5.3.9.2.3 Comparison of OHM Impacts

A comparison of the Preferred Northern and Noticed-Alternative Southern Routes revealed a significant difference in the number and density of sites with potential OHM concerns located along both routes. 76 sites with potential OHM concerns were identified along the Preferred Northern Route. In contrast, only nine sites with potential OHM concerns were identified along the Noticed-Alternative Southern Route. Due to use of proper soil and groundwater management techniques, impacts related to the spread of OHM are not anticipated to occur regardless of which route is selected. Nevertheless, the difference in these OHM site numbers speaks to the overall nature of historic pollution along the two routes: the Preferred Northern Route is generally less favorable than the Noticed-Alternative Southern Route. However, since the Preferred Northern Route will in all events be the site for the upgrading of the 115-kV lines, no advantage is gained by selecting the Noticed-Alternative Southern Route from the point of view of OHM. The two routes are therefore roughly comparable on this basis.

5.3.9.2.4 Mitigation Measures

During the construction of the Project, the effective management of soils and groundwater will be a key consideration. As part of the final Project design, WMECO will develop specific plans for characterizing the soils and groundwater along the routes (i.e., presence/absence of OHM) and subsequently for handling and managing such materials. Such plans will be developed based on the results of agency file reviews, pre-construction sampling and analyses along the approved Project routes, and the incorporation of applicable permit requirements.

5.3.10 Electric and Magnetic Fields

This section characterizes background electric and magnetic field (EMF) levels and provides calculations to compare the levels of EMF associated with existing and proposed transmission lines along the Preferred Northern Route and the Noticed-Alternative Southern Route.

In addition, a summary of the latest assessment of research on EMF by the World Health Organization (WHO) and its relevance to past practices and EFSB guidance in Massachusetts is provided in Exhibit 5.3.

Background Levels of Electric and Magnetic Fields

Electricity used in homes and workplaces is transmitted over considerable distances from generation sources to distribution systems. Electricity is transmitted as alternating current (AC) to all homes and over the electric lines that deliver power to neighborhoods, factories and commercial establishments. The power provided by electric utilities in North America oscillates 60 times per second, i.e., at a frequency of 60 hertz (Hz).

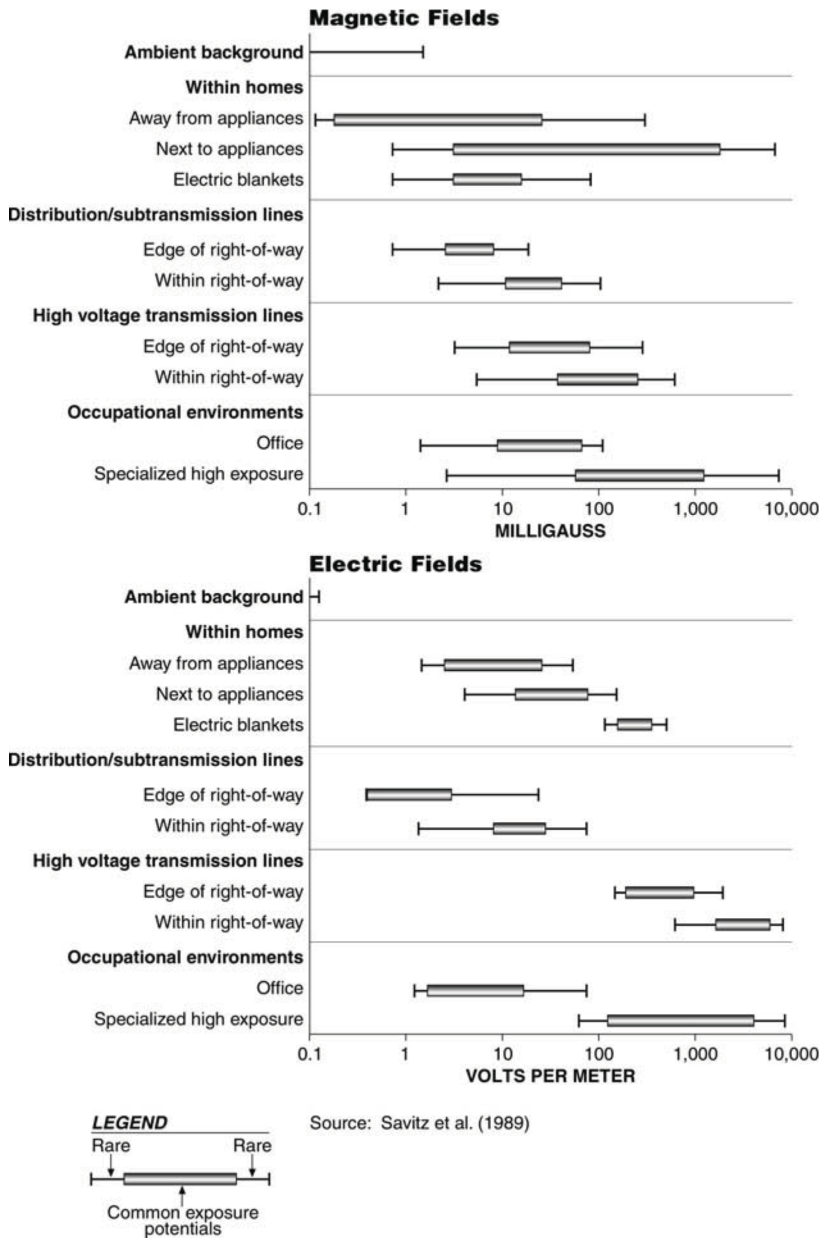
Electric fields are the result of voltages applied to electrical conductors and equipment. The electric field is expressed in measurement units of volts per meter (V/m) or kilovolts per meter (kV/m); 1 kV/m is equal to 1,000 V/m. Most objects including fences, shrubbery, and buildings easily block electric fields. Therefore, certain appliances within homes and the workplace are the major sources of electric fields indoors, while power lines are the major sources of electric fields outdoors (Figure 5-3, lower panel).

Magnetic fields are produced by the flow of electric currents; however, unlike electric fields, most materials do not readily block magnetic fields. The level of a magnetic field is commonly expressed as magnetic flux density in units called gauss (G), or in milligauss (mG), where 1 G = 1,000 mG.[11] The magnetic field level at any point depends on characteristics of the source, including the arrangement of conductors, the amount of current flow through the source, and its distance from the point of measurement. The levels of both electric fields and magnetic fields diminish with increasing distance from the source.

Background AC magnetic field levels in homes are generally less than 20 mG, even when not near a particular source, such as some appliances. Higher magnetic field levels are measured in the vicinity of distribution lines, sub-transmission lines, and transmission lines (Figure 5-3, upper panel).

[11] Scientists more commonly refer to magnetic flux density at these levels in units of microtesla (μT). Magnetic flux density in milligauss units can be converted to μT by dividing by 10, i.e., 1 milligauss = 0.1 μT.

Figure 5-3: Electric and Magnetic Field Levels in the Environment



The strongest sources of AC magnetic fields that are encountered indoors are electrical appliances (fields near appliances vary over a wide range, from a fraction of a mG to a thousand mG or more). For example, Gauger (1985)[12] reports the maximum AC magnetic field at 3 cm from a sampling of appliances as 3,000 mG (can opener), 2,000 mG (hair dryer), 5 mG (oven), and 0.7 mG (refrigerator). Similar

[12] Gauger JR. Household appliance magnetic field survey. IEEE Trans. Power App. Syst. 104:2436-2444, 1985.

measurements have shown that there is a tremendous variability among appliances made by different manufacturers. The potential contribution of different sources to overall exposure over long periods is not very well characterized, but both repeated exposure to higher fields for short times and longer exposure to lower intensity fields for a long time contribute to one's total exposure.

Calculation Methods and Assumptions

The major sources of EMF associated with the Project are the proposed and existing transmission lines on the existing ROW. Transformers and other equipment within the associated substations are also potential EMF sources, but would have little or no impact on exposure to the general public because, as experience indicates, EMF levels from substations "attenuate sharply with distance and will often be reduced to a general ambient level at the substation property lines. The exception is where transmission and distribution lines enter the substation" (IEEE Std. 1127-1990).[13] Hence, addressing the EMF associated with transmission lines effectively addresses potential EMF exposures from substations.

Pre- and post-construction electric and magnetic field levels were calculated using computer algorithms developed by the Bonneville Power Administration, an agency of the U.S. Department of Energy.[14] These algorithms have been shown to accurately predict electric and magnetic fields measured near power lines. The inputs to the program are data regarding voltage, current flow, circuit phasing, and conductor configurations. The fields associated with power lines were estimated along profiles perpendicular to lines at the point of lowest conductor sag, i.e., closest to the ground or opposite points of interest. All calculations were referenced to a height of 1 m (3.28 ft) above ground according to standard practice.[15] The program assumed that the transmission conductors were at a typical mid-span height for the entire distance between structures and flat terrain, and was instructed to model balanced currents on all phases. The electric field from the overhead line conductors was also calculated using the typical mid-span height.

The calculation of magnetic fields requires determining the currents that will flow on the lines of interest under each set of conditions to be studied. For the WMECO existing transmission system, these currents

13 Institute of Electrical and Electronics Engineers (IEEE). IEEE guide for the design, construction, and operation of safe and reliable substations for environmental acceptance. IEEE Standard 1127-1990, 1990.

14 Bonneville Power Administration (BPA). Corona and Field Effects Computer Program, 1991.

15 Institute of Electrical and Electronics Engineers (IEEE). IEEE recommended practice for instrumentation: specifications for magnetic flux density and electric field strength meters-10 Hz to 3 kHz. IEEE Standard 1308-1994, 1994.

are determined by factors including: system load level, generation dispatch, Connecticut import level and east-west power transfer levels, and assumptions about transmission line load flows as described below.

Exponent, WMECO's consultant, evaluated the possible phasing of the new and reconfigured lines to identify a phasing of these circuits that would minimize the magnetic field level at the edge of the ROW with the highest magnetic field. Between 6 and 1296 phasing combinations were evaluated in each cross section, the number depending on the number of transmission circuits in the cross section.

WMECO determined that the system to be modeled in 2012 was one that included transmission system changes already approved by ISO-NE, which are included in their system reliability models as of April 30, 2008, and which have expected in-service dates before 2012. For the 2017 modeling, this system topology was modified to include all four of the NEEWS projects in their proposed line configurations and not just the proposed Project.

The Noticed-Alternative Southern Route is longer than the Preferred Northern Route and therefore would have different electrical impedance and hence would affect system load flows somewhat. Likewise, any other line-route variations including undergrounding would cause small changes in line impedances and forecasted load flows. For purposes of magnetic field calculations for these project routes and design variations, however, the circuit currents were assumed not to change.

WMECO determined that it would provide magnetic field calculations for the year 2012 to represent the pre-Project conditions, and the year 2017 to represent the post-Project conditions five years later. WMECO elected to estimate an annual peak load (APL) conservatively from the ISO-NE's projected 90/10 system peak loads for the peak load condition on the transmission system in 2012 and to estimate 2017 peak loads by scaling ISO-NE's projected 90/10 level in 2016 to 2017 using the load-growth rates in their 2007-2016 Forecast Report of Capacity, Energy, Loads and Transmission, i.e., 32,250 MW in 2012 and 33,949 MW in 2017.

High conservative estimates of annual average loads (AAL) were based on a 61% annual load factor of the New England Transmission System, i.e., 19,830 MW in 2012 and 20,700 MW in 2017. WMECO supplied the results of system load-flow modeling of AAL and APL to Exponent for the modeling of magnetic fields in 2012 and 2017.

In addition, where distribution circuits are located on the project ROW, their peak loads in 2012 and 2017 were estimated by applying an annual 1% growth rate to June 2008 peak values. Their non-peak loading conditions were then estimated by use of the same percentages indicated above for the transmission circuits.

In summary, WMECO undertook magnetic field calculations for two pre-Project loading conditions in 2012 and two post-Project loading conditions in 2017. These were called Annual Average Load (AAL) and Annual Peak Load (APL). By the choice of load levels, and by the choice of import levels and generation dispatches described below, the resulting magnetic field calculations in each case will yield conservatively high values. Therefore, the AAL case should not be construed as indicative of an annual average exposure case, but rather a possible estimate of such a case, that is more likely to be conservatively high.

5.3.10.1 Existing Conditions

5.3.10.1.1 Preferred Northern Route

The proposed project along the Preferred Northern Route in Massachusetts involves the construction of a new 345-kV transmission line on existing ROWs on single- or double-circuit structures as described in cross sections XS-3 to XS-17 in Exhibit 5.1. In order to make room for the new circuit on all but one section of the route (XS-3), existing 115-kV lines will be reconfigured on monopole structures with vertical configurations of the conductors.

The EMF levels are highest on the ROW and decrease with distance away from the transmission lines resulting in lower EMF levels at the edge of the ROW and beyond. The effect of the proposed project on existing levels of EMF, however, is complex and varies by cross section.

Generally, the existing magnetic field levels at AAL will increase along both the eastern and western edges of the ROW in cross sections XS-3 to XS-11 after construction. In cross sections XS-12 to XS-17, the magnetic field levels will increase on one edge of the ROW and decrease on the other edge of the ROW. The change in the magnetic field levels in either direction is less than 70 mG. The electric field levels at the edges of the cross sections under existing conditions range from 0.00 to 0.47 kV/m. After construction, the edge of ROW levels will increase by < 0.57 kV/m. The magnetic field levels at the edges of ROWs computed at APL are not much greater than levels at AAL for most cross sections, and decrease at more than a third of the cross-section edges. The computed electric field levels will not change appreciably.

The calculated magnetic field levels at the edges of the proposed ROW at AAL, which are calculated for high average annual line loadings, of each cross section of the Preferred Northern Route are summarized in Table 5-1 in Exhibit 5.4. Graphical profiles of the calculated magnetic field levels at AAL for the cross sections are also compared in Exhibit 5.5. The calculated magnetic field levels at the APL, which might occur for a limited number of hours during the year, are summarized in Table 5-2 in Exhibit 5.4 and the calculated magnetic field profiles at APL are provided in Exhibit 5.5. The calculated electric field levels at the edges of the ROWs, which do not vary appreciably with load, are presented in Table 5-3, in Exhibit 5.4.

The calculated magnetic and electric fields associated with the transmission lines before and after construction of the project fall below the guideline values of 85 mG and 1.8 kV/m at the edge of the ROW referenced by the EFSB in the evaluation of EMF from proposed transmission facilities.

5.3.10.1.2 Magnetic and Electric Field Levels Along the Noticed-Alternative Southern Route

The proposed project along the Noticed-Alternative Southern Route in Massachusetts also involves the construction of a new 345-kV transmission line between the CT/MA border to the Agawam Substation, but this alternative route shifts the Agawam to Ludlow 345-kV line south to CT and about 5.4 miles further east reenters MA and then traverses east and then north in MA to connect to the Ludlow Substation, all on existing ROWs. The new line would parallel or join existing transmission lines on this ROW and be supported on H-frame or monopole vertical structures as illustrated on cross section layouts XS-S01 to XS-S04, and cross section layouts XS-S06, XS-S08, and XS-S09 in Exhibit 5.1. The proposed Project changes and EMF levels associated with cross sections XS-S05 and XS-S07, which describe the short portion of this route in Connecticut, are not addressed here.

In addition, existing 115-kV transmission lines are proposed to be re-configured between Orchard Junction and Ludlow Substation (XS-S10), Shawinigan Substation to Orchard Junction (XS-S11), Exit 6 Junction to Shawinigan Substation (XS-S12), Existing Structure 49091 to Exit 6 Junction (XS-S13), East Springfield Junction to Existing Structure 49091 (XS-S14), Chicopee Substation to East Springfield Junction (XS-S15), Piper Substation to Chicopee Substation (XS-S16) and Agawam Substation to Piper Substation (XS-S17). The existing 115-kV transmission line between Agawam Substation and South Agawam Switching Station (XS-S01 to XS-S03) is also proposed to be reconfigured to the same monopole vertical structures that also support the new 345-kV transmission line.

The EMF levels on the Noticed-Alternative Southern Route are highest on the ROW and decrease with distance away from the transmission lines resulting in lower EMF levels at the edge of the ROW and beyond.

Generally, the existing magnetic field levels at AAL will increase along both the eastern and western edges of the ROW by about 3 to 63 mG after construction of the new 345-kV line, with the exception of XS-S06, where the large phase spacing required for the long river crossing results in an 100 mG increase at a distance of 55 feet to the south of the centerline of the new 345-kV line and XS-S09, where the magnetic field would decrease slightly along the western edge of ROW after construction.[16].

The reconfiguration of the existing 115-kV transmission lines on the remaining 8 cross sections will reduce magnetic field levels at most ROW edges (up to 57 mG) and increase magnetic field levels by < 2 mG along 5 of 20 cross-section ROW edges.

The magnetic field levels computed at APL are not much greater (< 13 mG) and in some cases lower than those calculated for AAL at the ROW edges.

The computed electric field levels will not change very much between existing and post-construction conditions. The electric field levels at the edges of the cross sections under existing conditions range from 0.00 to 0.66 kV/m. Where electric field levels increase after construction, the increase will be < 1.67 kV/m.

The calculated magnetic field levels at the edges of the proposed ROW at AAL of each cross section of the Noticed-Alternative Southern Route (inclusive of the upgraded 115-kV lines on the Preferred Northern Route) are summarized in Table 5-4 in Exhibit 5.4. Graphical profiles of the calculated magnetic field levels at AAL for the cross sections are also compared in Exhibit 5.4. The calculated magnetic field levels at the APL, which might occur for a limited number of hours during the year, are summarized in Table 5-5 in Exhibit 5.4 and the graphical profiles of the calculated magnetic field levels at APL are provided in Exhibit 5.5. The calculated electric field levels at the ROW edges, which do not vary appreciably with load, are presented in Table 5-6, in Exhibit 5.4.

[16] The Noticed-Alternative Southern Route includes a 5.4-mile segment in CT that runs on an existing ROW between the CT Border (Suffield) and MA Border (Enfield). The field levels along this segment post-construction are similar to those along this alternative route of the new 345-kV line in MA.

The magnetic and electric field levels associated with the transmission lines before and after construction of the project fall below the reference values of 85 mG and 1.8 kV/m cited by the EFSB in the evaluation of EMF from proposed transmission facilities.

5.3.10.2 EMF Levels and Field Reduction

5.3.10.2.1 Comparison of EMF Levels

As for any electrical device or power line, electric and magnetic fields will be associated with the operation of the new and reconfigured transmission lines whether constructed on the preferred or the alternative route. The addition of new equipment to existing substations or other connection nodes is unlikely to have a major effect on existing ranges of electric or magnetic field levels except where new lines enter or leave the site.

The project will increase field levels at the edges of some cross sections of the routes and decrease levels at others. On both routes conductor configurations and the electric phasing of adjacent lines was selected to minimize magnetic fields. Along both routes where only changes are proposed to 115-kV lines, the post-construction magnetic fields are almost always lower. Overall, the fields from the proposed project will fall below the values of 85 mG and 1.8 kV/m referenced by the EFSB in the evaluation of EMF from proposed transmission facilities.

While there are no major differences between the Preferred Northern Route and the Noticed-Alternative Southern Route with regard to post-construction field levels, there are 35 percent more residences within 100 feet of the ROW and 48 percent more residences between 101 and 300 feet of the ROW along the Noticed-Alternative Southern Route (Table 4-4), as well as more public facilities and businesses within 300 feet of the ROW.

Health scientists at Exponent have reviewed the conclusions of national and international scientific and health organizations that have evaluated more than 30 years of research that includes thousands of studies. None of these organizations that conducted reviews of scientific and medical research has concluded that exposure to EMF is a demonstrated cause of any long-term adverse health effect. The WHO published one of the most comprehensive of these reviews in June 2007.[17]

The WHO Report concluded:

[17] World Health Organization (WHO). Environmental Health Criteria 238: Extremely Low Frequency (ELF) Fields. WHO, Geneva, Switzerland, ISBN 978-92-4-157238-5, 2007.

> New human, animal, and in vitro studies published since the 2002 IARC Monograph, 2002 do not change the overall classification of ELF as a possible human carcinogen (p. 347).
>
> Acute biological effects [i.e., short-term, transient health effects such as a small shock] have been established for exposure to ELF electric and magnetic fields in the frequency range up to 100 kHz that may have adverse consequences on health. Therefore, exposure limits are needed. International guidelines exist that have addressed this issue. Compliance with these guidelines provides adequate protection. Consistent epidemiological evidence suggests that chronic low-intensity ELF magnetic field exposure is associated with an increased risk of childhood leukaemia. However, the evidence for a causal relationship is limited, therefore exposure limits based upon epidemiological evidence are not recommended, but some precautionary measures are warranted (WHO, 2007, p. 355).

Exponent reviewed studies published after the WHO report and these studies do not alter the weight of the evidence reviewed by the WHO and other national and international health and scientific agencies that electric or magnetic fields are not a cause of cancer or any other disease process at the levels we encounter in our everyday environment. Exponent's summary of the WHO conclusions and major subsequent peer-reviewed studies is included in Exhibit 5.3 to this Section 5.

The WHO has recommended that exposures be limited by guidelines, such as those published by ICNIRP[18] and ICES,[19] and that low or no cost measures be taken to minimize exposures to EMF. As the proposed project will give rise to levels of EMF that are far below these guidelines and has incorporated designs to minimize the fields produced by adjacent transmission lines, it will meet these recommendations.

5.3.11 Tree Clearing

The existing environment and impacts and mitigation measures for the Preferred Northern Route and the Noticed-Alternative Southern Route are in the following subsections.

5.3.11.1 Existing Environment

The existing tree clearing for the Preferred Northern Route and the Noticed-Alternative Southern Route are summarized below.

[18] International Commission on Non-Ionizing Radiation Protection (ICNIRP). Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz). Health Phys. 74:494-522, 1998.

[19] International Committee on Electromagnetic Safety (ICES). IEEE Standard for Safety Levels with Respect to Human Exposure to Electromagnetic Fields 0 to 3 kHz C95. 6-2002. Piscataway, NJ: IEEE, 2002.