figure 2-22. page 38. July 1968.

notoriously poor atmospheric dispersion characteristics, these valleys will see significant degradation of air quality to unhealthy levels, especially so in congested areas.

This Knoxville/Oak Ridge area consists of linear valleys separated by ridges which will act very effectively to limit atmospheric dispersion and trap pollutants. In fact, the presence of these valleys and their ability to trap pollutants was one of many considerations in the 1940's in the selection of the Oak Ridge location for its contribution to the nation's nuclear weapons program.[33]

The inversion level is the demarcation between the mixed, turbid air at the surface and the clean air above. Vertical mixing of ground level pollution is limited to the atmosphere below the inversion level. The lower the inversion level, the smaller the volume of atmosphere that is available to disperse pollutants vertically. This will in turn result in higher and higher concentrations of pollutants for a given amount of pollutant emissions in a given time period. A pollutant released near the ground will spread in both lateral and vertical directions. Vertical dispersion of pollutants will cease when the top of the mixing layer (the inversion) is encountered. Lateral dispersion will continue until a barrier to dispersion is encountered, which in the case of the Orange Route will be the sides of the many valleys through which the Parkway will traverse. The speed at which this lateral and vertical dispersion occurs is directly related to the level of atmospheric turbulence. According to the inversion data just discussed, it is highly likely that there will be long periods where inversion or isothermal conditions will exist that will completely trap Orange Route pollution within the multiple valleys through which it will traverse.

The ability of the atmosphere to disperse air pollutants within the mixing zone below an inversion is directly related to the degree of atmospheric turbulence present. The more turbulent the atmosphere, the faster air pollutants will disperse both vertically and laterally, thereby minimizing atmospheric concentrations of pollutants. Atmospheric turbulence is dependent upon three dominant factors: 1) mechanical effects such as the roughness of the surface that an airstream flows over; 2) the vertical rate of increase of wind speed; and 3) the vertical temperature structure of the atmosphere. The mechanical effects are reduced with reduced wind speeds. Therefore, mechanical turbulence is low and less important than buoyancy effects in the Knoxville area due the region's very low mean annual wind speed.

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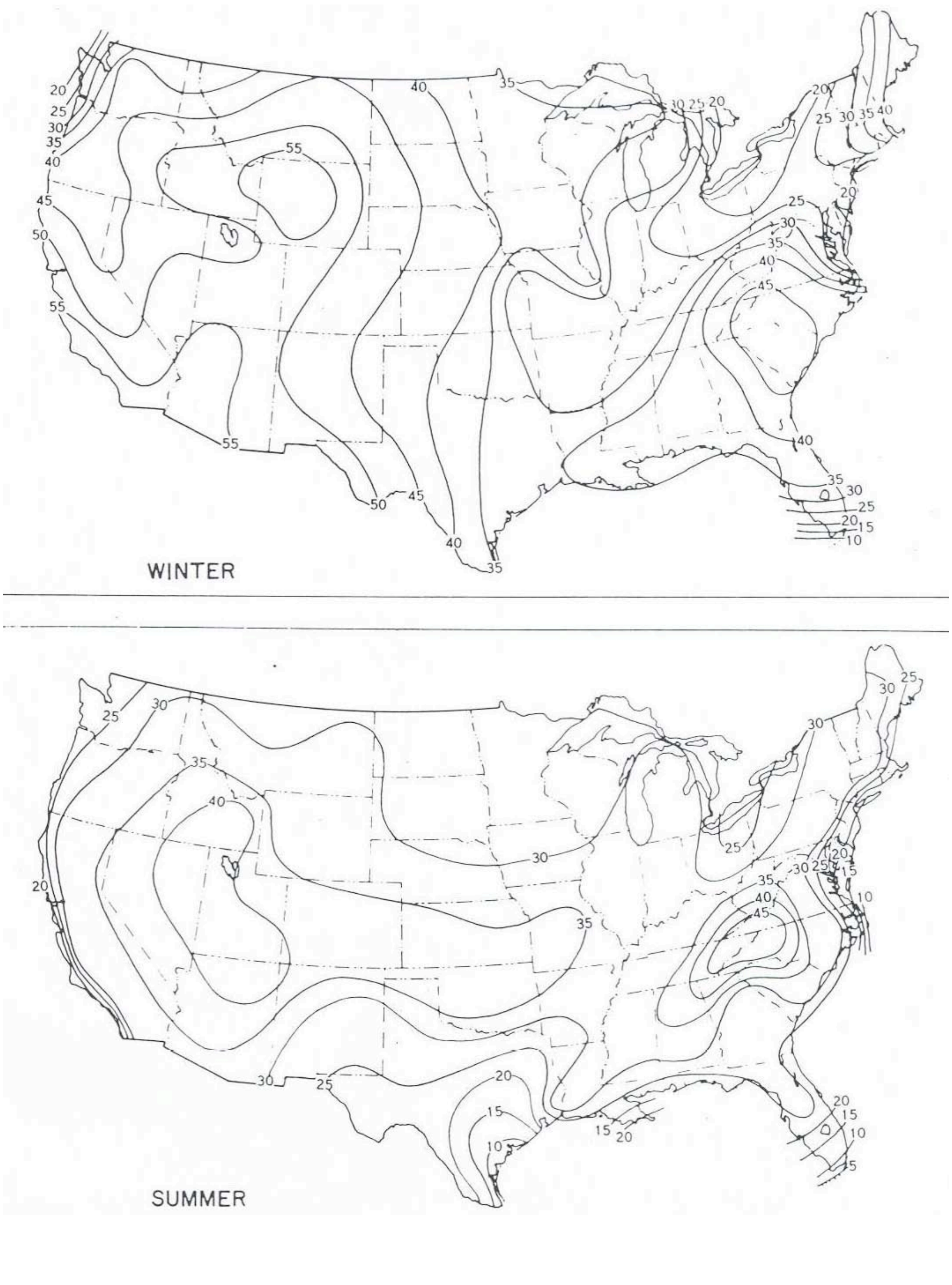
[33] http://en.wikipedia.org/wiki/Oak_Ridge,_Tennessee

Figure 4 – Percentage Frequency (percent of total hours) of the Occurrence of Inversions or Isothermal Conditions Based Below 500 Feet During the Winter and Summer.
(from Slade, David H., editor. Meteorology and Atomic Energy 1968. Figure 2-22. page 38. July 1968)



At higher wind speeds, mechanical effects on turbulence dominate. At lower wind speeds, buoyancy effects are more important. At lower wind speeds, atmospheric turbulence depends in large part on the vertical gradient of temperature. When the atmosphere is thermally stable, turbulent motions are suppressed; when it is thermally unstable, turbulent motions are enhanced.

Atmospheric pressure decreases with height, so a parcel of air that rises will decrease in pressure in response to its surroundings. The parcel will in turn increase in volume and decrease in temperature because of the expansion. If this process occurs adiabatically (no change in heat between the air parcel and its surroundings), then the rate of change in temperature with vertical height is called the adiabatic lapse rate. This lapse rate is approximately 1 degrees centigrade per 100 meters. Since the measurement of the vertical temperature profile is much more easily done than the measurement of atmospheric turbulence, the vertical temperature profile has historically been used to describe the level of atmospheric stability and atmospheric dispersion.

If the temperature in the atmosphere decreases at a rate greater than the adiabatic lapse rate (superadiabatic), all vertical motions are accelerated and dispersion is enhanced, since any parcels of air rising through this atmosphere will be warmer and therefore less dense than the surrounding environment at any given height. If the temperature in the atmosphere decreases at a rate less than the adiabatic lapse rate, all vertical motion is suppressed and dispersion depressed, since any parcel of air rising through this atmosphere will be cooler and more dense than its surroundings.

An exaggerated example of this is when an inversion exists. An inversion is an instance where atmospheric temperature increases with height above surface. A parcel of relatively warm air at the surface will rise, expand near adiabatically as it rises and cools, and will continue to rise until it reaches a level at which the surrounding air is warmer than it. Upon encountering an inversion aloft, then, where temperature rises with elevation, a parcel of rising air will be forced back downward and dispersion will be suppressed. An inversion defines the extent of vertical dispersion; it essentially places a lid on the atmosphere and pollutants can only disperse in the parcel of atmosphere beneath the inversion layer. The lower the inversion layer, the lower the lid on the mixing layer and the lower the available air to dilute air pollutants, and the higher the concentration of air pollutants that will result.

As shown in Figure 3, the east Tennessee area, including Knoxville and the Orange Route, has one of the highest incidence rates for low level inversions in the country. Or stated differently, the Knoxville area's atmosphere has one of the poorest abilities in the country to disperse air pollutants.

Each of the valleys, through which the Orange route is proposed, will act very efficiently to trap vehicle emissions. This is due to a number of factors. First, the high valley walls will minimize the opportunity for pollutants emitted at ground level to escape. Stagnation conditions are promoted in each valley as regional synoptic winds are insufficiently strong to provide a flushing action. This will be especially true during the dog days of summer when ground level ozone concentrations will be highest, and as regional, multi-day, high pressure stagnation conditions and their accompanying subsidence temperature inversions are common, and in the winter months when extreme ground-level temperature inversions naturally occur, stifling vertical dispersion of pollutants. Under these inversion conditions, convective mixing is minimized and pollutant concentrations rise.

Synoptic winds are generally from the southwest and northeast, and light throughout the year. The Knoxville/Oak Ridge area has one of the lowest average annual wind speeds in the country, with winds averaging from 4 miles per hour in Oak Ridge to 6 miles per hour in Knoxville, further minimizing the amount of natural mixing and dilution of pollutant concentrations.

Therefore, it is important in an area such as Knoxville, where dispersion is limited generally by synoptic conditions, to construct major sources of air pollutants where dispersion can be maximized, generally in open, flat terrain or in elevated terrain where winds are stronger, in order to get maximum benefit from the winds that do blow in the region. This would mean construction of a highway of this sort following ridges rather than locating in narrow, confined valleys. The currently proposed Orange route is opposite this recommendation; it is located in a corridor of valleys that would tend to minimize dispersion of pollutants emitted.

5.0 Significant Negative Impacts on Air Quality and Human Health Expected

5.1 Elevated Air Pollutant Levels Expected along Orange Route

The proposed route of the Knoxville Parkway will traverse a new corridor to the west of downtown Knoxville, in an area that is currently rural to only partially developed. Adverse air pollutant and health effects impacts currently occurring through the congested downtown corridor will be in large part shifted to this new, less developed western corridor.

The bypass is proposed to allow vehicular traffic (to a great extent this is expected to be large diesel trucks, according to TDOT) to bypass downtown congestion, by driving through Hardin Valley, and parts of Bull Run Valley, Raccoon Valley, and Wolf Valley. Valley locations are generally a very poor location of a source of air pollutants. Dispersion of pollutants in a valley is highly minimized and high concentrations can result when stagnant dispersion conditions exist, as previously discussed.

Heavy diesel truck traffic based on information provided by TDOT, since TDOT's project purpose and need describe the project as a bypass for through truck traffic to avoid traveling through the congested downtown I-40/I-75 corridor. Numerous new areas of congestion will be created immediately, while others will be created as in-fill development occurs. This in-fill development is likely to occur at a fast pace due to the Orange Route's relatively close proximity to downtown Knoxville and Oak Ridge.

Areas where congestion and higher pollutant impacts are especially likely to occur immediately upon the opening of an Orange Route include:

- each interchange along the route;
- areas to the east and west of the intersection with I-40 from Highway 321 to Highway 162;
- areas to the east and west of the Route's intersection with Highway 170 from Highway 9 to I-75; and
- the interchange with I-75.

Elevated $PM_{2.5}$ concentrations along the Orange route in excess of the NAAQS should be considered likely. Truck traffic volumes will be considerable, dispersion will be minimized generally and further minimized through the valleys where dispersion is naturally stifled. Background concentrations of $PM_{2.5}$ are already in excess of the standard in the region as the area is designated nonattainment for that pollutant. Further degradation of air quality along the Orange Route corridor can be expected.

In developing its final rule for $PM_{2.5}$ and PM10 conformity determinations, EPA completed a thorough review of more than 70 studies representing a cross-section of available studies looking at particle concentrations near roadways. EPA determined that these studies provided strong evidence of elevated $PM_{2.5}$ concentrations along roadways on a consistent basis from certain types of projects. The studies identified elevated $PM_{2.5}$ concentrations of 8% to 60% for high-traffic roadways to 285% for major truck stops, compared to background concentrations. Variables identified in the studies as key predictors of $PM_{2.5}$ concentrations include: Total traffic volume; volume of heavy-duty trucks; traffic congestion; and proximity to major facilities (within approximately 150 meters). Most studies showed elevation in $PM_{2.5}$, black carbon, or other components associated with major facilities (e.g., truck routes such as the Knoxville Parkway, intermodal or bus terminals).

Currently, the TDOT has not provided any analysis, using the sophisticated dispersion modeling techniques that are needed to handle the complex terrain, to determine the ambient concentrations of toxic or criteria pollutants along the Orange route or any other route considered. It appears from our review of the recently promulgated final conformity rule, that a hot spots analysis should be required.

We believe that hot spots, or elevated concentrations, of toxic air pollutants will be shown to occur, if an accurate hot spots analysis is conducted. A quantitative analysis of this type is outside the scope of this study, so only qualitative impacts are provided. However, it is clear from the literature that elevated levels of pollutants can be expected, based on the number of vehicles (especially heavy duty diesel trucks) and poor dispersion characteristics of the region and the valleys traversed, and that significant adverse health effects are associated with these elevated concentrations of toxic air pollutants from mobile sources.

5.2 Unacceptable Adverse Health Impacts to Exposed Population, Schools and School Children

The Orange route will pass adjacent to four current or planned schools with a student population over 11,000, including Hardin Valley Elementary (680 students), Pellissippi College (8,000 students), a proposed Hardin Valley High School (2,100 students), and Claxton Elementary (550 students). Adverse health impacts, including an increase in the number of cases of childhood asthma in students attending these schools will be significant. Numerous studies discussed in this report clearly document the significant health effects to children associated with exposure to mobile source air pollutants. Locating a major multilane highway with substantial diesel truck traffic near schools will result in significant exposure to elevated levels of toxic air pollutants, including diesel exhaust, with documented adverse health effects.

The negative impacts to human health, including increased cancer risk to the population who will be located adjacent to the Orange route, has not been quantified by TDOT since no hot spots analysis by modeling has been conducted. However, according to numerous studies and EPA reports discussed herein, the increase will occur and it will be substantial. Elevated concentrations of diesel particulate matter (and the other toxic air pollutants associated with this pollutant) will occur. Ashthma cases, including childhood asthma, will also increase substantially to the population that will become newly exposed to these elevated levels of toxic air pollutants along the Orange route.

6.0 Conclusions

This report evaluated the impacts to ambient air quality and human health from the proposed Orange Route of the Knoxville Parkway. The Knoxville Parkway is touted by the Tennessee Department of Transportation (TDOT) as a high capacity bypass for I-75 through traffic that if constructed would re-route through I-75 traffic, much of it heavy diesel truck traffic, away from a congested I-40/I-75 segment through downtown Knoxville. The Parkway Orange route would generally traverse Hardin Valley, Bull Run Valley, Raccoon Valley and Wolf Valley, all of which are located in what is now a rural, somewhat undeveloped area to the west of downtown between Knoxville and Oak Ridge.

Air quality in the area to be traversed by the Orange Route is already degraded and considered in violation of the NAAQS. Mobile sources are found to significantly contribute to the violations. Traffic on the Orange Route will significantly degrade the air quality along the Orange Route corridor. Elevated levels, or hot spots, of air pollutants are unavoidable due to the minimum atmospheric dispersion in the region and locally in the valleys the Route traverses.

The East Tennessee region was found to have one of the highest incidences of low level inversions, and one of the lowest average wind speeds in the country. These facts, combined with the Orange Route's location through a series of valleys, and the high numbers of vehicles and heavy duty diesel trucks expected to use the Orange Route, means that high concentrations of air pollutants will occur and significant negative impacts to human health will result from the Orange Route Parkway project. These impacts have not been accurately quantified by the TDOT using EPA-approved dispersion modeling techniques.

An increase in the incidences of various cancers and childhood asthma can be expected to occur. Significant health effects to children associated with exposure to mobile source air pollutants are known and are expected to occur since at least four schools will be located in close proximity to the Orange Route. Locating a major multilane highway with substantial diesel truck traffic near schools will result in significant exposure to elevated levels of toxic air pollutants, including diesel exhaust, with documented adverse health effects.

It is recommended that a detailed human health risk study be conducted to fully understand the potential impacts to human health associated with each of the alternative Routes. This will necessarily include the need to a sophisticated air quality dispersion modeling study using ambient meteorological data collected on-site along each alternative Route. The study should be conducted using an EPA-approved model capable of accurately predicting ambient air pollutant impacts in complex terrain such as that encountered along the Routes. The Orange Route's location in a series of valleys is not desirable for the purposes of minimizing impacts on air pollution and human health.

Further, we recommend that TDOT provide a public interest analysis as required by Section 109 of the FHWA. Costs of both the adverse health effects identified for each corridor under review, and their mitigation, must be identified before TDOT can identify the preferred alternative Route, or even determine whether construction of the Knoxville Parkway is in the public interest and should be constructed.