Analysis: Impact of Noise from the Purple Line Project

Prepared by: Donald W. MacGlashan

Major Sections: I. Introduction
II. Two types of noise to consider
III. Impact of LRT trains on the health of people
IV. Impact of noise on users of the trail
V. Impact of having only a four-foot sound barrier walls
VI. Noise impact on the parks
VII. Other impacts on the residential communities
VIII. Construction noise
IX. Appendix – Additional studies on transient nighttime noise
X. References
XI. Credentials and expertise

Length of report: 12 pages

This analysis was prepared by Donald W. MacGlashan, Retired Professional Engineer of Maryland. The same analysis was submitted in affidavit form as part of the record for the federal lawsuit about the Purple Line, Friends of the Capital Crescent Trail et al. v Federal Transit Administration et al.
I. Introduction

The issue of noise represents a major impediment for the communities living along the proposed Purple Line Project. The MTA FEIS Technical Report on Noise (Volume III) for the Purple Line glossed over many aspects of the noise issue and these missing issues are important to understanding the full impact that this project will create.

It should be noted, that after the FEIS and ROD were issued, Governor Hogan made major changes to reduce the project cost. One of these changes was the elimination of “green track,” that is, short vegetation between the rails, which the Governor’s office said would have helped reduce noise and runoff.

One way to discuss the FEIS issues is to look at six separate areas of noise impact:

1. Impact of not adequately addressing the issue of noise
   a. average noise as defined by the FTA
   b. transient noise – not discussed by MTA.

2. Impact of LRT noise on people’s health
   a. increased awareness by scientists of the impact of transient noise on health
   b. numerous studies now relate noise to various health issues, e.g. coronary heart disease, blood pressure, sleep disturbance, insomnia and depression.

3. Impact of noise on users of the trail
   a. Purple Line FEIS Technical volume barely acknowledges the existence of the Trail
   b. no noise impact analysis offered on the trail
   c. noise measurements were often taken hundreds of feet from the tracks with no adjustment for impact on trail users
   d. LRT horn usage.

4. Impact of noise on the parks

5. Impact of inadequate analysis of sound barrier walls

6. Other impacts on the residential communities; loss of wildlife due to LRT noise and transformer hum and location.

7. Construction noise.

II. Two types of Noise to consider

a. Average noise

MTA addressed average noise in FEIS Tables 2, 3, and 5. These values represent the average noise energy over a 24-hour period for each of the 53 locations that were measured. This average is expressed as the equivalent noise energy or $L_{eq}$. Additionally, the MTA applied the day-night level 10 dB penalty to the measured ambient noise level ($L_{eq}$), known as DNL or $L_{dn}$, to adjust for the fact that between 10 P.M. and 7 A.M. external noise more easily disturbs people’s sleep. And then MTA used the FTA (Federal Transit Administration) Land use Categories (FEIS Table 1) to determine what is an acceptable noise impact on residential communities for each level of ambient noise corrected for $L_{dn}$, i.e. no impact, moderate impact, or severe impact. Based on all these average values and using Category 2 of the land use table, FTA posits that communities should be able to endure an increase of ambient noise of 10 - 15 dB. FEIS Table 2 shows the results of applying those criteria. Based on the ambient noise and DNL values, Table 5 shows that the proposed LRT noise level, also a 24-hour noise level, meets the Category 2 criteria for every location.
b. Transient Noise

However, MTA omitted the effect of transient noise and its impact on people’s health. This is unfortunate because it is transient noise that is the main issue for light rail transit (LRT) systems. Transient noise, like that made by any LRT, occurs when there is a sudden rise in noise for a short time. This can be from many sources, a car or motorcycle speeding by, or a jackhammer. In the case of a LRT, a person standing near the LRT tracks will hear a sometimes gradual, sometimes rapid increase in noise level, depending on the speed of the LRT. At higher speeds, the noise peak can be 20 dB higher\(^1\) than the ambient noise. As it passes the person, it decreases back into the ambient noise level. For LRT systems, this is the type of noise people hear. It is the reality of a LRT system or any other type of transient noise situation. Figure 1 shows the general waveform that a LRT can make. Transient noise, unlike the 24-hour L\(_{eq}\), which is taken as a RMS measurement, uses SEL (Sound Exposure Level - shown in Figure 1). SEL enables one to ascertain the peak value of the noise for one second, which is a federal and industry standard. Figure 1 also shows the peak noise level, L\(_{max}\), the noise level that people hear, over the time interval that it takes the LRT to pass by.

![Figure 1](image)

Most LRT vehicles use steel wheels and, of course, steel rails. At higher speeds, like 40 mph, that combination generates more high frequency noise, some call it screeching, as the wheels round corners rubbing harder against the rails. This means the speed of a LRT will impact the peak noise level, the higher the speed, the higher the peak noise level. Conversely, the lower the speed, the quieter the LRT vehicles are. The Purple Line trains will be designed to run at speeds as high as 50 mph.

Because transient noise was not considered by MTA, it is important to show how the LRT transient noise peak level affects the Category 2 impact levels (FEIS Table 2) for communities. Using a modest transient peak noise level, it shows that a 12 dB peak noise level above the ambient level enters the severe impact area - meaning that people will find this level of noise highly annoying - for every level of measured ambient noise. Obviously, higher peak

\(^1\) FTA Transit Noise and Vibration Impact Assessment, Table 6-3 page 6-10 shows that for electric locomotives, the L\(_{max}\) noise level is 86 dBA, which is about 20 dB above the average ambient noise level.
levels will make the noise level even worse and higher into the severe impact area. The 24-hour $L_{dn}$ masks the effect of a 10 to 20 second noise peak so that it is never seen. It is this 10 to 20 second peak time in the severe impact category, recurring every seven to twelve minutes, that people will hear as they try to sleep at night, not the average $L_{dn}$. This is implicitly acknowledged in the document., FTA Transit Noise and Vibration Impact Assessment, paragraph 6.5 shown below:

The assessment of noise impact in this manual utilizes either the $L_{dn}$ or the $Leq$ descriptor. As such, in determining impact it is not necessary to determine and tabulate the maximum levels ($L_{max}$). However, it is often desirable to include computations of $L_{max}$ in environmental documents, particularly for rail projects, because the noise from an individual train passby is quite distinguishable from the existing background noise. The $L_{max}$ is also the descriptor used in vehicle specifications. Because $L_{max}$ represents the sound level heard during a transportation vehicle passby, people can relate this metric with other noise experienced in the environment. Particularly with rail transit projects, it is representative of what people hear at any particular instant and can be measured with a sound level meter. A comparison of $L_{max}$ with other sources can be made by referring to Figure 2.11. Thus, although $L_{max}$ is not used in this manual as a basis for assessing noise impact, it can provide people with a more complete description of the noise effects of a proposed project and should be reported in environmental documents. Equations for computing $L_{max}$ from SEL are given in Appendix F.

Why did the MTA not address this critically important aspect of noise?

III. Impact of LRT trains on the health of people

Although steady continuous high-level noise can damage the health of people, it is not the issue in a LRT system. A transient peak noise environment is what scientists are now concerned about and how it affects a person’s physiological and psychological health. Their understanding, although slow in coming because of its complexity, is well advanced, aided by many studies over the past thirty years. These studies often used different methodologies, but their conclusions are basically the same, that transient noise can be injurious to many people living near a LRT line or airport. The health conditions cited are:

- coronary heart disease
- high blood pressure
- sleep disturbance
- insomnia and
- depression.

Below are comments by three researchers. The reader will note that the last comment deals with aircraft passing over communities. This type of transient noise has the same effect on people as LRT rail noise:

1. “…Subjectively evaluated sleep quality decreased and reaction time increased [to transient noise] gradually with noise levels, whereas most physiological variables revealed the same reactions to both the lower and considerably stronger reactions to the highest noise load. Aircraft noise, rail and
road traffic noise caused similar after effects but physiological sleep parameters were most severely affected by rail noise. The equivalent noise level seems to be a suitable predictor for subjectively evaluated sleep quality but not for physiological sleep disturbances.”


2. “…Sleep disturbance Insomnia and broken sleep are unpleasant experiences and they can lead, the day after, to drowsiness, lower mood and poor performance, including slower reaction times. Sleep disturbance has been associated with coronary heart disease, but it is also possible that people affected by this illness are susceptible of being woken by noise.”


3. “… A recent review concluded that there is evidence that aircraft noise can cause disrupted sleep as evidenced by increased number and length of awakenings, reduced slow-wave sleep and REM sleep, increased heart rate and blood pressure, as well as effects on subjective sleep quality and increased noise annoyance but with only a small effect on task performance the next day (Hales Swift, 2010). These conclusions mirror those of an earlier synthesis of field studies which concluded that there was sufficient evidence that nocturnal noise exposure (defined as rail, road, and aircraft noise) was causing direct biological responses, at approximately 40dB SEL, as well as affecting well-being and quality of sleep (HCN, 2004). This report also found that evidence was weaker for an effect of nocturnal noise on social interaction, task performance, and on specific disease symptoms. Recent evidence from the laboratory and field, confirms that nocturnal aircraft noise assessed as both average noise exposure during the night in the home (LAeq) and the number of noise events impairs cognitive performance the following morning, as evidenced by slower reaction times and lower accuracy on cognitive tasks (Elmenhorst et al., 2010). These effects whilst small, were consistent and statistically significant, and could indicate an important public health implication of nocturnal aircraft noise exposure potentially influencing occupational performance.”

Charlotte Clark & Stephen A Stansfeld, Barts & the London School of Medicine, Queen Mary, University of London, September 2011

The MTA may think that its use of the 24-hour average noise level standard is correct and sufficient to describe all noise, but it is clearly not if scientific research is to be believed. The effects of a 10 to 20 seconds burst of noise during the sleeping hours obviously does have health consequences and should be considered as part of a noise analysis to protect people subjected to it.

The appendix of section IX lists other studies that address the nighttime-noise sleep issue, some dealing with nighttime aircraft noise as more studies have been done in that field than with rail noise. However, both have equivalent health effects.

It is also interesting to note that in recent years some European airports are placing nighttime restrictions on flights from 11 P.M. to 5 A. M. (or in some cities, 7 A.M.) in recognition that the noise from arriving and departing aircraft at night are causing health problems for nearby communities (see section X, Nos. 15 and 16).
IV. Impact of noise on users of the trail

The FEIS Technical Report acknowledges that there is a trail, but after that it only mentions it in regards to the sound barrier walls. There is no mention of the fact that the present Capital Crescent Trail is a pristine, quiet, tree-shaded park-like pathway for hikers and bikers. Nor was there any discussion offered on what the noise levels might be for trail users when the Purple Line is completed, or whether the noise levels would meet Federal sound level safety standards for trail users. Consequently, no noise measurements were made in the LRT’s right-of-way. Indeed, all measurements were made some distance away from the right-of-way, often hundreds of feet away. Even though Montgomery County will be responsible for building the new trail, it will need to know what the projected LRT sound levels will be within 14 feet of the LRT vehicles. None of this data were provided. There is no discussion in the FEIS whether the trail should be outside or inside the sound barrier walls. Logic would say that the trail should be outside the walls, otherwise, the trail users would be bombarded with noise as the sound bounces between wall and LRT.

Since the FEIS was released, Maryland Governor Hogan has modified the design conditions, replacing the “green track” bed with heavy gravel; and Montgomery County will construct the new trail with a concrete pathway. Both changes will increase the noise level for trail users. This is because there will be less absorption of sound from between the rails (no “green track”), and the present trail media (gravel, grass and packed dirt).

In the FEIS pages 15 and 16, the MTA addresses the issue of warning devices that are used to warn people and auto traffic at grade-level crossings. In one place, MTA refers to bells with maximum sound levels at 78 dB(A) at 50 feet, but in another part it refers to a horn being used but with no maximum sound level specified. In a May 2014 communications between the Town of Chevy Chase and the MTA, the Town asked at what sound level would the horn be used. The MTA reply in early July (2014) stated that that question would not be answered until the end of that month. It is over a year later, and this question has yet to be answered. If the MTA is required to follow Federal Railroad Administration (FRA) regulations for all railed vehicles, the sound level when approaching a highway intersection at grade level must be between 91 dB and 110 dB at 100 feet. Normally, its level is about 98 dBA. For a trail user, not noticing a train coming up behind him or her, this sound level would be frightening, and at 12 to 14 feet from the train, where the trail pathway is expected to be, the sound level (translated from 100 feet) could be close to the threshold of pain (120 dBA). As this sound level may exceed the safety standards, MTA should have stated whether it must comply with the stated FRA regulation or not. Further, use of the horn when going through residential areas during sleeping hours is highly likely to wake many homeowners. The MTA should have resolved this question as part of its FEIS effort.

V. Impact of having only a four-foot high sound barrier walls

MTA initially claimed that only a 12-inch wall was needed to dampen the LRT noise and only when pressed by the Town of Chevy Chase and other communities did it agree to install four-foot walls along the south side of the Purple Line from Bethesda to the Rock Creek Stream Valley Park (FEIS page 16). On the north side of the Purple Line, the trail would be four feet above the tracks or would have a four-foot sound wall between the trail and the adjacent community. MTA stated these walls would dampen the noise by 4 dB.

However, no data were given on the composition of these walls. Are they concrete, masonry, wood, AFTEC panels or are they sound absorbent material like Acoustiblok? The fact that the wall is only four feet tall indicates that MTA seems to lack
understanding on how to construct sound barrier walls. Sound can and does bounce in all directions and will certainly bounce from this four-foot wall back to the LRT vehicle and then from there into the community. Sound barrier walls must be designed to minimize reflected sound, and must consider whether community homes are lower or higher than the LRT vehicles themselves. Figure 2 shows how sound can bounce not just from one side of the LRT, but from both sides. In the Town of Chevy Chase and other communities, there are homes that are higher than the Purple Line right of way. Therefore, it is imperative that sound barrier walls be sufficiently high to block reflected noise. The four-foot wall is unlikely to be too useful.

Figure 2 (FHWA Illustration.)

An example of a more effective noise wall being planned in Sydney, Australia to help reduce the noise from its light rail system will be five meters (16.4 feet) high, and may also be augmented with large trees. The Sydney wall will be adjacent to a transit storage and repair yard, such as the one planned for the Purple Line at Lyttonsville, Maryland where rail lines and a storage and repair facility would overlook Rock Creek Regional Park. In the case of Lyttonsville, not only residents but park users and wildlife will also be affected by this permanent and non-minimal or non-de minimis "use" of the park that will continue throughout the days and into the late evenings. Rock Creek Regional Park is only one of many, from Elm Street Park to the eastern end of the line, that would be significantly affected on a permanent basis by noise from the project as currently planned.

The MTA FEIS (pg.16) also pledges to put sound absorbing skirts, covering the sides of the wheel trucks to dampen the sound. What evidence does MTA have that these skirts will reduce wheel noise by 8 dB? What is the material used to achieve this noise reduction? These questions are unanswered in the FEIS or the Record of Decision to the best of my knowledge. Indeed, to the extent that they were, the removal of the requirement to use “green track” from the project by the decision of the Governor as announced in late June and formally in the revised Requests for Proposals on July 15, 2015 would negate the accuracy of any assessment of noise done before then.

VI. Noise Impact to the Parks

The Purple Line will be passing through, over, or skirting by the borders of 12 different parks in going from New Carrollton to Bethesda, and therefore noise is very much an issue.

In the Draft EIS, these parks were considered in FTA Land Category 1, meaning that the parks were to be kept as quiet as possible and every effort should be made to stay outside their boundaries. In the Final EIS, however, all the parks were classified as Category 3 and that category adds 5 dB to account for land considered less sensitive to noise even though the "de minimis use" methodology implies that parks should be treated
differently. This begs the question of why this change? Table 3-2 of the FTA Transit Noise and Vibration Impact Assessment document does not include in Category 3 a description called "active parks" as stated in the FEIS. But, even with this inappropriate classification, the transient noise on park environments also exceeds the FTA criteria values for moderate impact (FEIS Table 5) and therefore will severely impact the environment of these parks. There may not be people sleeping there, but the every-seven-minute blast of noise is not what people expect in a park.

Maryland Governor Hogan has initiated changes to the Purple Line and one of these changes may be the elimination of the skirts that reduce noise covering the wheels of the Purple Line vehicles. It will be difficult to know about this or other variables until after the four proposals are received in November, or after the State has concluded its negotiations and chosen the final proposal and private partner in early 2016. According to the FEIS, however, these skirts would reduce the noise by 8 dB. The loss of these skirts, of course, will increase the peak noise by this amount, and make the park environments that much more unpleasant, creating a permanent impact on, or "use of" these parks for 30+ years or as long as the line operates. Also, as of September 2015, the Federal Government has not approved a Special Use permit for the Purple Line to cross Rock Creek Park, and the fact that the LRT noise level through this park is so high may make it problematical that it will.

VII. Other impacts on the residential communities

1. The loss of all the trees on the trail will diminish the wildlife population, and increase the noise from the LRT that will affect areas beyond the line itself. That noise is likely to scare off sensitive wildlife, including sensitive bird species that may remain nearby in neighboring backyards and green spaces. Communities will be the ones to pay the price as many of its residents are bird watchers and animal lovers.

2. MTA will be putting traction power substation (TPSS) buildings every mile or so to power the Purple Line. These buildings will house high power transformers that normally emit a humming sound. If these stations are placed in a community, will the hum be reduced to a level that a person cannot hear it three feet from these building? Also, nothing was said in the FEIS (pg. 17) about whether substations will be encroaching onto homeowner property or whether homeowners will have to turn over property to the state for these stations. Also not mentioned in the FEIS was the size of these buildings. Some people have reported that post-FEIS, the MTA said that they were about the size of an 18-wheeler truck trailer. If true, homeowners forced to have one on their property would find this to be unreasonable.

VIII. Construction Noise

Construction noise is perhaps the worst kind of noise because it encompasses not only transient noises, but multiple, continuously operating loud equipment noises. The MTA, in FEIS section 4.2, mentioned construction noise, but only superficially. It did list some of the typical equipment that it expected would be used and some of the activities, bridge construction, tunneling, and pile driving. It also listed general types of mitigation it would impose on the concessionaire, but without any specificity in how much noise reduction should be expected for mitigation technologies like:

- sound barrier walls
- sound baffling on generator and compressor engines
- moveable sound reduction screens for activities like jackhammers
MTA also mentioned that it would employ "the best available control technologies to limit excessive noise when working near residences", but without offering how it would do that. It did not even list the maximum noise levels that Montgomery and Prince Georges Counties or other affected jurisdictions, such as the Town of Chevy Chase, impose on construction work, the hours of the day when permitted noise levels change and the extent to which these limits would bind the project. The FEIS also expected the entire project to take five years, but again without breaking down the schedule in any meaningful way. For example, in a given residential area, how long should residents expect the construction work to go on, six months, one year, or longer? Commercial businesses as well as residents need to know what to expect. An estimated schedule would have been helpful.

Now that Governor Hogan has cut the funding for the project, it is not clear what the concessionaire will actually be required to provide from what was published in the FEIS. Many of the environmental aspects of the project have been eliminated. The Governor's June announcement and the amendments to the Request for Proposals since June have also indicated that normal limitations on the hours of the day allowed for construction would be expanded or waived to reduce the costs of construction. That by definition is an unusual increase in the impact of construction noise on the lives of residents, workers, park visitors and wildlife but its effects, potential mitigation and committed mitigation for them have not been assessed or confirmed despite the requirements in the regulations and guidance on mitigation for Environmental Impact Statements.2

---

2 § 1502.14 Alternatives including the proposed action.

This section is the heart of the environmental impact statement. Based on the information and analysis presented in the sections on the Affected Environment (§ 1502.15) and the Environmental Consequences (§ 1502.16), it should present the environmental impacts of proposal and the alternatives in comparative form, thus sharply defining the issues and providing a clear basis for choice among options by the decision-maker and the public. In this section agencies shall:

(a) Rigorously explore and objectively evaluate all reasonable alternatives, and for alternatives that were eliminated from detailed study, briefly discuss the reasons for their having been eliminated.

(b) Devote substantial treatment to each alternative considered in detail including the proposed action so that reviewers may evaluate their comparative merits.

(c) Include reasonable alternatives not within the jurisdiction of the lead agency.

(d) Include the alternative of no action.

(e) Identify the agency's preferred alternative or alternatives, if one or more exists, in the draft statement and identify such alternative in the final statement unless another law prohibits the expression of such a preference.

(f) Include appropriate mitigation measures not already included in the proposed action or alternatives.

The 2011 CEQ Guidance on Mitigation and Monitoring appears not to have been followed in the 2013 FEIS -

IX. Appendix – Additional Studies on Transient Nighttime Noise

• A field study of effects of road traffic and railway noise on polysomnographic sleep parameters, Gunn Marit Aasvang, Britt Øverland, Reidun Ursin and Torbjørn Moum, The Journal of the Acoustical Society of America, 129,3716 (2011)

• Marks, A.; Griefahn, B.; Basner, M. Event-related awakenings caused by nocturnal transportation noise, Noise Control Engineering Journal, Volume 56, Number 1, 1 January 2008, pp. 52-62(11)


• Hypertension and Exposure to Noise Near Airports: the HYENA Study
Lars Jarup,1 Wolfgang Babisch,2 Danny Houthuijs,3 Göran Pershagen,4 Klea Katsouyanni,5 Ennio Cadum,6 Marie-Louise Dudley,1 Pauline Savigny,1 Ingeburg Seifert,2 Wim Swart,3 Oscar Breugelmans,3 Gösta Bluhm,4 Jenny Selanders,4 Alexandros Haralabidis,5 Konstantina Dimakopoulou,5 Panayota Sourtzi,7 Manolis Velonakis,7 and Federica Vigna-Taglianti,6 on behalf of the HYENA study team
1Department of Epidemiology and Public Health, Imperial College London, St Mary’s Campus, Norfolk Place, London, United Kingdom; 2Department of Environment and Health at the Federal Environmental Agency (UBA), Berlin, Germany; 3National Institute of Public Health and Environmental Protection (RIVM), Bilthoven, the Netherlands; 4Institute of Environmental Medicine (IMM), Karolinska Institutet, Stockholm, Sweden; 5Department of Hygiene and Epidemiology, National and Kapodistrian University of Athens, Athens, Greece; 6Environmental Epidemiologic Unit, Regional Agency for Environmental Protection (ARPA), Piedmont Region, Grugliasco, Italy; 7Laboratory of Prevention, Nurses School, National and Kapodistrian University of Athens, Athens, Greece, Environmental Health Perspectives • Volume 116, Number 3, March 2008

• Aircraft Noise, Air Pollution, and Mortality From Myocardial Infarction,
Huss, Anke; Spoerri, Adrian; Egger, Matthias; Röösli, Martin; for the Swiss National Cohort Study Group, Epidemiology: Volume 21, Issue 6, pp 829-836, November 2010


• Frank P. Schmidt, Mathias Basner, Gunnar Krüger, Stefanie Weck, Boris Schnorbus, Axel Muttray, Murat Sariyar, Harald Binder, Tommaso Gori, Ascan Warnholtz, Thomas Münzel, Effect of nighttime aircraft noise exposure on endothelial function and stress hormone release in healthy adults, European Heart Journal, First published online 2 July 2013

• Tomoyuki Kawadaa & Shosuke Suzuki, Change in Rapid Eye Movement (REM) Sleep in Response to Exposure to All-Night Noise and Transient Noise, Archives of Environmental Health: An International Journal, Volume 54, Issue, 1999. Authors Affiliation: Department of Public Health, Gunma University School of Medicine, Maebashi, Japan
X. References


2. Final Environmental Assessment for Northern California Optimization of Airspace and Procedures in the Metroplex; Prepared by: United States Department of Transportation Federal Aviation Administration; Appendix E Basics of Noise; July 2014

3. Airport Noise Law; Statutes and Regulations; U.S., Revised February 27, 2011


6. Sound levels – decibels, intensity and distance; SchoolPhysics, 2012


8. What causes transformer noise, and how can it be eliminated?. Acme Electric; May 4, 2012


10. Audible Landscape, 4 physical Techniques to Reduce Noise Impacts; U.S Department of Transportation; Federal Highway Administration,

11. Maryland State Highway Administration; Sound Barriers Guidelines; Highway Traffic Noise

12. Sound Walls; Noise FAQ; Noise Walls; Washington State Department of Transportation

13. The New Generation of Highway Sound Barrier Walls; AFTEC [Corporation]

14. Acoustiblok.com [Corporation]; sound walls

15. Noise ban provides nightmares for German airports and airlines but better sleep for campaigning residents: Greenaironline.com 20 Apr. 2012

16. Night time restrictions at Amsterdam-Schiphol: By: Frenk Wubben and
Donald W. MacGlashan, received a B.E.E. from the University of Virginia in 1957. He worked for the Bendix Corporation for 19 years in the areas of research and development in both radar and low noise microwave technology. He received patents in both technologies. He delivered technical papers at engineering conferences in the U.S. He received his Professional Engineer license from the state of Maryland in 1968. He then worked at Booz Allen Hamilton for 14 years as a consultant in systems engineering. Clients were the U.S. Navy, Air Force, Marines, Army, and FAA. Technical papers were given in the U.S. and Europe. He retired in 1991. In 1994, he became a board member of the non-profit organization, Citizens for the Abatement of Aircraft Noise, Inc. CAAN provides technical and noise information on National and Dulles Airports, and promotes ways to reduce aircraft noise in the Metropolitan Washington D.C. area. He attended conferences and delivered papers on community noise impacts and twice testified before the U.S. House of Representatives on the effect of aircraft noise. He was appointed by the Governor of Maryland to the Citizens Advisory Committee of the Metropolitan Washington Airports Authority (MWAA). In his second term on this committee, he was elected vice president and then became president three months later when the committee president resigned. During his term as president, he and other committee members convinced MWAA management to publish quarterly reports on the noise levels at each of its 32 noise-monitoring stations so each community could see what the aircraft noise environment was for their community. He was later designated the CAAN representative to the Washington D.C. Council of Governments (COG) committee on aircraft noise (CONANDA). In this time period, he was appointed chair of a subcommittee to monitor the FAA redesign of the region’s airspace to ensure that communities were not unfairly overburdened with aircraft noise.

With respect to the Purple Line, he presently lives one-quarter mile from its right of way.

September 2015