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November 15, 2021

Michael P. Collins
Commissioner of Public Services and Engineering
City of Beverly
191 Cabot Street
Beverly, MA 01915

Re: Magnetic Field Assessment Review – Beverly Regional Transmission Reliability Project

Dear Mr. Collins:

I write to summarize my review of the Magnetic Field Assessment prepared by Exponent for the Beverly Regional Transmission Reliability Project – N-192 Cable Relocation. The review was conducted at the direction of the City of Beverly to ensure that electromagnetic fields (EMF) associated with the proposed project are properly evaluated. The City wishes to understand potential EMF impacts associated with the proposed cable and how those impacts could affect those who live or work in Beverly.

The review considered the following reports prepared by Exponent in May of 2019:

- *Beverly Regional Transmission Reliability Project – N-192 Cable Relocation; Magnetic Field Assessment* (Exponent, 2019)
- *Current Status of Research on Extremely Low Frequency Electric and Magnetic Fields and Health; 2014-2018* (Exponent, 2019)

Magnetic Field Assessment Review

The assessment of EMF associated with the Beverly Regional Transmission Reliability Project conducted by Exponent in May 2019 used CONSOL MultiPhysics software to model magnetic fields associated with the proposed underground cable. Magnetic fields are modeled at both forecasted average and peak loads on the proposed cable based on an electricity planning forecast for 2023. Because forecasted loads differ between the northern (north of the Beverly #12 Substation) and southern sections of the cable, modeling is conducted at different loads for different sections of the line. The modeling evaluates the five duct bank configurations proposed for the cable at the minimum target burial depth for each configuration.

The modeling software used by Exponent to conduct the evaluation, CONSOL MultiPhysics Version 5.4, is well-respected engineering software based on physics. It can be used to model many aspects of project design. Though not explicitly specified in Exponent's report, the AC/DC electromagnetic module of CONSOL MultiPhysics was most likely used to conduct the analysis. The AC/DC module utilizes the laws of physics relating to EMF (known as Maxwell's Equations) to model magnetic fields associated with electricity transmission. These laws of physics are very well understood. Models such as CONSOL MultiPhysics are verified against other models to ensure that the laws of physics have been implemented correctly. Assuming key inputs to the software are valid, such as the configuration of the underground cable and the loads on the cable, the results of the model should be a very accurate representation of anticipated EMF associated with the project.

Transmission of electricity generates both electric and magnetic fields. Electric fields are well-shielded by conducting materials. For the Beverly Project, the cable sheaths and overlying soil shield the electric field; hence, there is no reason to model or measure electric fields from the underground cables. Magnetic fields are not easily shielded; hence, evaluations of EMF associated with underground cables typically focus on magnetic fields. As is appropriate, the Exponent report focuses on magnetic fields.

Magnetic fields were modeled at a height of 1 meter above ground. This height is specified by the Institute of Electrical and Electronics Engineers (IEEE) and is the height at which EMFs are typical modeled or measured in submissions to the Massachusetts Energy Facilities Siting Board (EFSB). The report modeled five different configurations of the underground cable – the delta configuration proposed for use along most of the route, two square configurations used at the MBTA track crossing (Congress Street) and underneath the Veterans Memorial Bridge, a vertical configuration used when entering manholes, and a horizontal configuration used in short sections where the cable must be buried more shallowly due to existing utilities. The modeling considers reasonable worst-case situations including the minimum targeted burial depths and maximum forecasted loads. These aspects of the modeling are all consistent with EFSB requirements taken into consideration when permitting new transmission projects.

The City of Beverly has an interest in ensuring that the project minimizes exposure to magnetic fields associated with the transmission project to the extent feasible. Certain aspects of the underground cable have been intentionally designed to reduce magnetic fields. Along most of its distance, the cable will be in a delta (triangular) configuration, a configuration that minimizes total magnetic fields associated with the three phases of the transmission cable. Furthermore, the duct bank has been designed with a reasonably small distance between the three phases, which maximizes cancellation of the fields associated with the three conductors. Some sections of the line are in other configurations. Other configurations are necessary near existing utilities, when entering manholes, crossing the MBTA tracks, and beneath the bridge. The proposed line will be located beneath existing roads. The highest magnetic fields will therefore be in the roadway, not in locations where pedestrians, residents, and others spend the majority of their time.

One additional aspect that can affect magnetic fields above ground is the depth of the cable. Due to increased distance, the deeper the cable is buried, the lower magnetic fields will be above ground. Determining the best depth at which to locate a transmission line considers many factors, including magnetic fields, cost of construction, locations of existing utilities, cost and ease of maintenance or repairs, and other factors. The depth proposed for the Beverly project (minimum depth of 2.5 feet) is typical for the installation of underground cables. If, however, there were areas of particular concern where it would be desirable to further minimize magnetic fields associated with the transmission cable, this is one aspect of the design that could be altered to decrease magnetic field strength. Tables B-3, B-4, and B-7 of Exponent's report (pp. B-2 to B-3) suggest that magnetic fields associated with a cable buried at a depth of five feet are a factor of approximately two less than those for a cable buried at 2.5 feet.

Results of the Magnetic Field Assessment

The results of Exponent's magnetic field assessment of the project are summarized in Table 3, Figures 2-6, and the table of Appendix B in the report. For the delta configuration used for most of the line, at the minimum proposed burial depth, and at average loading, the maximum magnetic field modeled directly above the proposed duct bank is 24 mG for the southern section of the line (south of the Beverly #12 Substation) and 19 mG for the north section of the line. Magnetic field strengths decrease to 3.5 mG or less at a distance of 25 feet from the duct bank. Magnetic fields associated with the MBTA crossing and Veterans Memorial Bridge configurations are similar. While the configurations for those two locations are less ideal for magnetic field cancellation, the increased minimum depth at those locations (5 feet instead of 2.5 feet) results in similar magnetic field strengths. The vertical configuration near manholes and the flat configuration when necessary to avoid utilities result in higher maximum magnetic field strengths at average loads. Those two configurations result in a maximum magnetic field strength of approximately 50 mG on the southern section and 40 mG on the northern section.

Exponent also modeled magnetic fields associated with projected peak loads. At peak loads, the maximum modeled magnetic field strength directly above the duct bank is 41 mG for the delta configuration on the southern section of the project. These fields decrease to approximately 6 mG at 25 feet from the line. The maximum magnetic fields associated with any configuration at peak loads is 88 mG directly above both the manhole entry configuration and flat configuration on the southern portion of the line. These field decrease to 13 mG or less at 25 feet from the line.

These results are consistent with modeled (and measured) magnetic fields associated with similar 115 kV underground transmission cables at the modeled loads.

Because the federal government has no health-based guidelines for exposure to magnetic fields associated with electricity transmission, the Exponent report compares modeled magnetic field levels to guidelines developed by the International Committee on Electromagnetic Safety (ICES) and the International Commission on Non-Ionizing Radiation Protection (ICNIRP). These guidelines were developed to be protective of bodily tissues during short term exposure to low frequency (60 Hz) magnetic fields. The ICES guideline is 9,040 mG and the ICNIRP guideline is 2,000 mG. The modeled magnetic field strengths are well below these guidelines. While comparison to these guidelines is valid, magnetic field strengths at ground level from transmission lines never approach these guidelines, and the guidelines were developed for short-term exposure, not long-term exposure. Long-term guidelines have not been developed based on health effects because sufficient scientific data are not available to support long-term guidelines.

It is informative to compare magnetic field strengths associated with the proposed project to magnetic field strengths generally permitted for overhead transmission lines and underground cables in Massachusetts and other states. No state guidelines are based specifically on health effects. Regulatory agencies have not been able to identify an adverse health effect by which to define safe levels of magnetic fields from electricity distribution and use. Most guidelines are based primarily on ensuring that magnetic fields associated with transmission projects remain similar or less than those that have been permitted in the past. None of the guidelines have been developed using scientific methodologies. The Massachusetts EFSB does not use a specific maximum allowable limit for magnetic fields but has approved magnetic field levels as high as 85 mG at the edge of a right-of-way in the past. This level is not the maximum level allowed directly beneath an overhead line or directly above an underground cable. Much higher magnetic field strengths (hundreds of mG) have been approved directly beneath overhead lines or above underground cables. Some other states have identified specific allowable levels at the edge of rights-of-way including:

- Florida allows magnetic field strengths of 150 mG at the edge of a right-of-way.
- New York permits magnetic fields of 200 mG at the edge of a right-of-way.
- Connecticut concluded that no health-based EMF power frequency standards are necessary, but the Connecticut Siting Council has at times used a guideline of 200 mG at the edge of a right-of-way.

At the edge of the roadway, magnetic field strengths associated with the Beverly Project for all configurations and under both average and peak loads are less than levels that have been approved by the Massachusetts EFSB in the past. These levels are also less than guidelines developed by Florida, New York, and Connecticut for magnetic field strength at the edge of a right-of-way.

Literature Summary Related to EMF and Health Effects

Exponent conducted a review of the literature related to low frequency (50 Hz or 60 Hz) EMF and health effects. In general, this review is both a comprehensive and accurate summary of the literature. As indicated by the review, the health risk assessment of EMF conducted by the World Health Organization (WHO) in 2007 involved a comprehensive review of the literature up to that time. The task group responsible for the conclusions of the WHO report consisted of 21 scientists with a wide variety of backgrounds. The WHO review is generally considered to be a fair review with minimal bias.[1] Exponent's review updates the conclusions of the WHO review based on literature published between 2014 and 2018.

The key conclusions of the WHO review were that 50 Hz or 60 Hz EMF remains classified as a possible human carcinogen. Epidemiological studies indicate a correlation between exposure to 60 Hz magnetic fields at levels greater than 3 or 4 mG and an increased risk of childhood

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[1] Information from the WHO on electromagnetic fields is available at https://www.who.int/health-topics/electromagnetic-fields.

leukemia. This correlation does not necessarily indicate that EMF is the cause of the increased risk at low levels. Other explanations include selection bias in the studies or confounding factors that also correlate with exposure to EMF. Attempts to identify a mechanism and a direct causal relationship between magnetic fields and cancer have not been successful. The WHO strongly supports additional research to reconcile the epidemiological data which shows a correlation between EMF and childhood leukemia, and direct experimental data which have not been able to identify a risk or causal relationship whereby EMF causes childhood leukemia. Because no causal relationship can be established based on the WHO review, no exposure limits for EMF were recommended, but WHO did suggest some precautionary measures. WHO did not identify any strong relationships between EMF and other adverse health effects.

Exponent's update based on the literature between 2014 and 2018 does not significantly alter the findings of the WHO risk assessment. Exponent's review suggests that recent large studies and pooled analyses indicate weaker associations and non-statistically significant associations between EMF and childhood leukemia, but that the association between leukemia and magnetic fields in previous studies remains unexplained. It continues to be the case that scientific studies have been unable to identify a causal relationship between EMF and childhood leukemia.

Contact Information

Please contact me with any questions or comments about this review of Exponent's EMF modeling for the Beverly Regional Transmission Reliability Project. I may be reached at 857-366-2015 or richlester@gmail.com.

Sincerely,

Richard R. Lester, CEP
Certified Environmental Professional

cc: Mayor Michael P. Cahill