Appendix H
Electric and Magnetic Field Calculations

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Appendix H1:
EMF Report

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Electric and Magnetic Field Calculations

Jamestown to Ellendale 345-kV Transmission line

July 22, 2025

Electric and Magnetic Field Calculations

Introduction

The Applicants, through the assistance of their consultant, POWER Engineers, Inc., have performed a study to determine the magnitude of the electric and magnetic fields for the Jamestown to Ellendale 345 kV transmission line (Project). This study was performed using the Corona and Field Effects Program (CAFEP) developed by Bonneville Power Administration (BPA) and assumed a double circuit 345 kV monopole transmission line structure with either one or both circuits in service. Electric and magnetic field calculations were performed for two different operating conditions: (1) normal operating conditions; and (2) maximum operating conditions.

As demonstrated below, all calculated values from this study indicate that the electric and magnetic field strength from the Project will be well below the safe exposure levels specified by the IEEE Standard and ICNIRP guidelines. Thus, no adverse impacts are anticipated.

Assumptions

Electric fields are measured in kilovolts per meter (kV/m) and are proportional to the voltage of a transmission line. This study identified the magnitude of the electric field from the Project at varying distances from the centerline of the corridor assuming a maximum operating condition of 110% of the normal operating voltage, or 379.5 kV. Magnetic fields are measured in milligauss (mG) and are proportional to the current flow through a transmission line. This study identified the magnitude of the magnetic field from the Project at varying distances from the centerline of the corridor, assuming a normal operating condition of 900 Amps and a maximum operating condition of 3000 Amps per circuit.

Results

Based on the assumptions above, the magnitude of the electric field at varying distances from the centerline of the corridor is shown below in Figure 1 while the maximum electric field within the corridor and at the edge of the corridor is shown in Table 1. In accordance with the guidance provided in Institute of Electrical and Electronics Engineers (IEEE) standard 644-2019, the electric field strength was calculated assuming a minimum conductor clearance (near mid-span) measured at a point approximately 1 meter (3.28 feet) above ground.

Figure 1: Magnitude of the Electric Field at Varying Distances from Centerline of the Corridor

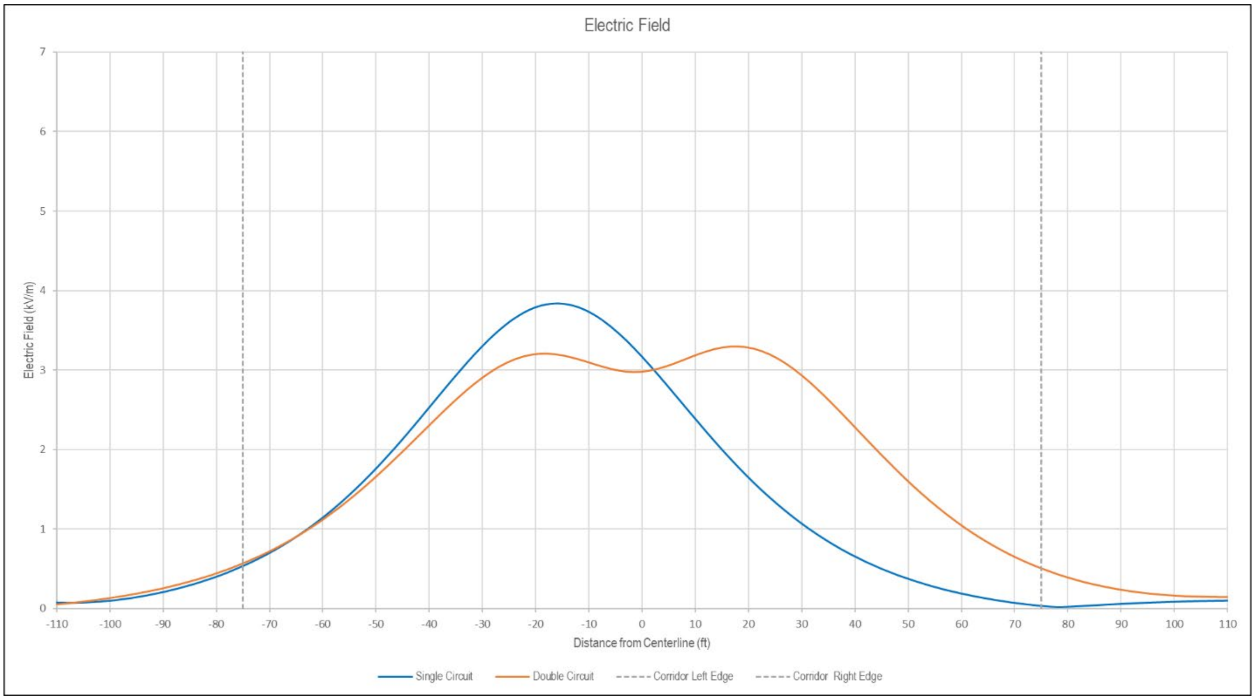

Table 1: Maximum Magnitude of Electric Field Within and at Edge of Corridor

Configuration	Maximum within Corridor	Maximum at Edge of Corridor
Single Circuit	3.83 kV/m	0.54 kV/m
Double Circuit	3.30 kV/m	0.57 kV/m

Likewise, the magnitude of the magnetic field at varying distances from the centerline of the corridor is shown below in Figure 2 while the maximum magnetic field within the corridor and at the edge of the corridor is shown in Table 2. Similar to the electric field calculations, the magnetic field strength was also calculated assuming a minimum conductor clearance (near mid-span) measured at a point approximately 1 meter (3.28 feet) above the ground per IEEE Standard 644-2019.

Figure 2: Magnitude of Magnetic Field at Varying Distances from Centerline of the Corridor

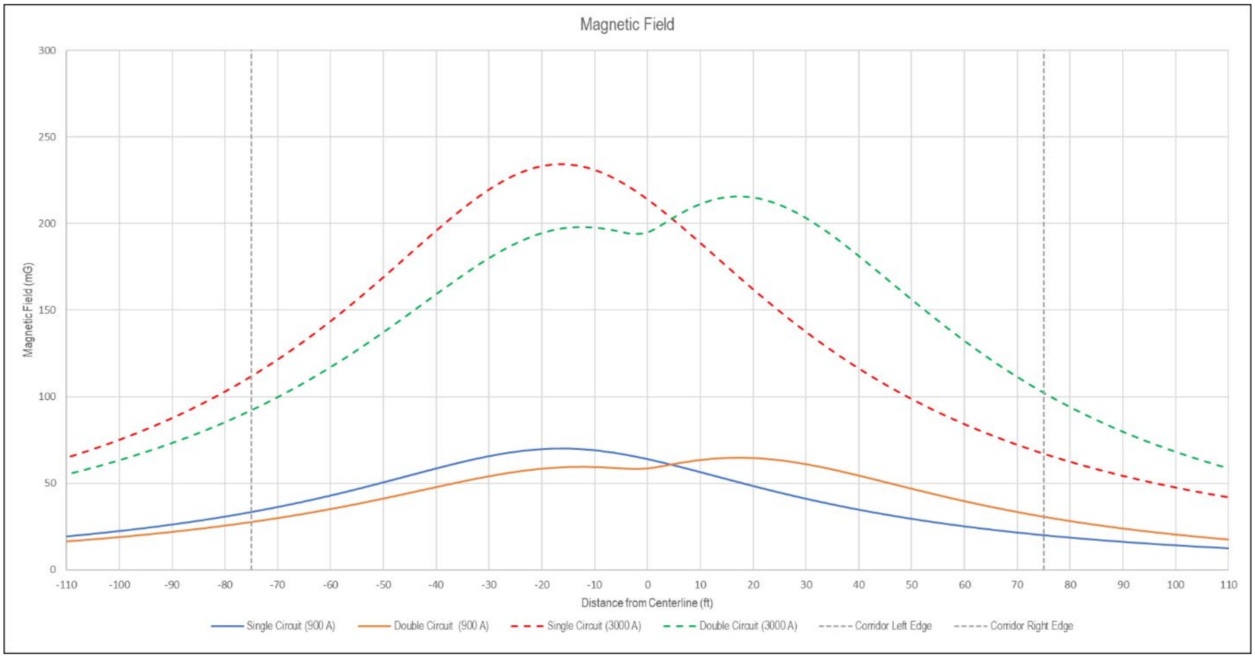

Table 2: Maximum Magnitude of Magnetic Field Within and at Edge of Corridor

Configuration	Line Load	Maximum within Corridor	Maximum at Edge of Corridor
Single Circuit	900 A	70.2 mG	33.5 mG
	3,000 A	234 mG	111 mG
Double Circuit	900 A	64.7 mG	30.7 mG
	3,000 A	216 mG	102 mG

Electric and Magnetic Field Criteria

There is no federal standard for criteria related to electric and magnetic fields. Therefore, industry standards were consulted to determine criteria for nationally recognized levels.

IEEE standard C95.1-2019[1] establishes limits for safe exposure levels to electric and magnetic fields based on a comprehensive review of scientific literature. Within this standard, exposure reference levels to protect against potential health effects from electric fields and magnetic fields are defined in Table 3 for unrestricted environments, such as living quarters, public areas, and workplaces.

[1]Synopsis of IEEE Std C95.1™-2019 “IEEE Standard for Safety Levels With Respect to Human Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz” | IEEE Journals & Magazine | IEEE Xplore. Accessed July 22, 2025. https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8910342.

Table 3: Unrestricted Environment Exposure Reference Levels from IEEE Standard C95.1-2019

Type	Unrestricted Environment Exposure Reference Level
Electric Fields (kV/m)	5 kV/m
Magnetic Fields (mG)	9,040 mG

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) published guidelines on recommended limits for electric and magnetic fields based on a collaboration of international scientists. These guidelines are more stringent than IEEE and include values for both occupational and general public exposure. A 2010 release of the ICNIRP guideline[2] establishes the following criteria, shown in Table 4, as the maximum acceptable exposure reference level for the general public.

Table 4: Reference Levels for General Public Exposure from ICNIRP Guideline

Type	Reference Level for General Public Exposure
Electric Fields (kV/m)	4.16 kV/m
Magnetic Fields (mG)	2,000 mG

Summary

Table 5 is a summary of the maximum electric and magnetic field strength at varying distances from the centerline of the Corridor compared to the limits defined in IEEE Standard C95.1-2019 and the ICNIRP guideline.

Table 5: Summary of Maximum Electric and Magnetic Field Strength from Project Compared to IEEE Standard and ICNIRP Guideline

<table>
<tr><th>Type</th><th>Number of Circuits In-Service</th><th>Maximum within Corridor</th><th>Magnitude at Edge of Corridor</th><th>IEEE Standard</th><th>ICNIRP Guideline</th></tr>
<tr><td rowspan="2">Electric Field (kV/m)</td><td>Single Circuit (379.5 kV)</td><td>3.83 kV/m</td><td>0.54 kV/m</td><td rowspan="2">5 kV/m</td><td rowspan="2">4.16 kV/m</td></tr>
<tr><td>Double Circuit (379.5 kV)</td><td>3.30 kV/m</td><td>0.57 kV/m</td></tr>
<tr><td rowspan="4">Magnetic Field (mG)</td><td>Single Circuit (900 Amps)</td><td>70.2 mG</td><td>33.5 mG</td><td rowspan="4">9,040 mG</td><td rowspan="4">2,000 mG</td></tr>
<tr><td>Double Circuit (900 Amps)</td><td>64.7 mG</td><td>30.7 mG</td></tr>
<tr><td>Single Circuit (3000 Amps)</td><td>234 mG</td><td>111 mG</td></tr>
<tr><td>Double Circuit (3000 Amps)</td><td>216 mG</td><td>102 mG</td></tr>
</table>

[2] 2010 ICNIRP Guidelines for Limiting Exposure to Time-Varying Electric and Magnetic Fields. Accessed July 22, 2025. https:/www.icnirp.org/cms/upload/publications/ICNIRPLFgdl.pdf

Through interactions with landowners and stakeholders, the Applicants have developed and distributed a document attached as Appendix H2 that discusses electric and magnetic fields and compares typical magnetic field exposure from a 345-kV high voltage transmission line to common household appliances used in everyday life. The graphs at the end of Appendix H2 illustrate that the exposure to magnetic fields from common household appliances is much higher than the exposure from a 345-kV high voltage transmission line at the edge of the corridor.

Conclusions

As shown above, all calculated values from this study indicate that the electric and magnetic field strength from the Project will be well below the safe exposure levels specified by the IEEE Standard and ICNIRP guidelines. Thus, no adverse impacts are anticipated.

Appendix H2:
EMF Handout

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ELECTRIC AND MAGNETIC FIELDS (EMF)

WHAT ARE EMFs?

EMFs consist of two different types of fields: Electric fields, which are produced by electric voltage, and magnetic fields, which are produced by electric current. EMFs are created by anything that conducts electricity, including transmission lines, household appliances and computers. The EMF values for transmission lines and the electric items we use daily are called extremely low-frequency (ELF) fields. ELFs are different from the frequency fields associated with radio waves, TV waves and cell phone signals, which have a much higher frequency.

WHERE ARE EMFs FOUND?

EMFs surround any electrical appliance or wire that can conduct electricity. These fields are at your home when you turn on a lamp, use a computer, or heat up food in a microwave. We also encounter a wide variety of EMFs in other ways – the earth's atmosphere, thunderstorms, and earth's core all produce electric or magnetic fields.

EMFs are strongest closest to their source, so the farther away you are from the source, the less EMFs reach your body. Below is a list of some common appliances and machines and the magnetic field levels found nearby.

	Magnetic field 6 inches from appliance (mG)	Magnetic field 2 feet away (mG)
Electric shaver	100	-
Vacuum cleaner	300	10
Dishwasher	20	4
Microwave oven	200	10
Hair dryer	300	-
Computers	14	2
Fluorescent lights	40	2
Copy machines	90	7
Garbage disposals	80	2

Source: *National Institute of Environmental Health Services / National Institutes of Health: EMF Associated with the Use of Electric Power*

WHAT ARE ELECTRIC AND MAGNETIC FIELDS?

Electric fields, measured in kilovolts per meter (kV/m), are created by voltage – the higher the voltage, the stronger the field. Anytime an electrical appliance is plugged in, even if it isn't on, an electric field is created around it. But these fields are easily blocked by walls, trees, and even your clothes and skin. Electric fields become weaker as you move away from the source.

Magnetic fields, measured in milliGauss (mG), are produced by electric current and only exist when an electric appliance is turned on – the higher the current, the greater the magnetic field. The strength of a magnetic field dissipates rapidly as you move away from its source. Unlike electric fields that are easily blocked by ordinary materials, magnetic fields do not interact with and are not affected by walls and clothes and other barriers.

WHAT EMF LEVELS ARE FOUND NEAR TRANSMISSION LINES?

Because EMF levels drop as you move away from the source, exposure to EMFs from transmission lines are reduced significantly by the distance from the lines. Magnetic fields from transmission lines at the edge of the right of way during normal operating conditions are typically lower than common household items.

WHAT ARE 'TYPICAL' RESIDENTIAL EXPOSURES TO MAGNETIC FIELDS?

Exposure levels may vary from individual to individual and from home to home, but a study by the Electric Power Research Institute (EPRI) puts the background levels of power line magnetic fields in the typical U.S. home at between 0.5 mG and 4 mG with an average of 0.9 mG. Levels rise the closer you are to the source of the field. Most people are exposed to greater magnetic fields at work rather than in their homes.

ARE EMFS HARMFUL TO HEALTH?

This issue has been studied for more than 30 years by government and scientific institutions all over the world. Several scientific organizations, including the American Medical Association, American Cancer Society, American Physical Society and National Academy of Sciences, have stated that the body of evidence in regard to ELF-EMF, particularly magnetic fields, indicates that exposure to these fields does not present a human health hazard. EMF exposure from transmission lines, which are high in the air and inside the negotiated easement, is minimal. An article titled Adult Cancers Near High-voltage Overhead Power Lines provided the following conclusion from a 2012 study, "our results do not support an epidemiologic association of adult cancers with residential magnetic fields in proximity to high-voltage overhead power lines."

ARE THERE STATE OR FEDERAL STANDARDS FOR EMF EXPOSURE?

Health standard authorities have not established national limits on EMF exposure due to inconsistent study results. The EMF levels produced by appliances vary from manufacturer to manufacturer and model to model. The designs of many newer model appliances, in general, often produce lower fields than older models. There is no federal certification program on EMF levels so beware of advertisements on appliances making claims of federal government certification of low or zero EMF levels.

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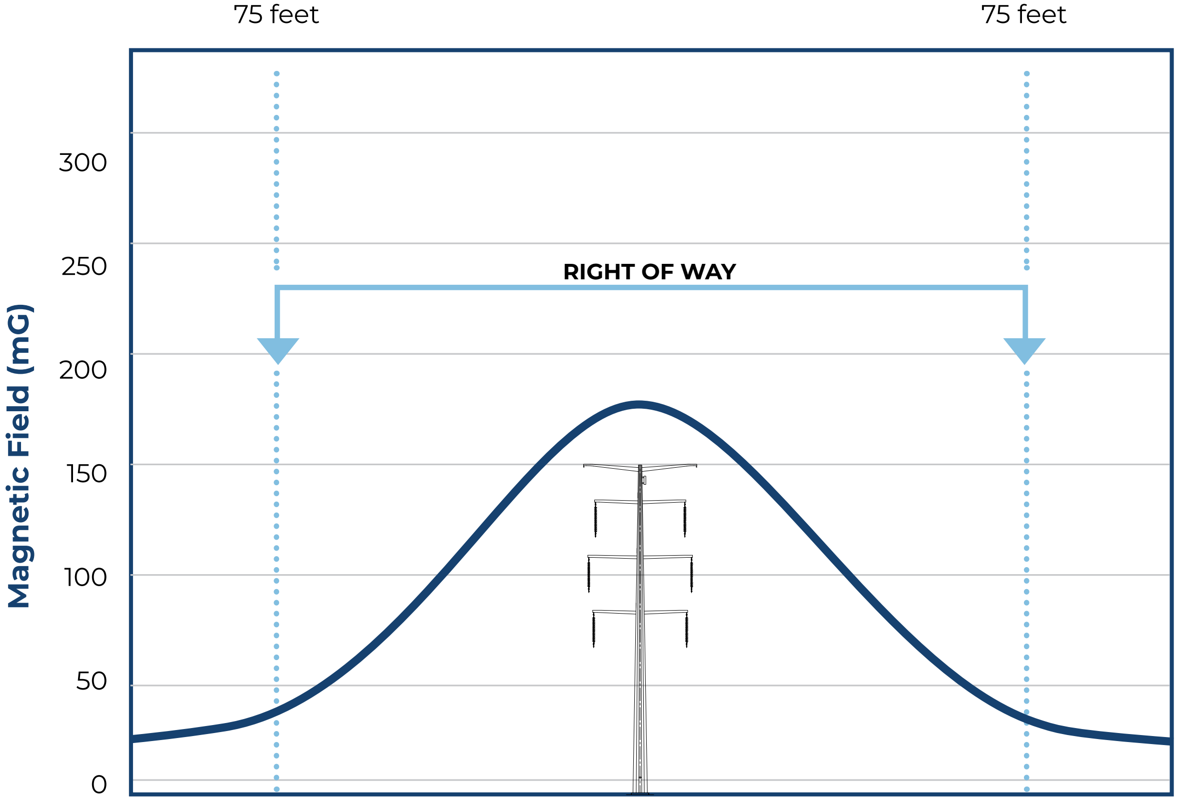
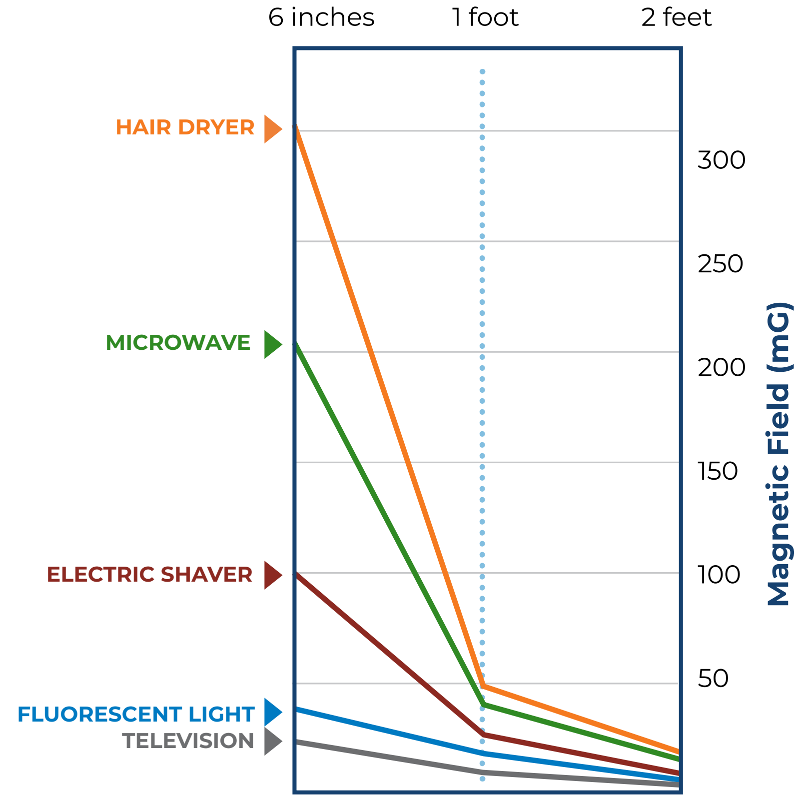
Use your phone's camera to scan the QR code to visit the project website.

ELECTRIC AND MAGNETIC FIELDS

Magnetic fields, measured in milliGauss (mG), are produced by electric current flowing through a wire or conductor – the higher the current, the greater the magnetic field. The strength of a magnetic field dissipates rapidly as you move away from its source.



The figure above illustrates the change in magnetic field relative to the pole structure location. The magnetic field values are comparable to similar 345-kV lines but do not necessarily reflect specific values for JETx.



Source: National Institute of Environmental Health Services/ National Institutes of Health: EMF Associated with the use of Electric Power.

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