Memorandum

To: Michelle Hook, Millennium Pipeline Company, LLC **Date:** March 14, 2017

From: Chris Long and Nicole Briggs, Gradient

Subject: Eastern System Upgrade Project Exposure Comparisons for Volatile Organic Compounds at the Hancock and Highland Compressor Stations

Overview

As part of the Eastern System Upgrade project, the Millennium Pipeline Company is seeking to construct and operate the Highland Compressor Station in Sullivan County, New York (NY), and to add compression to the Hancock Compressor Station in Delaware County, NY. Both of these sources are expected to operate under New York State Department of Environmental Conservation (NYSDEC) state facility permits, similar to the permit issued for the construction and operation of the Hancock Compressor Station in 2013 (DEC permit 4-1236-00708). As stated on the NYSDEC air permitting website,[1] state facility permits are issued to non-major (*i.e.*, minor source) facilities, which are facilities that typically have much lower emissions of air pollutants than major (*i.e.*, Title V) facilities. Permitting authorities generally issue minor source permits to facilities where the operating conditions, including permitted pollution control measures, result in air emissions that will not contribute to ambient air pollutant concentrations above health-based air quality benchmarks.

The volatile organic compounds (VOCs) that would be emitted from both compressor stations in the course of full capacity operating conditions are ubiquitous in indoor and outdoor air due to a number of common emission sources. Below, we provide exposure comparisons for five VOCs—benzene, ethylbenzene, formaldehyde, toluene, and xylene—to provide context on the VOC exposures that could occur as a result of emissions from the compressor stations as compared to VOC exposures from common activities. The comparisons are based on total annual VOC exposures from the compressor station emissions that were estimated in an ambient air modeling analysis described in the "Millennium Pipeline Company, LLC Eastern System Upgrade Project, Docket No. CP16-486-000 Supplemental Information – Human Health Risk Assessment Report." The highest model-predicted annual average ambient air concentrations at or beyond the facility fencelines were used from modeling analyses reflecting capacity operating conditions at the proposed Highland compressor station and at the expanded Hancock compressor station (including the previous operating capacity plus the proposed additional capacity). The estimated total annual VOC exposures for the compressor stations thus represent a hypothetical worst-case exposure scenario because they assume that the exposed person is present outdoors at the maximally impacted off-site location 24 hours a day, 7 days a week, and 365 days a year.

What these exposure comparisons tell us is that doing <u>any one</u> of these common activities at the specified frequency and duration contributes the same amount to our total air pollutant exposure as for hypothetical exposure to the modeled maximum annual-average air quality increments[2] for each of the compressor

[1] NYSDEC air permit and registration information can be accessed at http://www.dec.ny.gov/chemical/8569.html.

[2] An air quality increment is the concentration of an air pollutant due to a specific source, as opposed to the total concentration of an air pollutant, which includes the background concentration plus contributions from one or more sources.

stations. For example, consider a comparison where an exposure to benzene resulting from one year of full capacity operating conditions from the Highland compressor station is equivalent to 30 minutes of exposure during a common activity. This comparison means that a person would have a benzene exposure equivalent to the worst-case conditions in the region surrounding the Highland compressor station if they spent 30 minutes doing the specified activity one time during a year, 10 minutes doing the activity three times during a year, or any other combination of frequency and duration that sums to 30 total minutes during the year. Because all of us engage in a variety of these activities, the total duration of each separate activity could be much less than what is given below for the total exposure associated with these activities to equal the worst-case exposures associated with the compressor stations. In other words, even if we do not engage in all of these activities or we do so for lesser periods of time than assumed below, the sum of our exposures to the five VOCs from these and other everyday activities will still exceed worst-case yearly exposures associated with the compressor station emissions. Even with the use of modeled maximum air quality increments for the compressor stations that are representative of worst-case exposure conditions, these comparisons illustrate how exposures to the five VOCs will continue to be dominated by the everyday contributions from a variety of common sources and personal activities, rather than by emissions from the compressor stations.

Exposure Comparisons

With the exception of one comparison that is based on a model-estimated air concentration (benzene concentrations from the use of scented candles), the exposure comparisons listed below are based on air measurement data published in peer-reviewed scientific studies, government reports, and United States Environmental Protection Agency (US EPA) air quality databases. We searched for data representative of everyday VOC exposures using the US National Library of Medicine's PubMed biomedical literature database,[3] Elsevier's Scopus database,[4] and Google searches. We also consulted toxicological profiles that have been prepared for each of the VOCs by the US Department of Health and Human Services Agency for Toxic Substances and Disease Registry (ATSDR)[5] for information on key exposure sources, although we generally did not use exposure data reported in the toxicological profiles given the availability of data from more recent studies. Preference was given to studies or other data sources that met most or all of the following criteria:

1. Studies documenting exposures in the US or a country likely to have similar exposure pathways and sources (*e.g.*, Canada);
2. Studies documenting exposures likely to be relevant to residents of Sullivan and Delaware Counties;
3. Recently conducted studies with robust datasets relevant to current exposure conditions;
4. Studies with clearly documented and scientifically reliable methodologies; and
5. Studies conducted by, or at the request of, government agencies.

The Exposure Comparison Reference section at the end of this memo provides further details on the sources used for the exposure comparisons, and each exposure comparison below includes an end-note citation to match it with one of the references. If a study reported more than one exposure statistic, we used the following order of preference to select the statistic used for the exposure comparisons: 1) median or 50th percentile; 2) geometric mean; 3) arithmetic mean; and 4) mid-point of a range of values. In other

[3] Available at: http://www.ncbi.nlm.nih.gov/pubmed/
[4] Available at: http://www.scopus.com/
[5] Available at: https://www.atsdr.cdc.gov/ToxProfiles/Index.asp.

words, we relied on statistics representative of central tendency values, rather than statistics representative of extreme values, such as maximum detected concentrations or 95th percentiles. Each exposure comparison was calculated by dividing the highest model-predicted annual average ambient air concentration at or beyond the facility fencelines by the comparison concentration (*e.g.*, median exposure) from the study or other data source. These ratios were then used to calculate the total number of hours and minutes a person would need to be exposed to a specific source to have an equivalent exposure to that corresponding to being outdoors for an entire year at the location maximally impacted by the compressor station emissions. The calculated exposure time periods were then rounded up using the following rules: 1) exposures less than five minutes were rounded to five minutes; 2) exposures within five minutes of a quarter-hour increment were rounded up to that quarter hour (*e.g.*, 1 hour and 12 minutes was rounded to 1 hour and 15 minutes); and 3) all other exposures were rounded up to the nearest ten-minute increment (*e.g.*, 46 minutes was rounded to 50 minutes).

Benzene Comparisons

For the region surrounding the Highland compressor station, a year of breathing air with the maximum modeled compressor station benzene impact is equivalent to any one of the following–

- Spending about 40 minutes in a home with a regular smoker;[6] or
- Driving a car for about 5 minutes;[10] or
- Being outdoors for about 10 minutes at a gas station;[3] or
- Spending about 6 hours and 30 minutes in a home with a lit fragranced candle;[7] or
- Being outdoors in New York City for about 1 hour and 15 minutes;[4] or
- Spending about 40 minutes inside a house with an attached garage with a connecting door to the house (only the incremental exposure associated with the attached garage).[12]

For the region surrounding the proposed Hancock compressor station, a year of breathing air with the maximum modeled compressor station benzene impact is equivalent to any one of the following–

- Spending about 1 hour in a home with a regular smoker;[6] or
- Driving a car for about 10 minutes;[10] or
- Being outdoors for about 15 minutes at a gas station;[3] or
- Spending about 10 hours and 30 minutes in a home with a lit fragranced candle;[7] or
- Being outdoors in New York City for about 2 hours and 10 minutes;[4] or
- Spending about 1 hour inside a house with an attached garage with a connecting door to the house (only the incremental exposure associated with the attached garage).[12]

Ethylbenzene Comparisons

For the region surrounding the Highland compressor station, a year of breathing air with the maximum modeled compressor station ethylbenzene impact is equivalent to any one of the following–

- Driving a car for about 45 minutes;[10] or

- Being outdoors for about 50 minutes at a gas station;[11] or
- Spending about 4 hours and 15 minutes in a home with a regular smoker;[6] or
- Being outdoors in New York City for about 12 hours and 40 minutes;[13] or
- Spending about 1 hour and 30 minutes inside a house with an attached garage with a connecting door to the house (only the incremental exposure associated with the attached garage).[12]

For the region surrounding the proposed Hancock compressor station, a year of breathing air with the maximum modeled compressor station impact is equivalent to any one of the following–

- Driving a car for about 1 hour and 10 minutes;[10] or
- Being outdoors for about 1 hour and 15 minutes at a gas station;[11] or
- Spending about 7 hours in a home with a regular smoker;[6] or
- Being outdoors in New York City for about 20 hours and 40 minutes;[13] or
- Spending about 2 hours and 20 minutes inside a house with an attached garage with a connecting door to the house (only the incremental exposure associated with the attached garage).[12]

Formaldehyde Comparisons

For the region surrounding the Highland compressor station, a year of breathing air with the maximum modeled compressor station formaldehyde impact is equivalent to any one of the following–

- Spending about 20 minutes near an electric oven undergoing a cleaning cycle;[1] or
- Driving a car for about 3 hours;[2] or
- Being outdoors in New York City for about 27 hours and 30 minutes;[4] or
- Spending about 30 minutes broiling fish in an electric oven;[1] or
- Spending about 15 hours in a home with a regular smoker;[6] or
- Breathing air for one hour after applying facial moisturizer on about 19 separate occasions;[5] or
- Spending about 1 hour and 40 minutes in a room with new wood laminate flooring.[8]

For the region surrounding the proposed Hancock compressor station, a year of breathing air with the maximum modeled compressor station formaldehyde impact is equivalent to any one of the following–

- Spending about 30 minutes near an electric oven undergoing a cleaning cycle;[1] or
- Driving a car for about 5 hours;[2] or
- Being outdoors in New York City for about 44 hours and 50 minutes;[4] or
- Spending about 50 minutes broiling fish in an electric oven;[1] or
- Spending about 24 hours and 30 minutes in a home with a regular smoker;[6] or
- Breathing air for one hour after applying facial moisturizer on about 30 separate occasions;[5] or
- Spending about 2 hours and 45 minutes in a room with new wood laminate flooring.[8]

Toluene Comparisons

For the region surrounding the Highland compressor station, a year of breathing air with the maximum modeled compressor station toluene impact is equivalent to any one of the following–

- Spending about 2 hours and 50 minutes in a home with a regular smoker;[6] or
- Driving a car for about 20 minutes;[10] or
- Spending about 5 minutes inside a nail salon;[9] or
- Being outdoors for about 30 minutes at a gas station;[3] or
- Being outdoors in New York City for about 11 hours;[13] or
- Spending about 30 minutes inside a house with an attached garage with a connecting door to the house (only the incremental exposure associated with the attached garage).[12]

For the region surrounding the proposed Hancock compressor station, a year of breathing air with the maximum modeled compressor station toluene impact is equivalent to any one of the following–

- Spending about 4 hours and 40 minutes in a home with a regular smoker;[6] or
- Driving a car for about 30 minutes;[10] or
- Spending about 10 minutes inside a nail salon;[9] or
- Being outdoors for about 40 minutes at a gas station;[3] or
- Being outdoors in New York City for about 17 hours and 50 minutes;[13] or
- Spending about 50 minutes inside a house with an attached garage with a connecting door to the house (only the incremental exposure associated with the attached garage).[12]

Xylene Comparisons

For the region surrounding the Highland compressor station, a year of breathing air with the maximum modeled compressor station xylenes impact is equivalent to any one of the following–

- Spending about 2 hours and 30 minutes in a home with a regular smoker;[6] or
- Driving a car for about 20 minutes;[10] or
- Being outdoors for about 30 minutes at a gas station;[11] or
- Being outdoors in New York City for about 3 hours and 20 minutes;[13] or
- Spending about 30 minutes inside a house with an attached garage with a connecting door to the house (only the incremental exposure associated with the attached garage).[12]

For the region surrounding the proposed Hancock compressor station, a year of breathing air with the maximum modeled compressor station xylenes impact is equivalent to any one of the following–

- Spending about 4 hours and 10 minutes in a home with a regular smoker;[6] or
- Driving a car for about 30 minutes;[10] or

- Being outdoors for about 50 minutes at a gas station;[11] or
- Being outdoors in New York City for about 5 hours and 30 minutes;[13] or
- Spending about 40 minutes inside a house with an attached garage with a connecting door to the house (only the incremental exposure associated with the attached garage).[12]

Exposure Comparison References

1. ARCADIS Geraghty & Miller, Inc. (Research Triangle Park, NC); Fortmann, Roy; Kariher, P; Clayton, R. 2001. "Indoor Air Quality: Residential Cooking Exposures (Final)." Report to California Air Resources Board (CARB). 231p.

   This report was selected because it documents a robust study of residential cooking exposures that was conducted by CARB. We used the formaldehyde measurements collected during single exposure events (Table 3-18). We only used the measurements representative of electric stove use, as it is our understanding that the majority of households in Sullivan and Delaware counties do not have gas stoves.

2. Health Effects Institute, Air Toxics Review Committee (Boston, MA). 2007. "Mobile-Source Air Toxics: A Critical Review of the Literature on Exposure and Health Effects." HEI Special Report 16. 240p.

   This report was used because it reports measurements taken inside vehicles by Riediker *et al.* (2003) that are not available in the original study publication. In particular, Riediker *et al.* (2003) [reference #10, below] did not include the study's formaldehyde results in its data tables.

3. Kalenge, S; Lebouf, RF; Hopke, PK; Rossner, A; Benedict-Dunn, A. 2013. "Assessment of exposure to outdoor BTEX concentrations on the Saint Regis Mohawk Tribe reservation at Akwesasne New York State." *Air Qual. Atmos. Health* 6(1):181-193. doi: 10.1007/s11869-011-0159-y.

   This study, which was conducted by a tribal government and a university, was selected because it is a recent study that measured personal benzene, toluene, ethylbenzene, and xylenes (BTEX) concentrations for gasoline filling station workers. Although this study made measurements for all of the BTEX species, only the benzene and toluene concentrations were reported in the Kalenge *et al.* (2013) publication. (However, the ethylbenzene and xylenes concentrations were reported in the 2010 St. Regis Mohawk Tribe report [reference #11, below].) We used the gas station geometric mean concentrations from Tables 3 and 4.

4. Kheirbek, I; Johnson, S; Ross, Z; Pezeshki, G; Ito, K; Eisl, H; Matte, T. 2012. "Spatial variability in levels of benzene, formaldehyde, and total benzene, toluene, ethylbenzene and xylenes in New York City: A land-use regression study." *Environ. Health* 11:51. doi: 10.1186/1476-069X-11-51.

This study was selected because it is a recent study focused on BTEX and formaldehyde measurements in New York City (NYC), and it was assumed that many residents of Sullivan and Delaware Counties spend time in NYC. We used the mean concentrations from "distributed sites" (70 sites with air toxics monitoring scattered throughout the NYC boroughs that the study authors refer to as "distributed sites") for benzene and formaldehyde (Table 3), which were the only VOCs for which the study reported individual measurements (*i.e.*, the other VOCs were combined into a single BTEX measurement).

5. Lefebvre, MA; Meuling, WJ; Engel, R; Coroama, MC; Renner, G; Pape, W; Nohynek, GJ. 2012. "Consumer inhalation exposure to formaldehyde from the use of personal care products/cosmetics." *Regul. Toxicol. Pharmacol.* 63(1):171-176. doi:10.1016/j.yrtph.2012.02.011.

This study was selected because it is a recent study of exposures from personal care products where exposures were measured in an indoor environment simulating standard bathroom conditions without contamination from other household VOC sources. The study only measured formaldehyde, and we used the facial lotion 60-minute mean room concentrations from Table 5.

6. Nazaroff, W; Singer, BC. 2004. "Inhalation of hazardous air pollutants from environmental tobacco smoke in US residences." *J. Expo. Anal. Environ. Epidemiol.* 14:S71-S77.

This study was chosen because it is a robust study of exposures to tobacco smoke in US households that reported measurement data for all five VOCs considered in this memo. We used the midpoint of the exposure concentration ranges reported in Table 2 for nonsmokers living with a smoker.

7. Petry, T; Vitale, D; Joachim, FJ; Smith, B; Cruse, L; Mascarenhas, R; Schneider, S; Singal, M. 2014. "Human health risk evaluation of selected VOC, SVOC and particulate emissions from scented candles." *Regul. Toxicol. Pharmacol.* 69(1):55-70. doi: 10.1016/j.yrtph.2014.02.010.

This study was chosen because it is a recent study of exposures from the use of scented candles in a home. The study included a robust set of candle emissions measurements which were subsequently used to model indoor air pollutant concentrations. We used the 24-hour average benzene concentrations estimated using a 2-box model for a representative living room (Table 7).

8. Pierce, JS; Abelmann, A; Lotter, JT; Ruestow, PS; Unice, KM; Beckett, EM; Fritz, HA; Bare, JL; Finley, BL. 2016. "An assessment of formaldehyde emissions from laminate flooring manufactured in China." *Regul. Toxicol. Pharmacol.* 81:20-32. doi: 10.1016/j.yrtph.2016.06.022.

This study was chosen because it is a recent study of formaldehyde emissions from CARB-compliant wood laminate floor products. We averaged the mean concentrations from rooms 1 and 2 for all post-installation 24-hour samples, which spanned samples taken 1-35 days after installation (Table 2).

9. Quach, T; Gunier, R; Tran, A; Von Behren, J; Doan-Billings, PA; Nguyen, KD; Okahara, L; Lui, BY; Nguyen, M; Huynh, J; Reynolds, P. 2011. "Characterizing workplace exposures in Vietnamese women working in California nail salons." *Am. J. Public Health* 101 (Suppl. 1):S271-S276. doi: 10.2105/AJPH.2010.300099.

   This study was chosen because it is a robust community-based participatory research study for US nail salons. We used the mean area toluene concentration, which averaged room measurements from three nail salons (Table 3).

10. Riediker, M; Williams, R; Devlin, R; Griggs, T; Bromberg, P. 2003. "Exposure to particulate matter, volatile organic compounds, and other air pollutants inside patrol cars." *Environ. Sci. Technol.* 37(10):2084-2093. doi: 10.1021/es026264y.

    This study was chosen because it is a robust study of air pollutant exposures within vehicles that was conducted by investigators at the US EPA and the University of North Carolina for a suburban US locale. We used the mean benzene, toluene, ethylbenzene, and xylene concentrations measured in patrol cars (Table 2).

11. St. Regis Mohawk Tribe, Environment Division (Akwesasne, NY). 2010. "Characterization of Benzene and Other Air Toxics in Akwesasne." 23p.

    This study was used because it provides a more comprehensive summary of personal BTEX measurements for gasoline filling station workers than the Kalenge *et al*. (2013) study described above. Specifically, this report includes statistics for ethylbenzene and xylene. We used the gas station geometric mean concentrations for these two VOCs from Tables 5.4 and 5.6.

12. Wheeler, AJ; Wong, SL; Khouri, C; Zhu, J. 2013. "Predictors of indoor BTEX concentrations in Canadian residences." *Health Rep.* 24(5):11-17.

    This study was selected because it is a recent study conducted by scientists at Health Canada that focused on BTEX concentrations in different types of private homes. For all four BTEX compounds, we estimated mean VOC concentrations associated with an attached garage by calculating the difference between the mean VOC concentration for homes with attached garages with a connecting door and the mean VOC concentration for homes with a detached garage (Table 4). We summed the m-,p- xylene and o-xylene concentrations to determine total xylenes concentrations.

13. US EPA Air Quality System (AQS) data for New York City (NYC).

    Ethylbenzene, toluene, and xylene data were downloaded from US EPA's AQS Data Mart[6] to supplement the Kheirbek *et al*. (2012) study, which only reported benzene and formaldehyde data for NYC. We averaged all 2015 measurements from the five NYC sites measuring these compounds. We downloaded 2015 data because this was the most recent, complete year of data available through AQS.

[6] Available at: http://aqsdr1.epa.gov/aqsweb/aqstmp/airdata/download_files.html