Appendix E
Electric and Magnetic Field (EMF) Report

Electric- and Magnetic-Field Assessment

Derby Junction to Ansonia 115-kV Transmission Line Rebuild Project

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April 22, 2022

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Acronyms and Abbreviations

CSC	Connecticut Siting Council
BMP	Best Management Practices
BPA	Bonneville Power Administration
CELT	Capacity, Energy, Loads, and Transmission
EMF	Electric and magnetic fields
Exponent, Inc.	Exponent
G	Gauss
Hz	Hertz
ICES	International Committee on Electromagnetic Safety
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IEEE	Institute of Electrical and Electronics Engineers
ISO-NE	Independent System Operator or New England
kV	Kilovolt
kV/m	Kilovolt per meter
mG	Milligauss
NESC	National Electrical Safety Code
Project	Derby Junction to Ansonia 115-kV Transmission Line Rebuild Project
ROW	Right-of-way
SCENIHR	Scientific Committee on Emerging and Newly Identified Health Risks
UI	The United Illuminating Company
WHO	World Health Organization

Notice

At the request of The United Illuminating Company (UI), Exponent, Inc., (Exponent) modeled the electric and magnetic fields associated with the rebuild of existing 115-kilovolt transmission circuits between Derby Junction in Shelton and Ansonia Substation in Ansonia (the Derby Junction to Ansonia 115-kV Transmission Line Rebuild Project [Project]). This report summarizes work performed to date and presents the findings resulting from that work. In the analysis, we have relied on geometry, material data, usage conditions, specifications, and various other types of information provided by UI. We cannot verify the correctness of this input data and rely on the client for the data's accuracy. UI has confirmed to Exponent that the summary of data provided to Exponent contained herein is not subject to Critical Energy Infrastructure Information restrictions. Although Exponent has exercised usual and customary care in the conduct of this analysis, the responsibility for the design and operation of the Project remains fully with the client.

The findings presented herein are made to a reasonable degree of engineering and scientific certainty. Exponent reserves the right to supplement this report and to expand or modify opinions based on review of additional material as it becomes available, through any additional work, or review of additional work performed by others.

The scope of services performed during this investigation may not adequately address the needs of other users of this report, and any re-use of this report or its findings, conclusions, or recommendations presented herein other than for permitting of this Project are at the sole risk of the user. The opinions and comments formulated during this assessment are based on observations and information available at the time of the investigation. No guarantee or warranty as to future life or performance of any reviewed condition is expressed or implied.

Executive Summary

To maintain the reliability of the bulk transmission grid in the region, The United Illuminating Company (UI) proposes to rebuild three existing 115-kilovolt (kV) transmission circuits (all constructed on double-circuit configurations) located within an existing approximately 4.1-mile UI right-of-way (ROW), extending from Derby Junction in the City of Shelton (Fairfield County), across the Housatonic River to Indian Well Substation in the City of Derby (New Haven County), and through portions of the City of Derby to Ansonia Substation in the City of Ansonia (New Haven County). This rebuild work is referred to as the Derby Junction to Ansonia 115-kV Transmission Line Rebuild Project (Project).

At the request of UI, Exponent, Inc. (Exponent) *measured* the 60-Hertz electric- and magnetic-field (EMF) levels associated with the existing 115-kV lines on the ROW between Derby Junction and UI's Ansonia Substation. Exponent also *calculated* EMF levels associated with operation of both the existing (primarily double-circuit lattice structures) and rebuilt 115-kV transmission lines (primarily double-circuit monopoles, with some single-circuit monopoles, on the ROW).

Because of the unique construction constraints associated with this Project, the new monopoles will be offset from the existing structures at various locations along the ROW.[1] Between Derby Junction and Indian Well Substation, this offset is approximately 10 feet or less with a somewhat larger offset near the Housatonic River crossing. Between Indian Well and Ansonia substations, the offset between existing and proposed structures is typically about 15 feet or less, but extends to approximately about 40 feet in a few limited locations. UI proposes to acquire additional permanent easements (as necessary) to ensure the new transmission line conductors maintain necessary horizontal clearances to adjacent property as mandated by the National Electrical Safety Code, as well as UI's standard design criteria.[2]

The EMF from the proposed transmission lines are calculated to be similar to or lower than existing levels. However, the realignment of the rebuilt monopoles in relation to the existing structures will cause a corresponding shift in the location of maximum EMF levels compared to existing levels, resulting in an increase in the EMF levels on one side of the existing structure centerline and a corresponding similar decrease in EMF levels on the other side. Overall, EMF levels as a result of the Project are calculated either

1 Maintaining the existing structure centerline for the new structures would require an extended electrical outage during construction. Therefore the new structures must be offset from existing structures to maintain electrical service for customers throughout the construction of the Project.

2 Both before and after the proposed Project, there are adjacent buildings (including some residential buildings) that are or will be inside the existing or proposed ROW edge.

not to change significantly (between Indian Well and Ansonia substations) or to decrease compared to existing levels (between Derby Junction and Indian Well Substation).

At average loading, magnetic-field levels at the existing ROW edge will increase or decrease by similar amounts (maximum increase or decrease of about 15 to 16 milligauss [mG]) as a result of this realignment. Electric-field levels at the existing ROW edge will increase (1.3 kilovolts per meter [kV/m]) or decrease (0.5 kV/m) by small amounts. EMF levels at the edge of the *proposed* ROW generally decrease compared to those at the edge of the *existing* ROW after construction of the Project due to generally greater ROW-widths after the Project. While there are some small increases (2.7 mG and 0.4 kV/m or less) in short portions of the route, there are much larger decreases (up to 23 mG and 1.2 kV/m) in other portions. Overall, the average proposed ROW-edge EMF decreases by 7.8 mG and 0.2 kV/m compared to the average EMF level at the existing ROW edge.

Regardless of the alignment of the rebuilt monopoles in relation to the existing structures, EMF levels decrease rapidly with distance for both the existing and proposed (rebuilt) configurations. After the Project in all portions of the route, the magnetic-field at approximately 100 feet from the edge of the proposed ROW will either decrease compared to existing levels (between Derby Junction and Indian Well Substation) or will be less than 1 mG (between Indian Well and Ansonia substations). At this distance, all existing and proposed electric-field levels will be 0.1 kV/m or less.

The measured and calculated EMF levels associated with the Project are far below international safety and health-based standards for EMF. The engineering design and other activities initiated by UI demonstrate compliance with the Connecticut Siting Council's Best Management Practices regarding EMF.

Note that this Executive Summary does not contain all of Exponent's technical evaluations, analyses, conclusions, and recommendations. Hence, the main body of this report is always the controlling document.

Introduction

Project Background

To improve the reliability of the transmission grid in conformance with the National Electrical Safety Code (NESC), The United Illuminating Company (UI) proposes to rebuild three existing 115-kilovolt (kV) overhead transmission circuits located within an existing approximately 4.1-mile UI right-of-way (ROW), extending from Derby Junction in the City of Shelton (Fairfield County), across the Housatonic River to Indian Well Substation in the City of Derby (New Haven County), to Ansonia Substation in the City of Ansonia (New Haven County). The existing 115-kV transmission circuits are arranged in a double-circuit configuration, supported on 40 structures, including 29 lattice steel towers that were installed almost 100 years ago. This Derby Junction to Ansonia 115-kV Transmission Line Rebuild Project (Project) will involve:

- Rebuilding the 115-kV lines by installing new monopoles, conductors, insulators, and related hardware;
- Connecting the rebuilt lines to Derby Junction, Indian Well Substation, and Ansonia Substation; and
- Removing the existing transmission line structures (mostly consisting of lattice steel towers), conductors, and related hardware;

The existing 115-kV lines between Derby Junction, Indian Well Substation, and Ansonia Substation are arranged in a double-circuit configuration and include:

- The 1560-3 Line, which extends for approximately 4.1 miles from Derby Junction to Ansonia Substation;
- The 1808-2 Line, which is co-located with the 1560-3 Line for approximately 1.5 miles from Derby Junction to Indian Well Substation; and
- The 1594 Line, which is co-located with the 1560-3 Line for approximately 2.6 miles from the Indian Well Substation to Ansonia Substation.

At the request of UI, Exponent, Inc. (Exponent) measured the 60-Hertz (Hz) electric- and magnetic-field (EMF) levels associated with the existing 115-kV lines. Exponent also calculated the EMF levels associated with the operation of both the existing and rebuilt 115-kV lines (using both 2-dimensional and 3-dimensional models, where appropriate assuming peak and peak daily average loading in 2022 and projected peak and peak daily average loading within 5 years after the line is placed in service (i.e., in 2029).

This report provides a summary of the modeling configurations, technical background, assessment criteria, calculation methods, and results. Attachment A provides a summary of the electrical loading. Attachments B and C provide tabular and graphical summaries of calculated results, respectively. Attachment D provides measurements of pre-construction EMF levels. A calibration certificate for the meter used to measure EMF levels is provided in Attachment E.

Project Configurations

In the current design, the new monopole structures will be offset from the existing lattice structures at various locations along the ROW. Between Derby Junction and Indian Well Substation, this offset is approximately 10 feet or less with a somewhat larger offset near the Housatonic River crossing. Between Indian Well and Ansonia substations, the offset between existing and proposed structures is typically about 15 feet or less, but extends to approximately about 40 feet in a few limited locations. UI proposes to acquire additional permanent easements (as necessary) to ensure the new transmission line conductors maintain necessary horizontal clearances to adjacent property as mandated by the National Electrical Safety Code, as well as UI's standard design criteria.[3]

Figure 1 is a map of the Project route and Figure 2 shows the dominant configurations of the existing and proposed transmission line structures. Figure 2(a) shows existing structures (for the 1560-3 and 1808-2 Lines) between Derby Junction and Indian Well Substation; and Figure 2(b) shows the existing structures (for the 1560-3 and 1594 Lines) between Indian Well and Ansonia substations. Figure 2(c) shows the proposed rebuilt transmission line configuration for most of the route.[4,5]

[3] Both before and after the proposed Project, there are adjacent buildings (including some residential buildings) that are or will be inside the existing or proposed ROW edge.

[4] Other configurations are used in certain locations where UI proposes to replace the existing double-circuit lattice tower with two single-circuit monopoles (e.g., near Indian Well Substation and near Ansonia Substation).

[5] Exponent understands that there will be no changes to Indian Well and Ansonia substations that will affect EMF levels from these facilities. Therefore EMF from the substations is not discussed further.

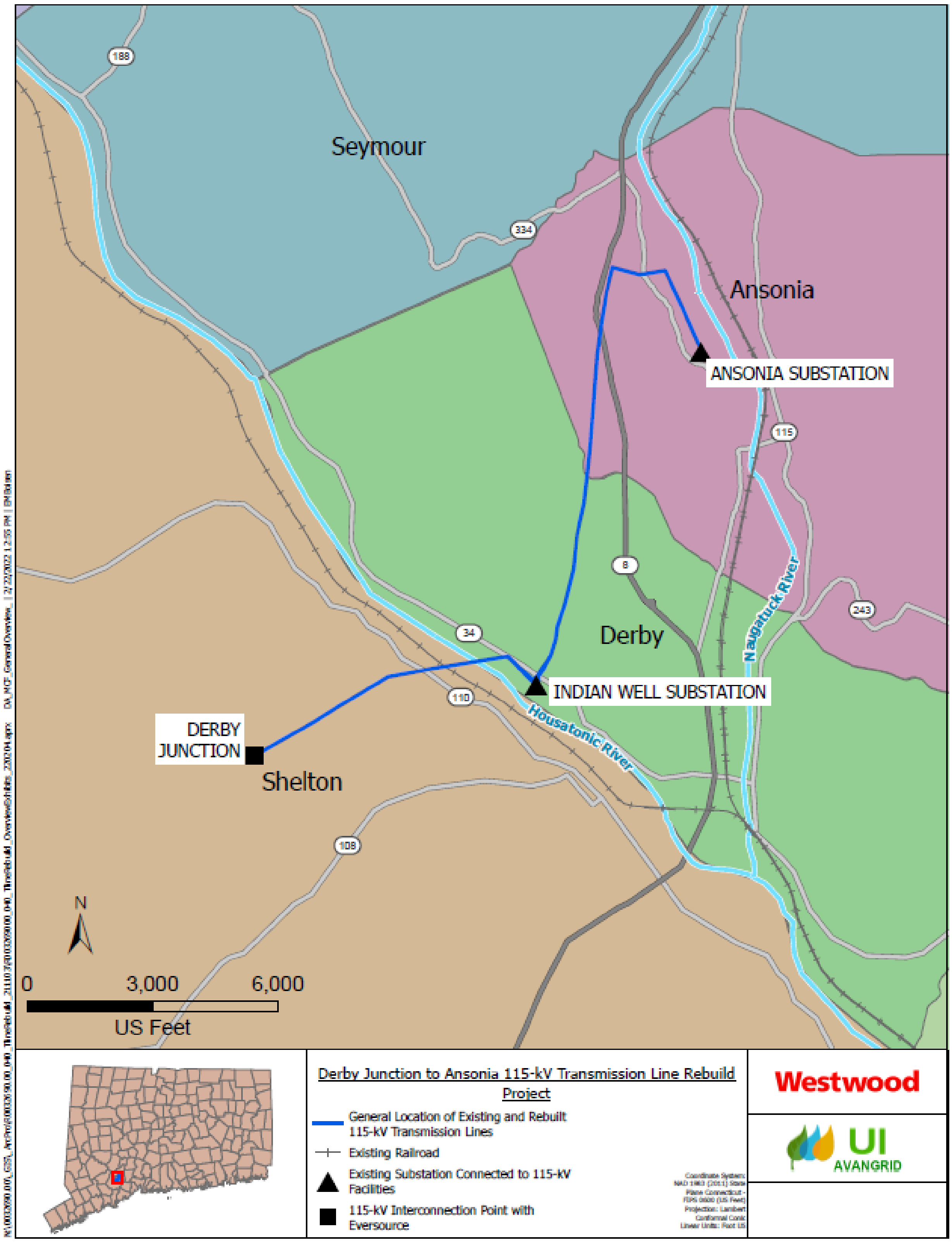

Figure 1. Overview of the Project route.

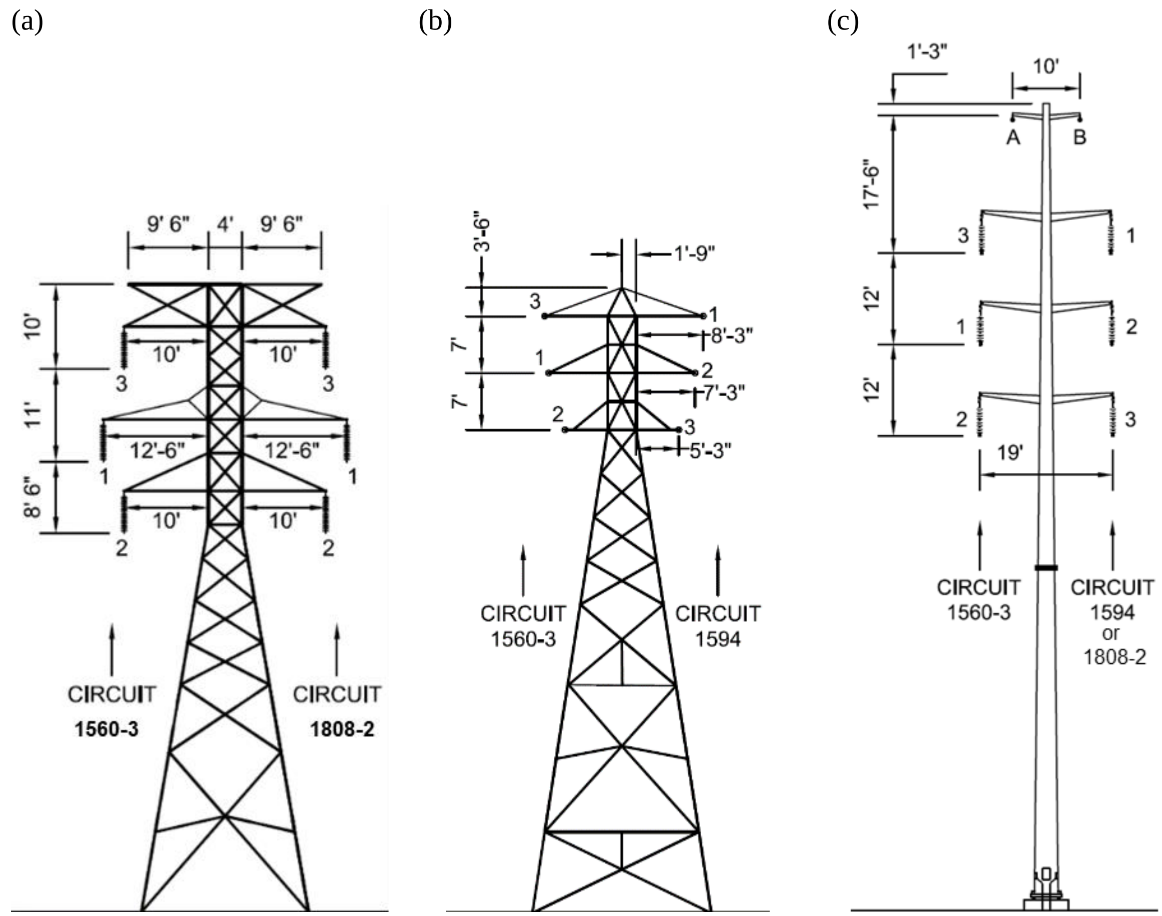

Figure 2. (a) Predominant existing structures between Derby Junction and Indian Well Substation; existing structures between Indian Well Substation and Ansonia Substation; and (c) predominant proposed structures.

Technical Background

Electricity is an integral part of modern infrastructure; therefore, people living in modern communities are surrounded by sources of EMF. Figure 3 depicts typical EMF levels measured in residential and occupational environments and EMF levels measured on or at the edge of distribution line and transmission line ROWs.

Magnetic Fields

The current flowing in the conductors of transmission lines and substation buswork generate magnetic fields near the conductors. The strength of Project-related magnetic fields in this report are expressed as magnetic flux density in units of milligauss (mG), where 1 Gauss (G) = 1,000 mG. These currents (and thus magnetic fields) vary in direction and magnitude with a 60-Hz cycle. The load currents—expressed in units of Amperes—vary with the demand for electricity from customers, so the magnetic fields around the conductors vary proportionately to the load. Therefore, measurements or calculations of the magnetic field present a snapshot at only one moment in time. On a given day, throughout a week, or over the course of months and years, the magnetic-field level can change depending upon the patterns of power demand on the bulk transmission system.

Electric Fields

The voltage on the conductors of transmission lines generates an electric field in the space between the conductors and the ground. Many objects are conductive—including fences, shrubbery, and buildings—and thus shield electric fields. In this report, electric-field levels calculated for the transmission lines are expressed in units of kilovolts per meter (kV/m), where 1 kV/m = 1,000 volts per meter.

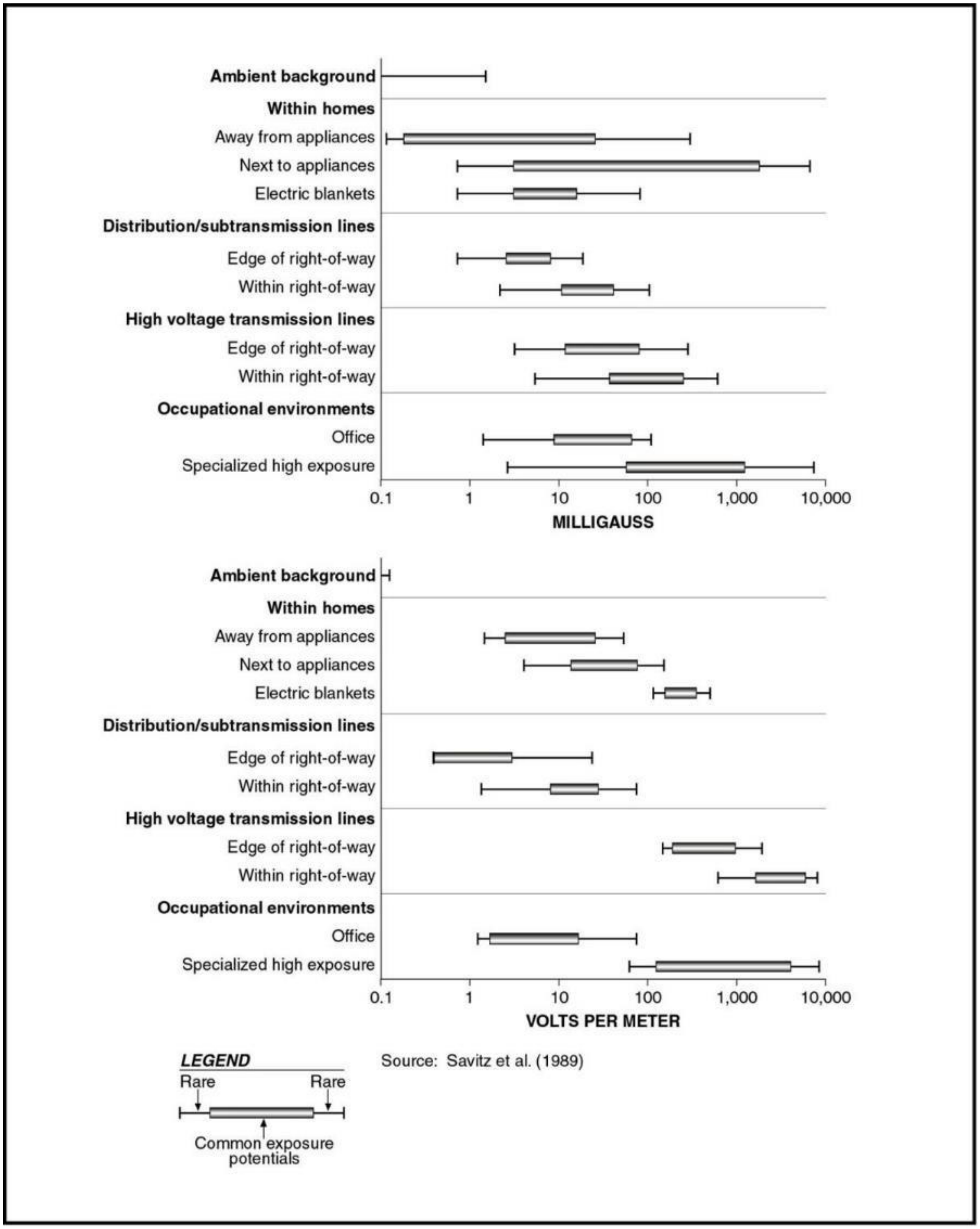

Figure 3. Electric- and magnetic-field levels in the environment.

Assessment Criteria

Neither the Federal government nor the State of Connecticut has enacted standards for magnetic fields or electric fields from power lines or other sources at extremely-low frequencies, although the Connecticut Siting Council (CSC) developed guidelines for the siting of new transmission lines, discussed below.

Relevant health-based EMF assessment criteria include exposure limits recommended by scientific organizations. These exposure limits are included in guidelines developed to protect health and safety and are based on reviews and evaluations of relevant health research. These guidelines include exposure limits for the general public recommended by the International Committee on Electromagnetic Safety (ICES) and the International Commission on Non-Ionizing Radiation Protection (ICNIRP) to address health and safety issues (ICNIRP, 2010; ICES, 2019, 2020).

In a June 2007 Factsheet, the World Health Organization (WHO) included recommendations that policy makers should adopt international exposure limit guidelines, such as those from ICNIRP or ICES (Table 1), for public and occupational exposure to EMF (WHO, 2007).

Table 1. ICNIRP and ICES guidelines for EMF exposure at 60 Hz

	Exposure (60 Hz)	
	Electric Field	Magnetic Field
ICNIRP		
Occupational	8.3 kV/m	10 G (10,000 mG)
General Public	4.2 kV/m	2 G (2,000 mG)
ICES		
Occupational	20 kV/m	27.1 G (27,100 mG)
General Public	5 kV/m*	9.040 G (9,040 mG)

*Within power line ROWs, the guideline is 10 kV/m under normal load conditions.

Connecticut Siting Council Best Management Practices

The CSC adopted "EMF Best Management Practices for the Construction of Electric Transmission Lines in Connecticut" (BMP) based on a consensus of health and scientific agencies that the scientific evidence "*reflects the lack of credible scientific evidence for a causal relationship between MF* [*magnetic field*] *exposure and adverse health effects*" (CSC, 2014, p. 3). Nevertheless, the CSC concluded that precautionary measures for the siting of new transmission lines in the state of Connecticut are appropriate and advocates "*the use of effective no-cost and low-cost technologies and management techniques on a project-specific basis to reduce MF exposure to the public while allowing for the development of efficient and cost-effective electrical transmission projects*" (CSC, 2014, p. 4).

The CSC's EMF BMP guidance (CSC, 2014) expresses the CSC's interest in "*evidence of any new developments in scientific research addressing MF and public health effects or changes in scientific consensus group positions regarding MF*" (CSC, 2014, p. 5). Although the CSC's 2014 BMP guidance serves as the primary reference to new developments in EMF scientific research for this Project, Exponent notes that the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) of the European Union issued an opinion report in 2015 in which the Committee concluded that research published up to 2014 did not confirm any adverse health effects from EMF exposure. The SCENIHR review is the most comprehensive review completed since the WHO review in 2007 (WHO, 2007). The conclusions of the 2015 SCENIHR review are consistent with the conclusions expressed in the WHO report and the CSC's EMF BMP published in 2014.

The Project does not involve the development of new transmission lines, but rather rebuilding the existing 115-kV transmission lines, which will be slightly offset from the current structures, within the existing and expanded UI ROW. The project includes "no cost/low-cost" design recommendations consistent with the CSC's EMF BMPs, such as:

1. **Height of Support Structures**: The taller monopole structures will raise the heights of the conductors of all the rebuilt 115-kV transmission lines compared to both existing structures and will be higher than minimum clearances required by the NESC.

2. **Structure Design and Optimum Phasing**: The proposed transmission line structures, similar to the existing structures, are dual-circuit structures, with conductors arranged vertically, which reduces the average distance between line conductors and ground. The proposed line configuration with two circuits on the same vertical monopoles, combined with the optimum phasing UI selected, will result in mutual-cancellation of EMF from the two transmission lines, resulting in lower overall EMF levels compared to other structure designs or phasing alternatives.[6]

[6] Where constructed on two separate vertical monopoles (e.g., Structure 2-4 and Structure 17-19), UI has proposed maintaining the optimal phasing of the two transmission lines. Additionally, the horizontal conductor-conductor separation is similar to that of the double-circuit monopoles resulting in similar EMF levels for the structures with two monopoles compared those with double-circuit monopoles.

Methods

EMF Measurements

Magnetic-field measurements of the existing UI transmission lines along the Project route were performed on February 24, March 2, and March 25, 2022. The purpose of these measurements was to characterize magnetic-field levels along the existing ROW and adjacent areas. The measurements were taken at a height of approximately 3.28 feet (1 meter) above ground in general accordance with the standard methods for measuring near power lines (e.g., IEEE, 2019). Field levels were expressed as the total field computed as the resultant of field vectors measured along vertical, transverse, and longitudinal axes.[7] The fields were measured with meters calibrated using methods like those described in Institute of Electrical and Electronics Engineers (IEEE) Standard 644-2019.

In addition to magnetic-field measurements along the existing ROW, Exponent also collected EMF measurements in nearby residential areas. Results of these measurements are summarized in the Results section below, with additional details provided in Attachment D.

EMF Modeling

Exponent calculated EMF levels at a height of 3.28 feet (1 meter) above ground, reported as the root mean square value of the field in accordance with IEEE Standards C95.3-2021 and 644-2019 (IEEE, 2019, 2021). Calculations were performed using both 2-dimensional and 3-dimensional models (where appropriate) assuming peak and peak daily average loading in 2022 and projected peak and peak daily average loading within 5 years after the line is placed in service (i.e., in 2029).

2-Dimensional Modeling

For the majority of the Project route, Exponent used computer algorithms developed by the Bonneville Power Administration (BPA), a division of the U.S. Department of Energy, to calculate EMF for the Project transmission lines. UI provided the data regarding voltage, current flow, phasing, and conductor configuration. These parameters have been confirmed to accurately predict EMF levels measured near operating transmission lines when used as inputs to the BPA algorithms (e.g., Chartier and Dickson, 1990; Perrin et al., 1991). The models assume that each conductor is infinite in length, above an infinite flat earth, with no conductive objects nearby, and that the conductors are all parallel to each other at a

[7] Measurements along the vertical, transverse, and longitudinal axes were recorded as root-mean-square magnitudes. Root mean square refers to the common mathematical method of defining the effective voltage, current, or field of an alternating current system.

fixed height above ground. Locations where this modeling method was used are identified in Figure 4 in green.

In some places along the route, including Coon Hollow Road, there are significant terrain changes adjacent to the transmission lines, with some buildings at elevations comparable to or above the transmission line conductors. Although the CSC BMP states, "[*i*]*n accordance with industry practice, the calculation shall be done at* [*a height of*] *… 1 meter above ground level …*" (CSC, 2014, p. 7), Exponent also undertook modeling of the EMF fields at these locations at multiple heights above ground to obtain a clear understanding of the EMF fields due to the transmission lines. This modeling, accounting for variation in terrain at adjacent buildings, was performed for the lines from Structures 5 to 15 and is identified in Figure 4 with in yellow.

3-Dimensional Modeling

For most of the route between the Derby Junction and the Ansonia Substation, 2-dimensional modeling was used to calculate magnetic-field levels accurately and conservatively.[8] For the remainder of the route, Exponent used 3-dimensional modeling because the proposed transmission line structure configuration and conductor orientation changes from span to span. This type of modeling accounts both for the change in conductor configuration between structures and for potential changes in the geographic routing direction of the transmission lines. The areas where 3-dimensional modeling was employed included:

- Two spans in Shelton (Structures 356 to 358);
- Several spans near Indian Well Substation (Structures 2 to 4) in Derby; and
- Several spans near Ansonia Substation (Structures 15 to 21) in Ansonia.

In these portions of the route, Exponent modeled magnetic-field levels associated with the existing and proposed configurations of the transmission lines using the software program SUBCALC, which was developed by the Electric Power Research Institute, and is licensed as part of the Enertech EMF Workbench Suite. The software models magnetic fields, and accounts for the 3-dimensional arrangement of transmission line conductors (including sag). The same information regarding loading, phasing, and conductor clearance used for the 2-dimensional modeling was used for this 3-dimensional modeling. Locations where 3-dimensional modeling was employed is shown in Figure 4 in pink.

[8] In this context, 'conservatively' means 'overestimates.'

Figure 4 details where 2-dimensional modeling (with and without evaluation of terrain variation) and 3-dimensional modeling was used.

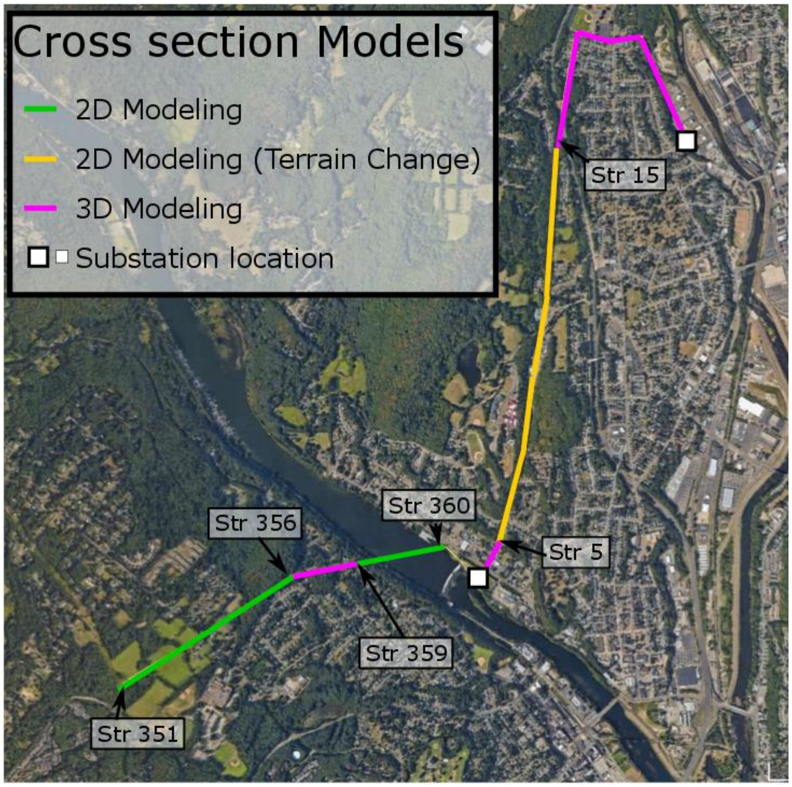

Figure 4. Overview of the route segments containing modeled cross sections along the Project route.[9]

Loading

The flow of electrical current on conductors is commonly referred to as the load or loading. A summary of the loading for each model is provided in Attachment A, along with a summary of the process undertaken by UI to determine these loading levels based on reports from the Independent System Operator of New England (ISO-NE). The loading used for modeling also is summarized in a table available from Exponent upon request, consistent with Critical Energy Infrastructure Information restrictions.

Phase Optimization

Where two transmission lines are located on the same ROW, the specific arrangement of the conductors of each circuit will have an effect on the calculated EMF levels. Therefore, Exponent performed a phase-

[9] The portion of the route from Structure 360 to Indian Well Substation primarily includes transition structures and is in an industrial area (far from any residences) so was not modeled.

optimization analysis in which all possible phasing configurations of the rebuilt lines were analyzed to identify the particular phasing that reduces the highest magnetic-field level at either ROW edge to a minimum level and considers the magnetic-field contributions of all the lines on the ROW. Phase optimization is one way to minimize EMF levels consistent with recommendations to apply low-cost measures (WHO, 2007, CSC, 2014). This optimization analysis was then used by UI to evaluate the constructability of various scenarios and was incorporated into the design of the transmission lines. The optimal phasing of the rebuilt 1808-2 Line (between Derby Junction and Indian Well Substation) and the 1594 Line (between Indian Well and Ansonia substations) is 2-1-3 (top-to-bottom). The phasing of the 1560-3 transmission line (3-1-2, top to bottom) is unchanged.

Results and Discussion

Measured EMF Levels

EMF measurements were obtained within the existing ROW (as close to the edges of the ROW as could be safely measured) and at or near the boundaries of the adjacent properties, listed in Attachment D. Measured magnetic-field levels within the existing ROW averaged 4.5 mG with a maximum value of 12 mG. Magnetic-field levels in other areas within 300 feet of the existing ROW were generally lower, consistent with the rapid decrease in levels with distance. The average measured magnetic field in these areas (outside the ROW) varied from approximately 0.2 mG to 6.1 mG. Electric-field levels on the ROW were measured to be 0.5 kV/m or less and at the ROW edges and beyond were 0.1 kV/m or less, decreasing to background levels rapidly with distance from overhead transmission or distribution sources.

Attachment D provides both annotated aerial photographs of measurement locations and measured EMF values collected while walking within the existing ROW and adjacent to residential properties. Attachment D also provides measured magnetic-field values along a path transecting the transmission lines in a field between Structures 351 and 352.Table D-2 of Attachment D provides summary statistics for all obtained measurements.

Calculated EMF Levels

The calculated EMF levels from the Project are far below accepted levels of exposure to the general public in ICNIRP or ICES standards. The highest EMF levels are in the portion of the route between Derby Junction and Indian Well Substation.[10] An example of these calculations is shown for Structures 352 to 356 in Figure 5 and Figure 6, which show the graphical representations of the calculated magnetic- and electric-field levels on the same scale as the ICNIRP reference levels: 2,000 mG and 4.2 kV/m, respectively. The scale of the graph on the right is changed to magnify the small differences between the calculated existing and proposed EMF levels. Even directly beneath the transmission lines where EMF levels are highest, EMF levels are more than 35-fold below the lowest health-based limit (i.e., ICNIRP reference level). Farther from the transmission lines, at the existing and expanded ROW boundary (where applicable) and beyond, EMF levels are still lower. In other proposed Project configurations (e.g.,

[10] EMF levels are higher between Derby Junction and Indian Well Substation due to a combination of higher loading on the 1808-2 Line than on the 1594 Line and (for existing calculations) the larger existing phase spacing of conductors compared to proposed structures between Indian Well and Ansonia substations.

between Indian Well and Ansonia substations where loading levels are lower), the EMF levels are even lower, and therefore very far below the lowest limit for exposure of the general public.

The calculated EMF levels for existing and proposed configurations of the 115-kV lines are discussed below. Attachment B contains a tabular summary of calculated magnetic-field levels at average and peak loading (Table B-1 and Table B-2, respectively) and electric-field levels (Table B-3). Attachment C provides graphical profiles of calculated magnetic-field levels (Figure C-1 to Figure C-15) and electric-field levels (Figure C-16 to Figure C-30) illustrating the calculated EMF level along transects perpendicular to each segment of the Project route for existing and proposed conditions. These graphical profiles provide a visual summary of the calculated field levels, along with representations of the existing and proposed structures, for illustrative purposes. These results also show changes in the existing and proposed structure locations and ROW boundaries. Additional calculations of magnetic-field levels using 3-dimensional models of the transmission line structures are shown with in contour plots in Attachment C, Figure C-31 to Figure C-33.

The EMF from the proposed transmission lines are calculated to be similar to or lower than existing levels. However, the realignment of the rebuilt monopoles in relation to the existing structures will cause a corresponding shift in the location of maximum EMF levels compared to existing levels, resulting in an increase in the EMF levels on one side of the existing structure centerline and a corresponding similar decrease in EMF levels on the other side. Overall, EMF levels after construction of the Project were calculated not to change significantly (between Indian Well and Ansonia substations) or to decrease compared to existing levels (between Derby Junction and Indian Well Substation).

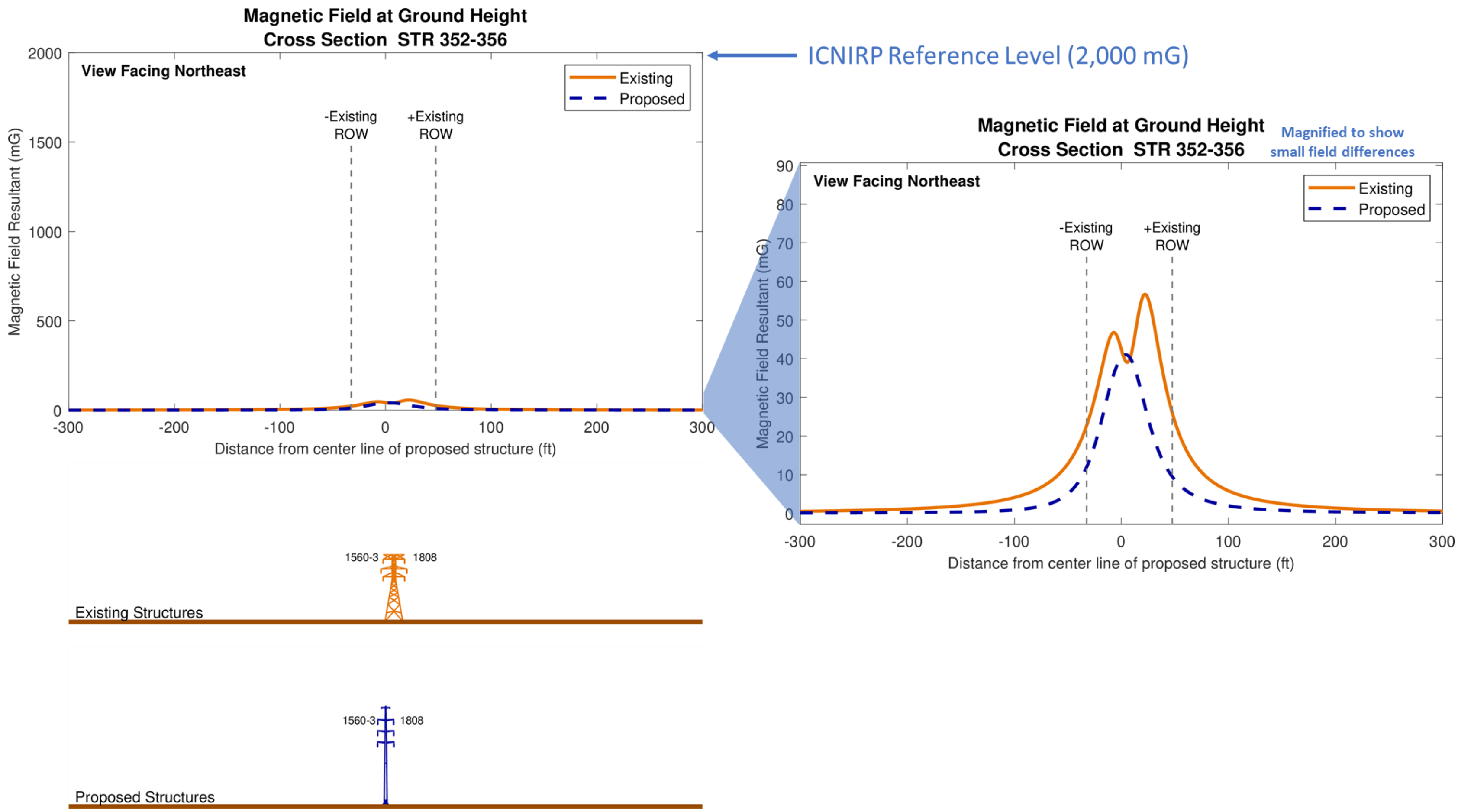

Figure 5. Magnetic-field levels on the portion of the route between Structures 352 and 356 (between Derby Junction and Indian Well Substation in Shelton) compared to the ICNIRP limit of 2,000 mG.

ICES limits for magnetic fields are 9,040 mG. Note the change in scale of the figure at the right to magnify the small differences in existing and proposed calculated field levels.

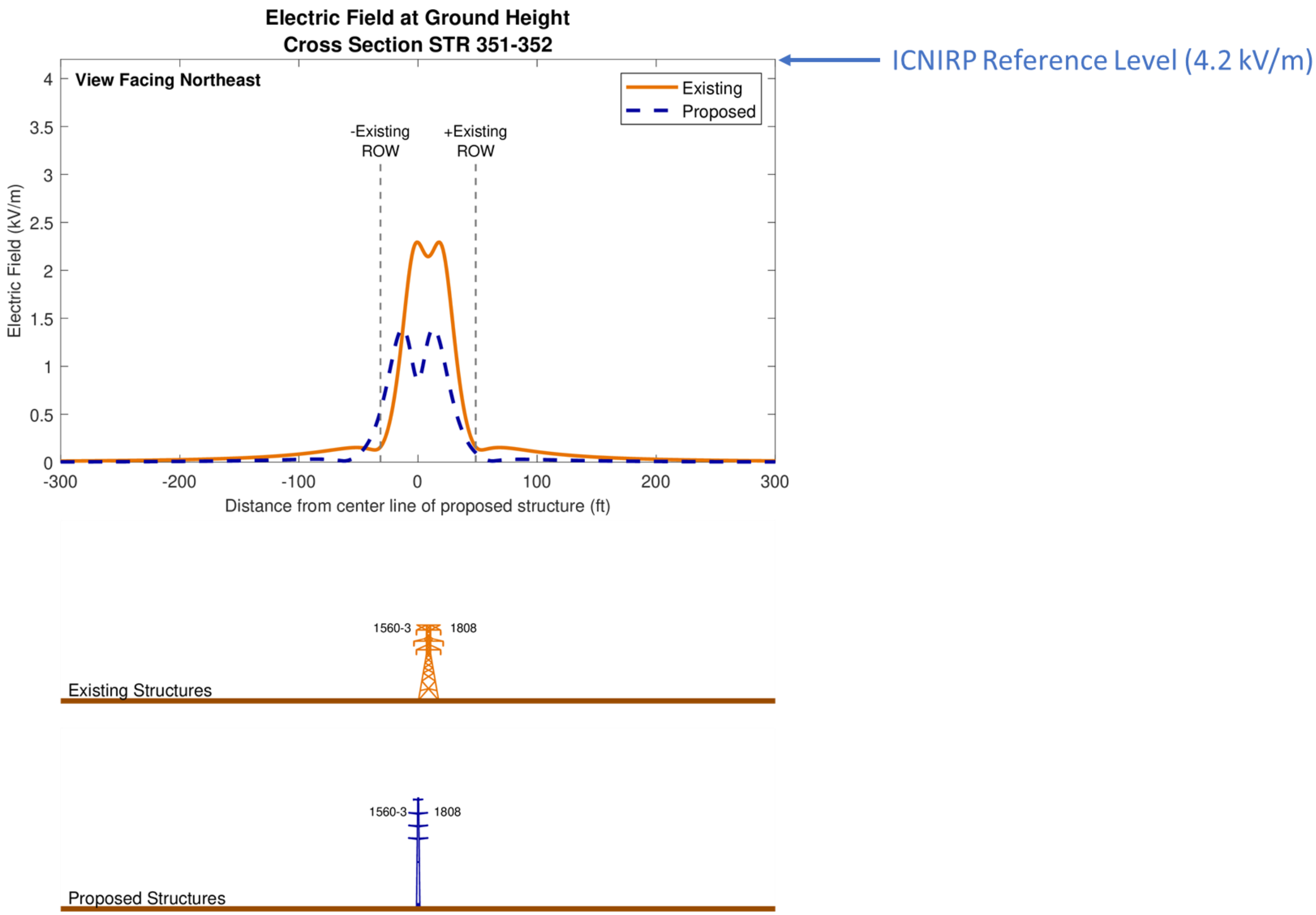

Figure 6. Electric-field levels on the portion of the route between Structures 352 and 356 (between Derby Junction and Indian Well Substation in Shelton) compared to the ICNIRP limit of 4.2 kV/m.

ICES limits for electric fields within a transmission line ROW are 10 kV/m.

Magnetic Fields

2-Dimensional Modeling

The design of the proposed transmission lines is generally the same throughout the entire route from Derby Junction to Ansonia Substation; in contrast, the existing structures between Derby Junction and Indian Well Substation differ from the typical existing structures between Indian Well and Ansonia substations. Exponent's assessment therefore concluded that rebuilding the transmission lines will affect the EMF levels on the route segment from Derby Junction to Indian Well Substation differently than the EMF levels on the route segment between Indian Well and Ansonia substations.

- Between Derby Junction and Indian Well Substation, the existing transmission line structures have greater phase-phase spacing, lower conductor heights and suboptimal phasing compared to the proposed configuration. Therefore the new structures will generally reduce EMF levels below existing levels. The current on the circuit 1808-2 (between Derby Junction and Indian Well) is higher than the current on the circuit 1594 (between Indian Well and Ansonia substations), leading to higher magnetic fields between Derby Junction and Indian Well Substation than between Indian Well and Ansonia substations.
- Between Indian Well and Ansonia substations the existing transmission line structures have smaller phase-phase spacings than the proposed structures; however the proposed structures have greater conductor heights and optimal phasing compared to existing structures. The net result of these design features is that there are similar EMF levels for the existing and proposed transmission line configurations.

The Project will change the *location* of the maximum EMF levels, which will be shifted on the ROW due to the realignment of the rebuilt monopoles in relation to the existing structures. This realignment will cause the location of maximum EMF levels also to be slightly offset compared to existing levels, resulting in an increase in the EMF levels on one side of the existing structure centerline and a corresponding similar decrease in EMF levels on the other side.

At average loading, the highest magnetic-field level underneath the existing lines between Derby Junction and Indian Well Substation was calculated to be 57 mG (Structures 351-356), decreasing to 42 mG or less for the proposed configuration (see Attachment B, Table B-1).[11] Between Indian Well and Ansonia substations, EMF levels from the transmission lines before and after the Project are lower and are not calculated to change significantly as a result of the transmission line rebuild: at average loading the maximum proposed magnetic-

[11] Magnetic-field levels at a height of 1 meter (3.28 feet) above the Housatonic River (Structures 359 and 360) are somewhat higher due to greater phase-phase separation. However, these levels are likely significantly overestimated as the minimum conductor heights were modeled as 19 feet (existing) and 23 feet (proposed), while the actual conductor heights are likely to be much greater (>45 feet).

field level of approximately 32 to 33 mG is virtually unchanged from the 31 mG calculated for the existing configuration.

At the existing ROW edge (at average loading), magnetic-field levels will increase or decrease by similar amounts (maximum increase or decrease of about 15 to 16 mG) as a result of the offset of the rebuilt monopoles from the existing structures.[12] UI's planned expansion of the ROW to maintain necessary clearances means that *existing* EMF levels at the *existing* ROW edge will be comparable to or lower than *proposed* EMF levels at the *proposed* ROW edge. While there are some small increases in ROW-edge magnetic-field levels (2.7 mG or less) in short portions of the route, there are much larger decreases (up to 23 mG) in other portions. Overall the average proposed ROW-edge magnetic-field level is approximately 7.8 mG lower than the average magnetic-field level at the existing ROW edge.

Regardless of the alignment of the rebuilt monopoles in relation to the existing structures, EMF levels decrease rapidly with distance for both the existing and proposed (rebuilt) configurations (see Appendix B, Table B-1 and Table B-2). Magnetic-field levels at the ROW edge between Derby Junction and Indian Well Substation will decrease as a result of the Project. Between Indian Well and Ansonia substations, magnetic-field levels for both existing and proposed configurations decrease to less than 1 mG within approximately 100 feet of the proposed ROW edge. The magnetic-field levels were calculated to be similar for peak and average loading, as summarized in Attachment B.

Additionally, in some portions of the route (e.g., Structures 5 to 15 along Coon Hollow Road and further north across State Route 8), the terrain around the transmission line is such that the closest buildings are at vertical heights comparable to the transmission line conductors. However, accessible areas and buildings are sufficiently far away from the conductors that calculated EMF levels at these greater elevations above ground at the transmission line poles remain within 2 mG of the levels calculated in accordance with standard procedures (at a height of 3.28 feet [1 meter] above ground) as summarized in Attachments B and C.

3-Dimensional Modeling

Additional calculations of magnetic-field levels using 3-dimensional models of the transmission line structures are shown in Figure C-31 to Figure C-33. The results of these calculations are quite similar to the 2-dimensional calculations described above but show that ground-level magnetic-field levels decrease

[12] Changes in magnetic-field levels at a height of 1 meter (3.28 feet) above the Housatonic River (Structures 359 and 360) are somewhat greater (increase or decrease of about 20 or 21 mG). However, these levels are likely significantly overestimated because the minimum conductor heights were modeled as 19 feet (existing) and 23 feet (proposed), while the actual conductor heights are likely to be much greater (>45 feet).

dramatically near structures (where conductors are higher above ground) compared to the midspan (where conductors are closer to ground).

These figures also show that, consistent with the results of the 2-dimensional modeling, the magnetic-field levels are calculated to decrease on portions of the route between Derby Junction and Indian Well Substation and are calculated not to change significantly on portions of the route between Indian Well and Ansonia substations (but rather to shift east or west slightly depending on the relocation of the proposed transmission line centerline relative to the existing centerline). Magnetic-field levels fall to 1 mG or less much more rapidly for the proposed configuration than for existing (along the ROW between Derby Junction and Indian Well Substation) and that the distance at which magnetic-field levels from the transmission lines fall to 1 mG or less (between the Indian Well and Ansonia substations) is quite similar between the existing and proposed configurations.

Electric Fields

The calculated profiles of electric fields also decrease on portions of the route between Derby Junction and Indian Well Substation and do not change significantly on portions of the route between Indian Well and Ansonia substations. Similar to the magnetic-fields, the realignment of the rebuilt monopoles in relation to the existing structures results in a corresponding shift in the calculated electric-field levels to the location of the proposed structures. The maximum electric-field level under the existing lines (between Derby Junction and Indian Well Substation) is 2.3 kV/m, decreasing to a maximum of 1.4 kV/m in the proposed configuration.[13]

At the existing ROW edge, electric-field levels will increase (1.3 kV/m) or decrease (0.5 kV/m) by small amounts as a result of the Project. UI's proposed ROW expansion, as required to maintain necessary clearances, means that existing electric-field levels at the existing ROW edge will be comparable to proposed electric-field levels at the proposed ROW edge, with the maximum increase of 0.4 kV/m and a maximum decrease 1.2 kV/m.

Regardless of the offset of the rebuilt transmission lines from locations of the existing structures, electric-field levels decrease rapidly with distance for both the existing and proposed configurations. For both existing and proposed configurations, the electric-field at approximately 100 feet from the proposed ROW will be 0.1 kV/m or less.

[13] Electric-field levels at a height of 1 meter (3.28 feet) above the Housatonic River (Structures 359 and 360) are somewhat higher due to greater phase-phase separation. However, these levels are likely significantly overestimated as the minimum conductor heights were modeled as 19 feet (existing) and 23 feet (proposed), while the actual conductor heights are likely to be much greater (>45 feet).

At locations where there were significant terrain height changes around the transmission lines (e.g., along Coon Hollow Road), the nearest structures were sufficiently far away such that calculated electric-field levels were *de minimus*.

Conclusions

This report summarizes measurements and calculations of the EMF levels associated with the pre-Project configuration and post-Project configurations of the Project. The EMF levels associated with the operation of the existing and rebuilt transmission lines were calculated using methods that are accepted within the scientific and engineering community and that have been found to match well with measured values. Elements of the Project design reduce magnetic-field levels, consistent with the CSC's EMF BMPs design goals (e.g., taller structures, and optimal phasing). Additionally, all measured and calculated EMF levels associated with the Project were a small fraction of recommended health-based limits.

The new structures will be offset from the existing structures at various locations along the ROW, thus shifting the location of maximum EMF levels to one side or the other. UI proposes to acquire additional permanent easements (as necessary) to ensure the new transmission line conductors maintain necessary horizontal clearances to adjacent property as mandated by the National Electrical Safety Code, as well as UI's standard design criteria.[14]

Pre-construction EMF measurements along the Project route were generally consistent with those calculated for the existing configurations of the transmission lines. Measured EMF levels outside the existing ROW were generally lower than those measured inside the ROW, consistent with the rapid decrease in EMF levels with distance.

The EMF from the proposed transmission lines are calculated to be similar to or lower than existing levels. However, the realignment of the rebuilt monopoles in relation to the existing structures will cause a corresponding shift in the location of maximum EMF levels compared to existing levels, resulting in an increase in the EMF levels on one side of the existing structure centerline and a corresponding similar decrease in EMF levels on the other side. Overall, EMF levels after construction of the Project were calculated not to change significantly (between Indian Well and Ansonia substations) or to decrease compared to existing levels (between Derby Junction and Indian Well Substation).

Regardless of the alignment of the rebuilt monopoles in relation to the existing structures, EMF levels decrease rapidly with distance for both the existing and proposed (rebuilt) configurations.. After the Project, the magnetic-field level at approximately 100 feet from the proposed ROW will either decrease as a result of the Project (between Derby Junction and Indian Well Substation) or will be 1 mG or less (between Indian

[14] Both before and after the proposed Project, there are adjacent buildings (including some residential buildings) that are or will be inside the existing or proposed ROW edge.

Well and Ansonia substations). At this distance, all existing and proposed electric-field levels will be 0.1 kV/m or less.

The measured and calculated EMF levels associated with the Project are far below international safety and health-based standards for EMF. The engineering design and other activities initiated by UI include design elements consistent with the CSC's BMP regarding EMF.

References

Chartier V and Dickson L. Results of Magnetic Field Measurements Conducted on RossLexington 230-kV Line. Report No. ELE-90-98. Portland, OR: Bonneville Power Administration, 1990.

Connecticut Siting Council (CSC). Electric and Magnetic Fields Best Management Practices for the Construction of Electric Transmission Lines in Connecticut. New Britain, CT: CSC. Revised February 20, 2014. https://portal.ct.gov/-/media/CSC/EMF_BMP/revisions_updates/754BMPfinalpdf.pdf

Connecticut Siting Council (CSC). Application Guide for an Electric Substation Facility. New Britain, CT: CSC, 2016. https://portal.ct.gov/-/media/CSC/Guides/2016Guides/ElecSubApplicationGuide616pdf.pdf

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 Std. 1308-1994, Reaffirmed 2010). New York: IEEE, 1994.

Institute of Electrical and Electronics Engineers (IEEE). IEEE Standard Procedures for Measurement of Power Frequency Electric and Magnetic Fields from AC Power Lines (ANSI/IEEE Std. 644-2019). New York: IEEE, 2019.

Institute of Electrical and Electronics Engineers (IEEE). IEEE Recommended Practice for Measurements and Computations of Electric, Magnetic, and Electromagnetic Fields with Respect to Human Exposure to Such Fields, 0 Hz to 300 GHz (IEEE Std.™ C95.3-2021). New York: IEEE, 2021.

International Commission on Non-Ionizing Radiation P. ICNIRP Statement - Guidelines for Limiting Exposure to Electromagnetic Fields (1 Hz to 100 kHz). Health Phys 99( ):818-836, 2010.

International Committee on Electromagnetic Safety (ICES). IEEE Standard for Safety Levels with Respect to Human Exposure to Electromagnetic Fields 0 to 300 GHz. IEEE Std C95.1-2019 (Revision of IEEE Std C95.1-2005/ Incorporates IEEE Std C95.1-2019/Cor 1-2019). New York: IEEE, 2019.

International Committee on Electromagnetic Safety (ICES). IEEE Standard for Safety Levels with Respect to Human Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz (Std. C95.1): Corrigenda 2. New York: IEEE, 2020.

Perrin N, Aggarwal R, Bracken T, Rankin R. Survey of Magnetic Fields near BPA 230-kV and 500-kV Transmission Lines. Portland, OR: Portland State University, 1991.

Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR). Opinion on Potential Health Effects of Exposure to Electromagnetic Fields (EMF). Luxembourg: European Commission, 2015.

Savitz DA, Pearce NE, Poole C. 1989. Methodological issues in the epidemiology of electromagnetic fields and cancer. Epidemiol Rev 11:59-78.

World Health Organization (WHO). Fact Sheet No. 322: Electromagnetic Fields and Public Health – Exposure to Extremely Low Frequency Fields. Geneva, Switzerland: World Health Organization, 2007.

Attachment A

Transmission Line Loading

The flow of electrical current on conductors is commonly referred to as the load or loading. UI Transmission Planning provided the pre- and post-Project loadings for the Project-related 115-kV transmission lines, based on reports from ISO-NE as described below.

UI is required by the CSC's BMP to provide calculations of EMF for "pre and post project conditions, under: 1) peak load conditions at the time of application filing, and 2) projected seasonal maximum 24-hour average current load on the line anticipated within five years" of the operational in-service date (CSC, 2014). Line loadings for existing and proposed conditions were provided by UI.

Loading levels were provided to Exponent by UI. Excerpts from the power flow analysis supporting these load levels are quoted below.

> Forecast values in the 2021 ISO-NE Capacity, Energy, Loads, and Transmission (CELT) Report were used to determine the projected 2022 peak load level and to calculate the 2029 estimated peak daily average load level including the effects of energy efficiency and distributed generation in reducing peak system demand.[15]

The analysis steps performed by UI for determining the peak daily average load (2025-2029) include:

- UI first "[c]ollect[ed] actual hourly NE Load levels from 2020 by using the ISO-NE Standard Market Design (SMD) hourly data from the year prior to the CELT publication year … The 2021 CELT report is based on 2020 data and so this data was used to maintain consistency. The hourly data can be found here: http://www.iso-ne.com/isoexpress/web/reports/pricing/-/tree/zone-info"
- Next, UI "[d]etermine[d] the peak daily average load by finding the average load for each day of the year and then determining the single day with the highest value …"
- Finally, "[t]he Seasonal Maximum 24-hour Average Load was calculated from the ISO-NE forecasted 50/50 peak by using the same ratio between 24-hour average and absolute peak used observed in 2020 actual data."

The specific loading values used in the calculations of magnetic fields are classified as Critical Energy/Electric Infrastructure Information and available to the CSC upon request.

[15] Ansonia to Derby Junction Transmission Line Rebuild EMF Power Flow Report, dated January 6, 2022.

Attachment B

Tabular Results of Calculated EMF Levels

Table B-1. Magnetic-field levels (mG) at average loading*

Cross section	Configuration	Location: –100 feet from proposed ROW	– Existing ROW	–Proposed ROW	Max	+ Existing ROW	+ Proposed ROW	+100 feet from proposed ROW
Derby Junction to Indian Well Substation								
STR 351-352	Existing	2.5	23	23	57	26	26	2.6
	Proposed	0.5	13	13	42	9.5	9.5	0.8
STR 352-356	Existing	2.5	23	23	57	26	26	2.6
	Proposed	0.4	12	12	41	9.5	9.5	0.8
STR 359	Existing	2.3	26	11	82	29	29	3.0
	Proposed	1.0	47	20	52	8.4	8.4	1.0
STR 360	Existing	2.3	29	14	73	26	26	2.9
	Proposed	1.0	44	20	52	11	11	1.1
Indian Well Substation to Ansonia Substation								
STR 5	Existing	0.4	3.4	3.4	31	4.1	4.1	0.5
	Proposed	0.7	6.1	6.1	33	4.8	4.8	0.5
STR 6	Existing	0.4	3.0	2.8	31	15	5.2	0.5
	Proposed	0.7	5.4	5.0	33	18	6.2	0.6
STR 7	Existing	0.4	2.1	2.1	31	28	3.5	0.4
	Proposed	0.5	2.7	2.7	32	32	5.9	0.6
STR 8	Existing	0.3	1.5	1.5	31	29	2.4	0.4
	Proposed	0.4	1.6	1.6	32	25	5.9	0.6
STR 9	Existing	0.6	15	7.2	31	8.3	3.5	0.4
	Proposed	0.8	15	8.4	33	17	6.2	0.6
STR 10	Existing	0.5	15	4.3	31	8.3	7.0	0.5
	Proposed	0.9	28	9.7	32	6.6	5.6	0.6

Cross section	Configuration	Location						
		–100 feet from proposed ROW	– Existing ROW	–Proposed ROW	Max	+ Existing ROW	+ Proposed ROW	+100 feet from proposed ROW
STR 11	Existing	0.3	15	1.7	31	8.3	8.3	0.6
	Proposed	0.6	32	4.8	32	4.4	4.4	0.5
STR 12	Existing	0.3	15	1.4	31	8.3	8.3	0.6
	Proposed	0.6	30	4.8	32	3.4	3.4	0.5
STR 13	Existing	0.3	15	1.3	31	8.3	8.3	0.6
	Proposed	0.6	27	4.8	32	3.0	3.0	0.5
STR 14	Existing	0.5	15	4.2	31	8.3	3.3	0.4
	Proposed	0.7	14	5.0	33	19	6.2	0.6
STR 15	Existing	0.7	15	14	31	8.3	2.6	0.4
	Proposed	0.9	10	9.7	32	24	5.9	0.6

* At locations where there were significant terrain height changes around the transmission lines, the nearest structures were sufficiently far away such that calculated magnetic-field levels at heights above ground level (at the structure centerline) were all within 2 mG or less of those reported here.

Table B-2. Magnetic-field levels (mG) at peak loading*

Cross section	Configuration	Location						
		–100 feet from proposed ROW	– Existing ROW	–Proposed ROW	Max	+ Existing ROW	+ Proposed ROW	+100 feet from proposed ROW
Derby Junction to Indian Well Substation								
STR 351-352	Existing	2.5	23	23	57	26	26	2.6
	Proposed	0.5	14	14	42	9.3	9.3	0.8
STR 352-356	Existing	2.5	23	23	57	26	26	2.6
	Proposed	0.5	13	13	41	9.3	9.3	0.7
STR 359	Existing	2.1	26	11	83	29	29	3.1
	Proposed	1.1	48	21	52	8.4	8.4	1.0
STR 360	Existing	2.3	30	14	73	26	26	3.0
	Proposed	1.1	46	21	52	11	11	1.1
Indian Well Substation to Ansonia Substation								
STR 5	Existing	0.4	3.6	3.6	32	3.6	3.6	0.4
	Proposed	0.8	6.7	6.7	34	4.9	4.9	0.6
STR 6	Existing	0.4	3.2	2.9	32	14	4.6	0.5
	Proposed	0.7	6.0	5.5	34	18	6.3	0.7
STR 7	Existing	0.4	2.2	2.2	32	28	3.1	0.4
	Proposed	0.6	3.1	3.1	33	33	6.0	0.7
STR 8	Existing	0.3	1.6	1.6	32	30	2.2	0.4
	Proposed	0.4	1.8	1.8	33	27	6.0	0.7
STR 9	Existing	0.6	16	7.6	32	7.4	3.1	0.4
	Proposed	0.9	17	9.2	34	17	6.3	0.7
STR 10	Existing	0.5	16	4.5	32	7.4	6.1	0.5
	Proposed	1.0	30	11	33	6.7	5.7	0.7

Cross section	Configuration	Location						
		–100 feet from proposed ROW	– Existing ROW	–Proposed ROW	Max	+ Existing ROW	+ Proposed ROW	+100 feet from proposed ROW
STR 11	Existing	0.3	16	1.8	32	7.4	7.4	0.5
	Proposed	0.7	33	5.3	33	4.5	4.5	0.6
STR 12	Existing	0.3	16	1.5	32	7.4	7.4	0.5
	Proposed	0.7	30	5.3	33	3.6	3.6	0.6
STR 13	Existing	0.3	16	1.4	32	7.4	7.4	0.5
	Proposed	0.7	27	5.3	33	3.2	3.2	0.5
STR 14	Existing	0.5	16	4.4	32	7.4	2.9	0.4
	Proposed	0.7	15	5.5	34	19	6.3	0.7
STR 15	Existing	0.7	16	15	32	7.4	2.3	0.4
	Proposed	1.0	11	11	33	25	6.0	0.7

* At locations where there were significant terrain height changes around the transmission lines, the nearest structures were sufficiently far away such that calculated magnetic-field levels at heights above ground level (at the structure centerline) were all within 2 mG or less of those reported here.

Table B-3. Electric-field levels (kV/m)*

Cross section	Configuration	Location: –100 feet from proposed ROW	– Existing ROW	–Proposed ROW	Max	+ Existing ROW	+ Proposed ROW	+100 feet from proposed ROW
Derby Junction to Indian Well Substation								
STR 351-352	Existing	0.1	0.2	0.2	2.3	0.2	0.2	0.1
	Proposed	<0.1	0.5	0.5	1.4	0.1	0.1	<0.1
STR 352-356	Existing	0.1	0.2	0.2	2.3	0.2	0.2	0.1
	Proposed	<0.1	0.5	0.5	1.4	0.1	0.1	<0.1
STR 359	Existing	<0.1	0.3	0.2	3.5	0.3	0.3	0.1
	Proposed	<0.1	1.3	0.7	1.8	0.1	0.1	<0.1
STR 360	Existing	<0.1	0.4	0.2	3.1	0.3	0.3	<0.1
	Proposed	<0.1	1.8	0.7	1.8	0.2	0.2	<0.1
Indian Well Substation to Ansonia Substation								
STR 5	Existing	<0.1	0.1	0.1	1.5	0.1	0.1	<0.1
	Proposed	<0.1	<0.1	<0.1	1.4	0.1	0.1	<0.1
STR 6	Existing	<0.1	0.1	0.1	1.5	1.1	0.1	<0.1
	Proposed	<0.1	<0.1	<0.1	1.4	1.2	0.2	<0.1
STR 7	Existing	<0.1	0.1	0.1	1.5	1.5	0.1	<0.1
	Proposed	<0.1	<0.1	<0.1	1.4	1.0	0.2	<0.1
STR 8	Existing	<0.1	0.1	0.1	1.5	1.5	0.1	<0.1
	Proposed	<0.1	<0.1	<0.1	1.4	1.3	0.2	<0.1
STR 9	Existing	<0.1	0.3	0.1	1.5	0.4	0.1	<0.1
	Proposed	<0.1	0.6	0.1	1.4	1.2	0.2	<0.1
STR 10	Existing	<0.1	0.3	0.1	1.5	0.4	0.2	<0.1
	Proposed	<0.1	1.4	0.2	1.4	0.3	0.2	<0.1

Cross section	Configuration	Location						
		–100 feet from proposed ROW	**– Existing ROW**	**–Proposed ROW**	**Max**	**+ Existing ROW**	**+ Proposed ROW**	**+100 feet from proposed ROW**
STR 11	Existing	<0.1	0.3	0.1	1.6	0.4	0.4	<0.1
	Proposed	<0.1	1.0	<0.1	1.4	0.1	0.1	<0.1
STR 12	Existing	<0.1	0.3	0.1	1.5	0.4	0.4	<0.1
	Proposed	<0.1	1.0	<0.1	1.4	<0.1	<0.1	<0.1
STR 13	Existing	<0.1	0.3	0.1	1.5	0.4	0.4	<0.1
	Proposed	<0.1	1.2	<0.1	1.4	<0.1	<0.1	<0.1
STR 14	Existing	<0.1	0.3	0.1	1.5	0.4	0.1	<0.1
	Proposed	<0.1	0.5	<0.1	1.4	1.3	0.2	<0.1
STR 15	Existing	<0.1	0.3	0.2	1.5	0.4	0.1	<0.1
	Proposed	<0.1	0.3	0.2	1.4	1.3	0.2	<0.1

* At locations where there were significant terrain height changes around the transmission lines, the nearest structures were sufficiently far away such that calculated electric-field levels were *de minimus*.

Attachment C

Graphical Profiles of Calculated EMF

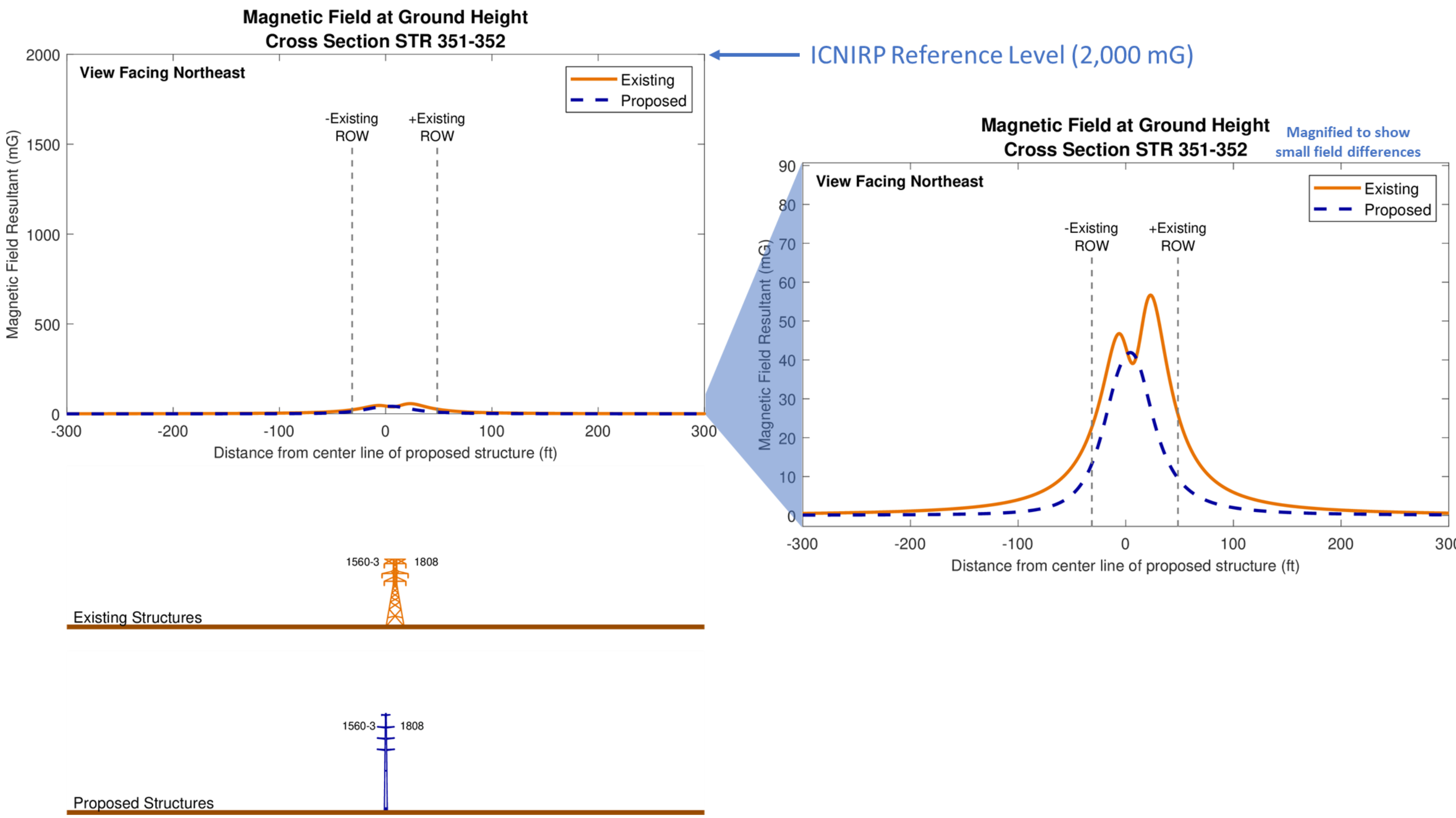

Figure C-1. Magnetic-field profile across Structures 351 and 352 (between Derby Junction and Indian Well Substation) at average loading.

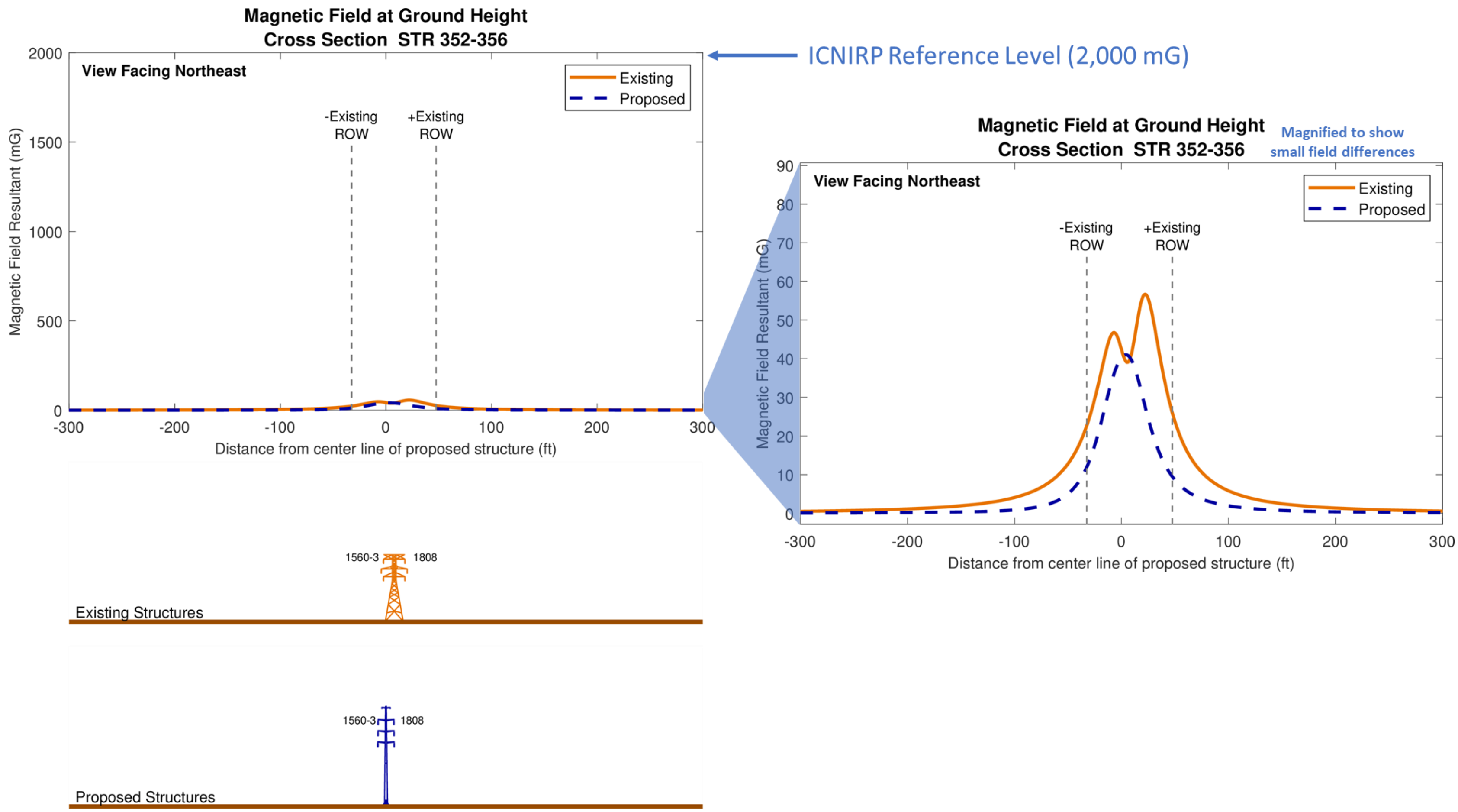

Figure C-2. Magnetic-field profile across Structures 352 to 356 (between Derby Junction and Indian Well Substation) at average loading.

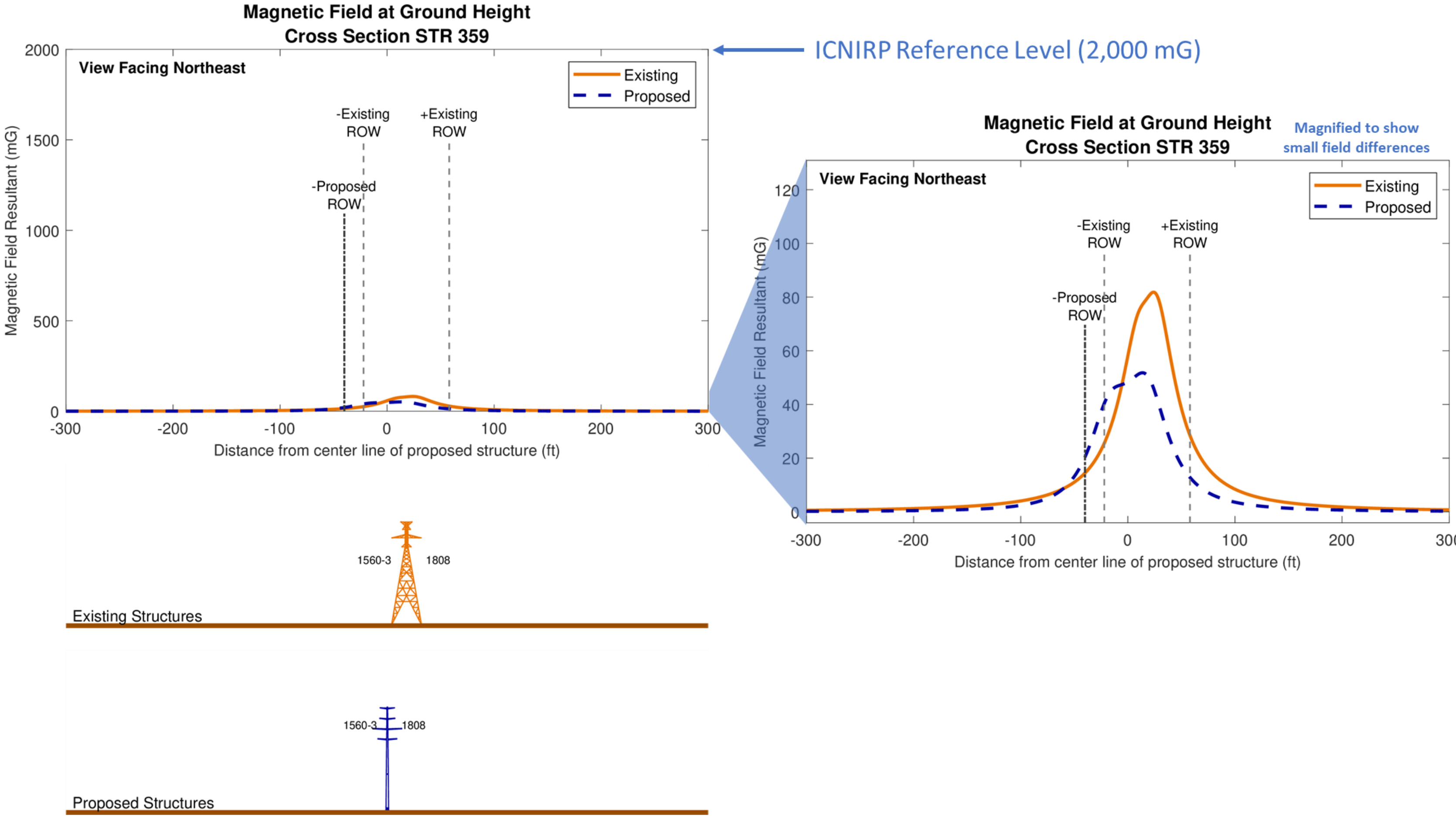

Figure C-3. Magnetic-field profile across Structure 359 (between Derby Junction and Indian Well Substation) at average loading.

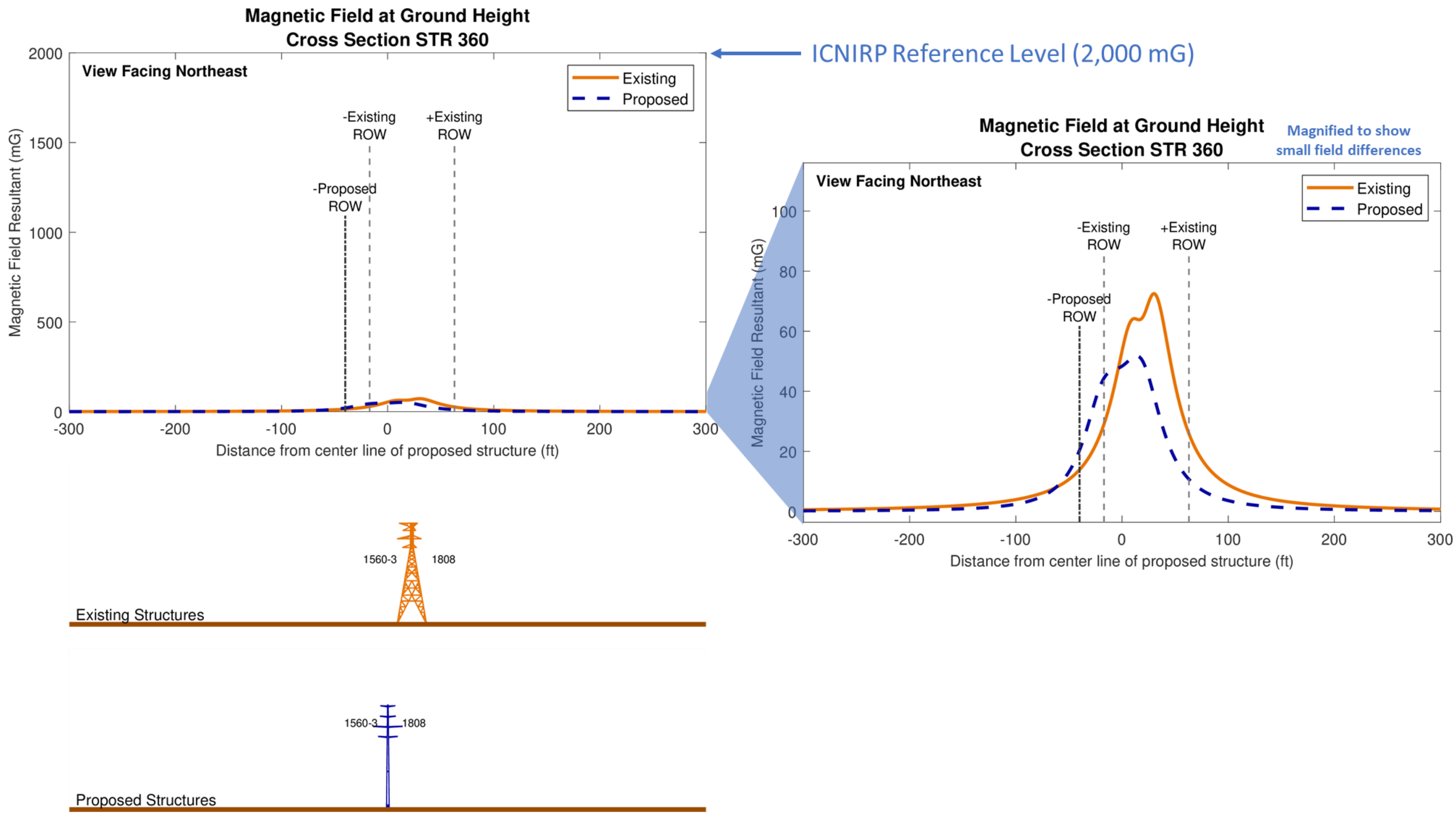

Figure C-4. Magnetic-field profile across Structure 360 (between Derby Junction and Indian Well Substation) at average loading.

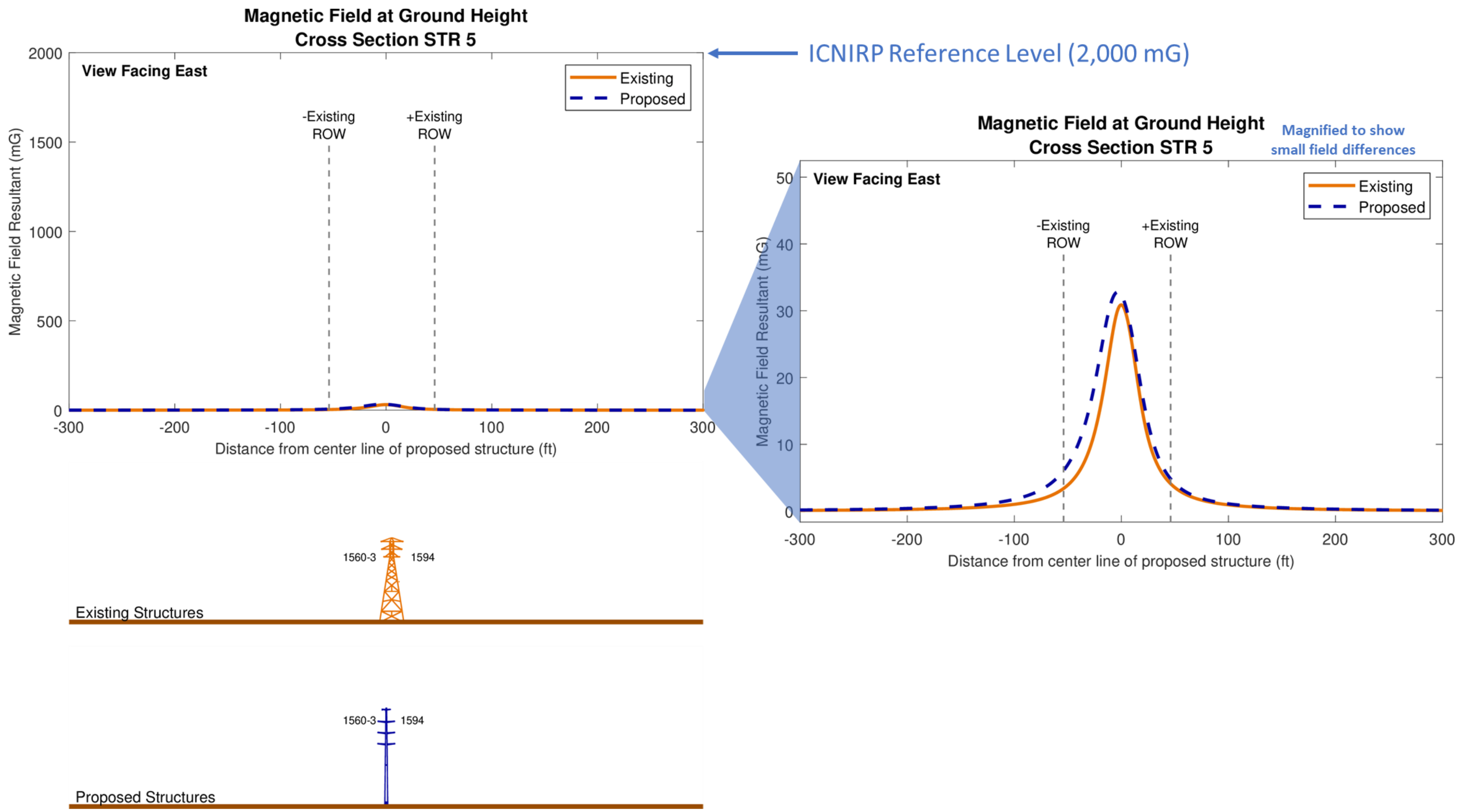

Figure C-5. Magnetic-field profile across Structure 5 (between Indian Well and Ansonia substations) at average loading.

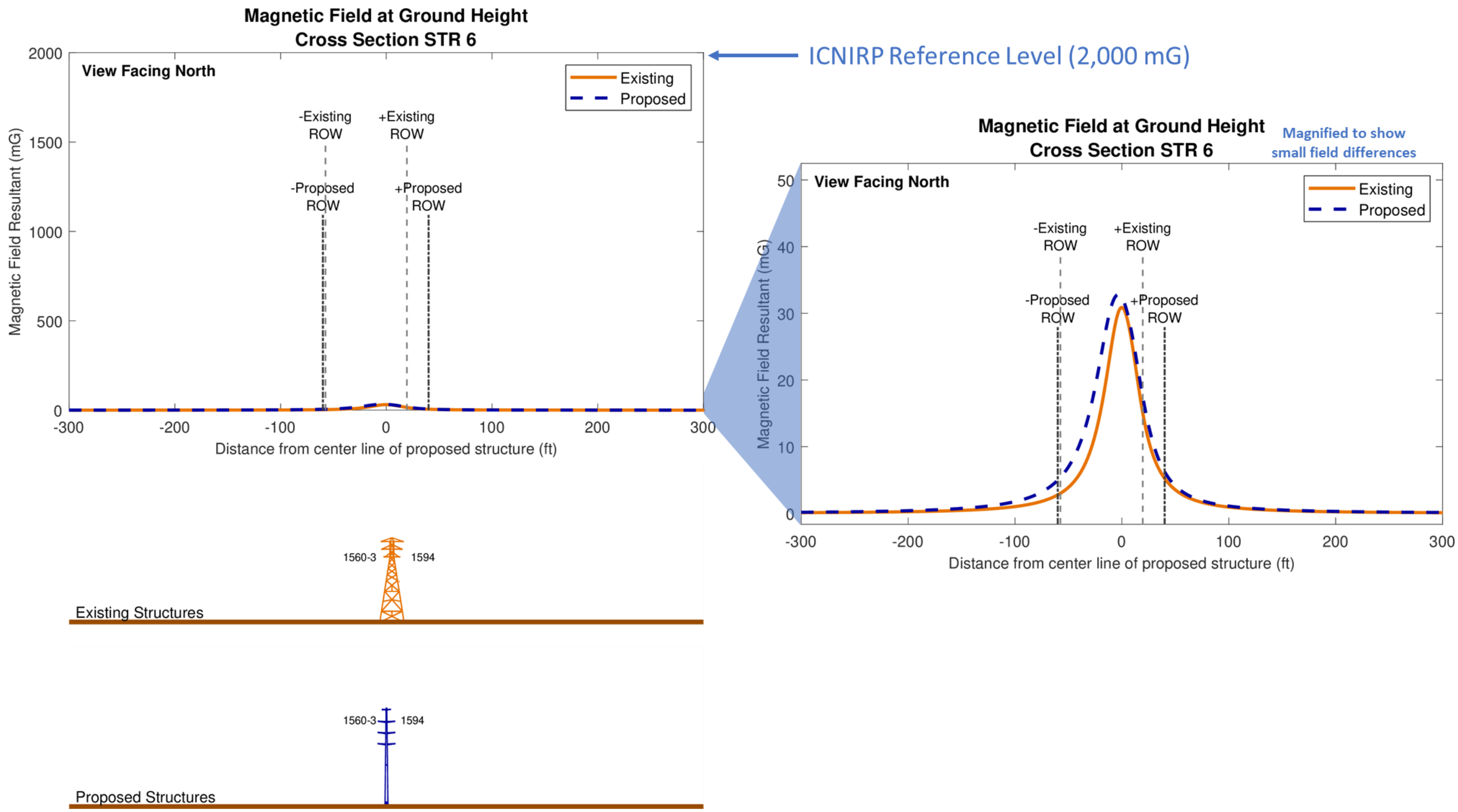

Figure C-6. Magnetic-field profile across Structure 6 (between Indian Well and Ansonia substations) at average loading.

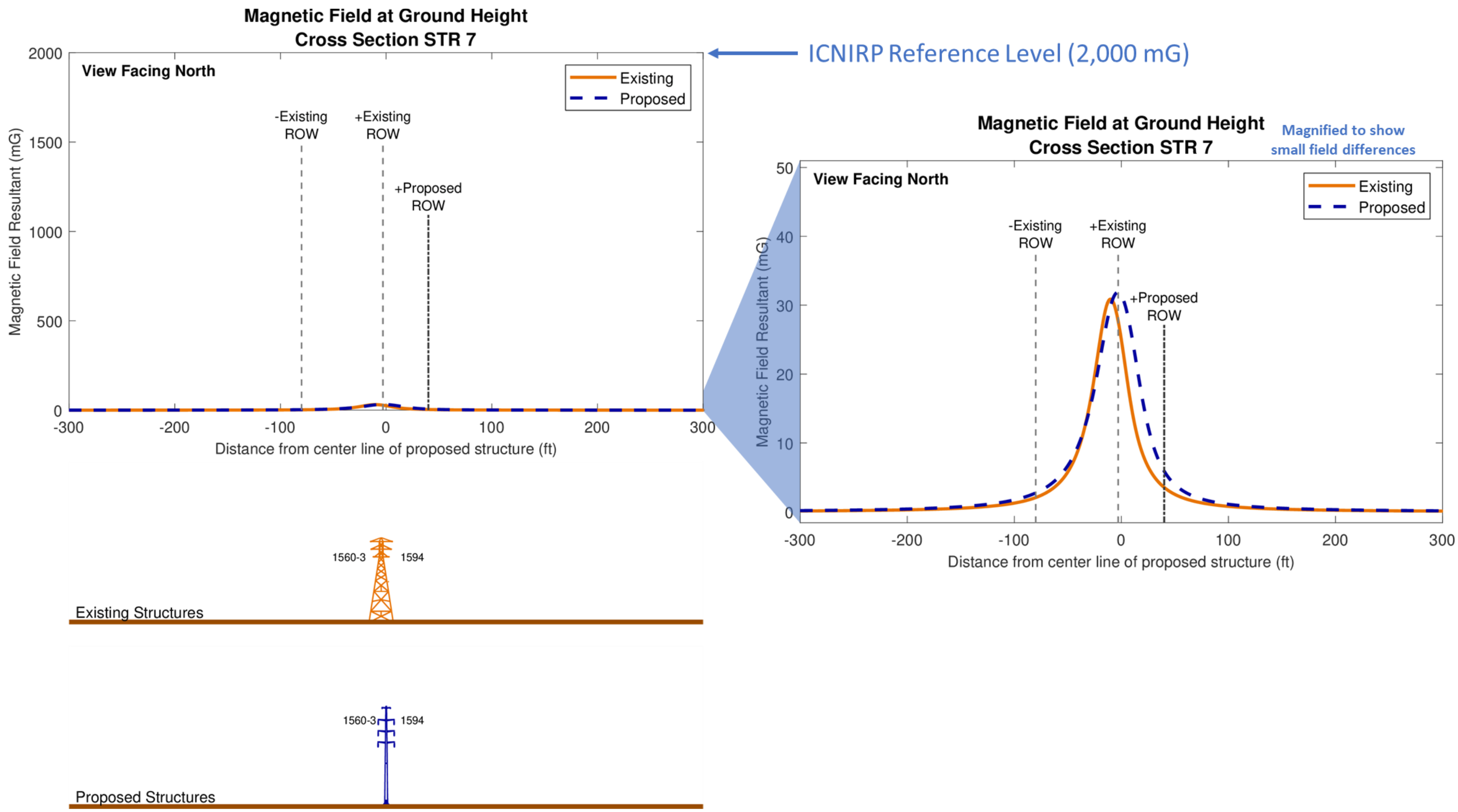

Figure C-7. Magnetic-field profile across Structure 7 (between Indian Well and Ansonia substations) at average loading.

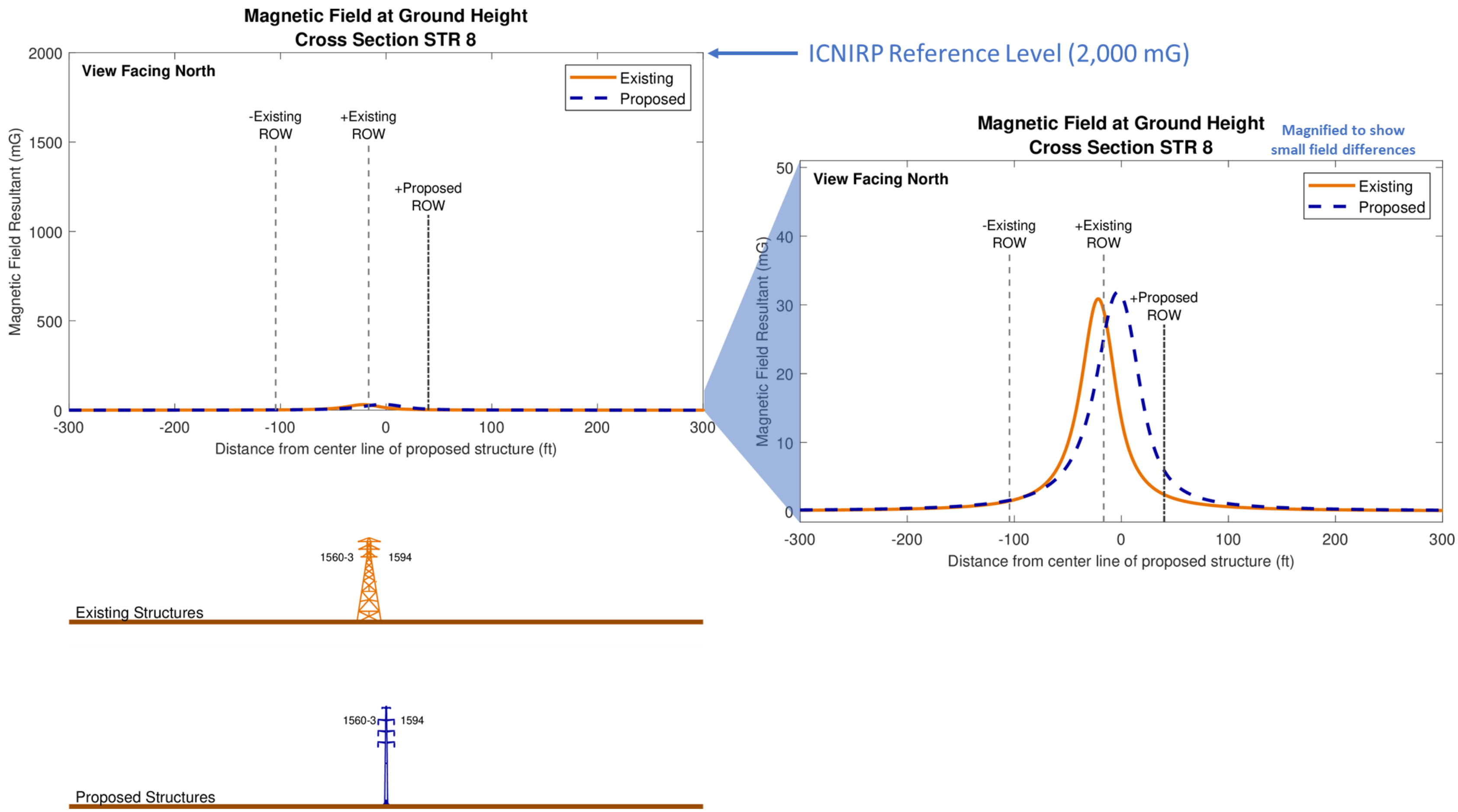

Figure C-8. Magnetic-field profile across Structure 8 (between Indian Well and Ansonia substations) at average loading.

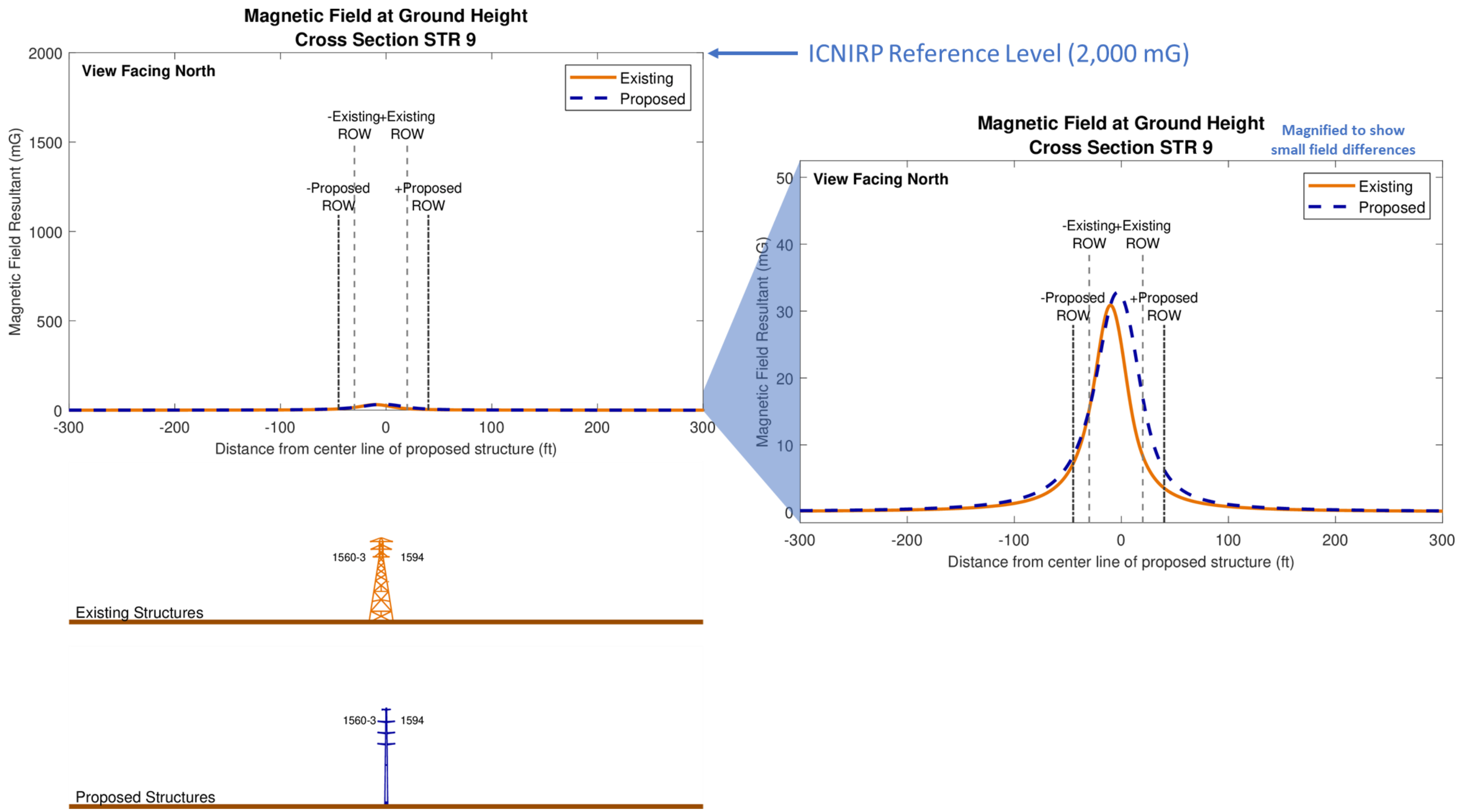

Figure C-9. Magnetic-field profile across Structure 9 (between Indian Well and Ansonia substations) at average loading.

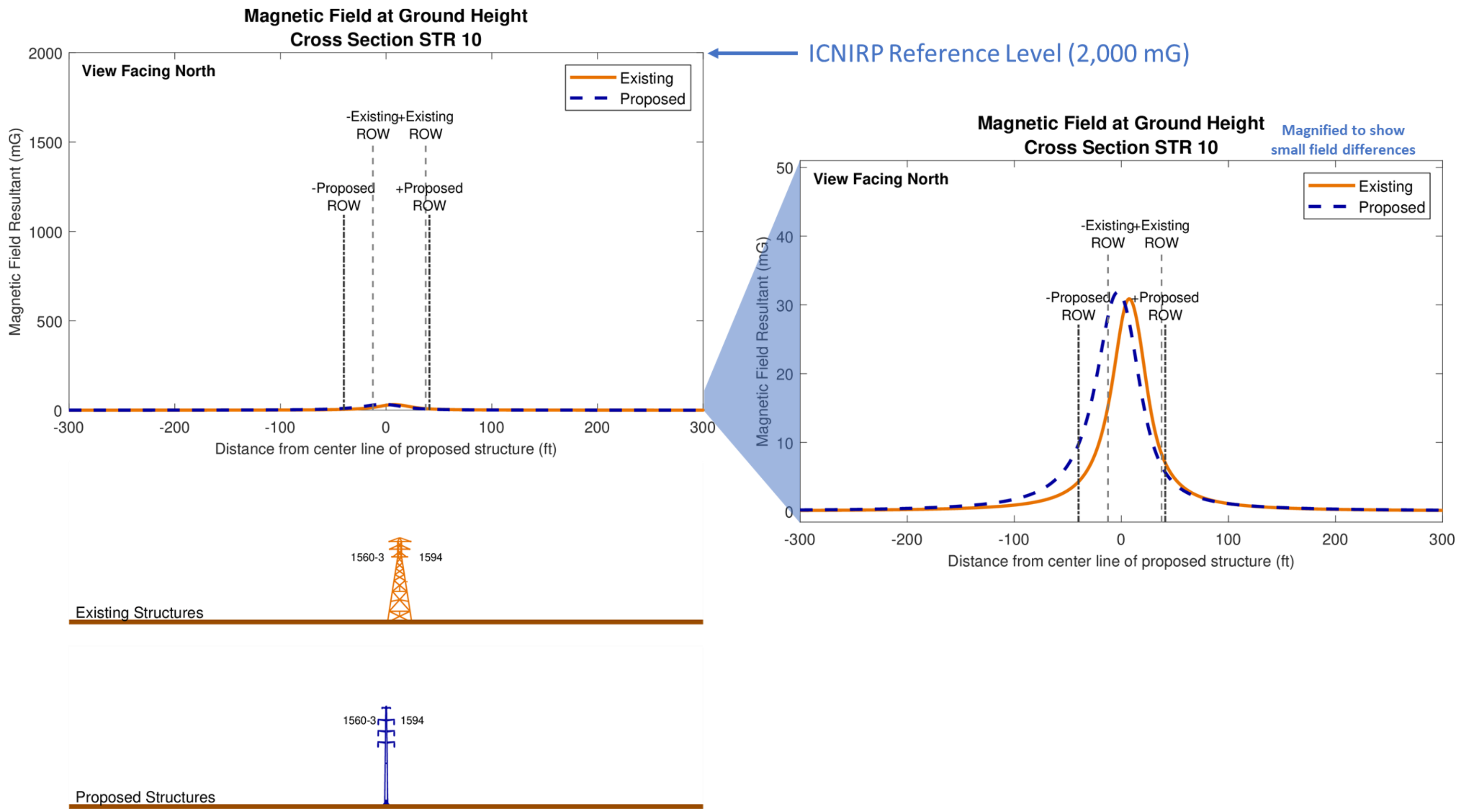

Figure C-10. Magnetic-field profile across Structure 10 (between Indian Well and Ansonia substations) at average loading.

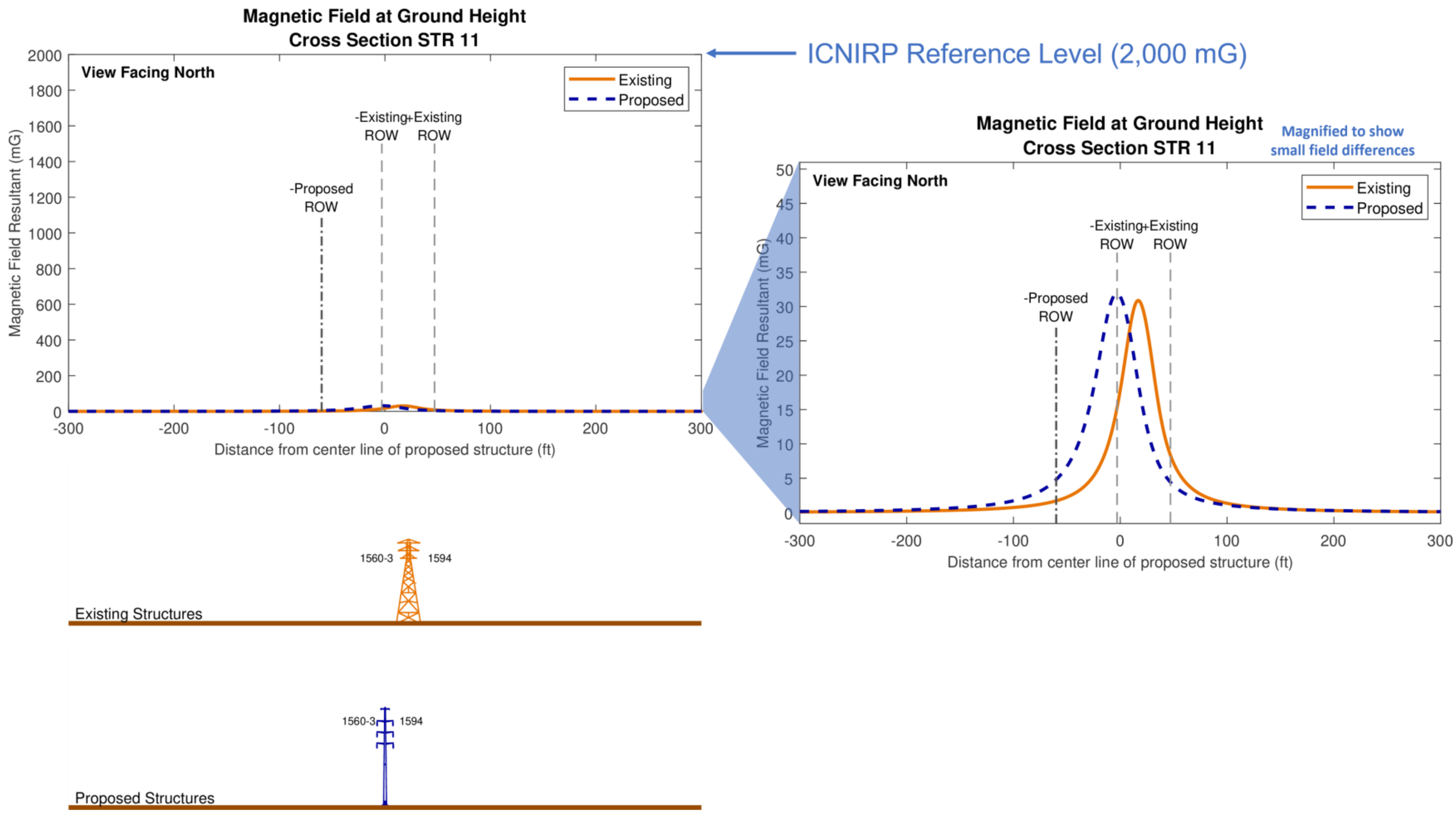

Figure C-11. Magnetic-field profile across Structure 11 (between Indian Well and Ansonia substations) at average loading.

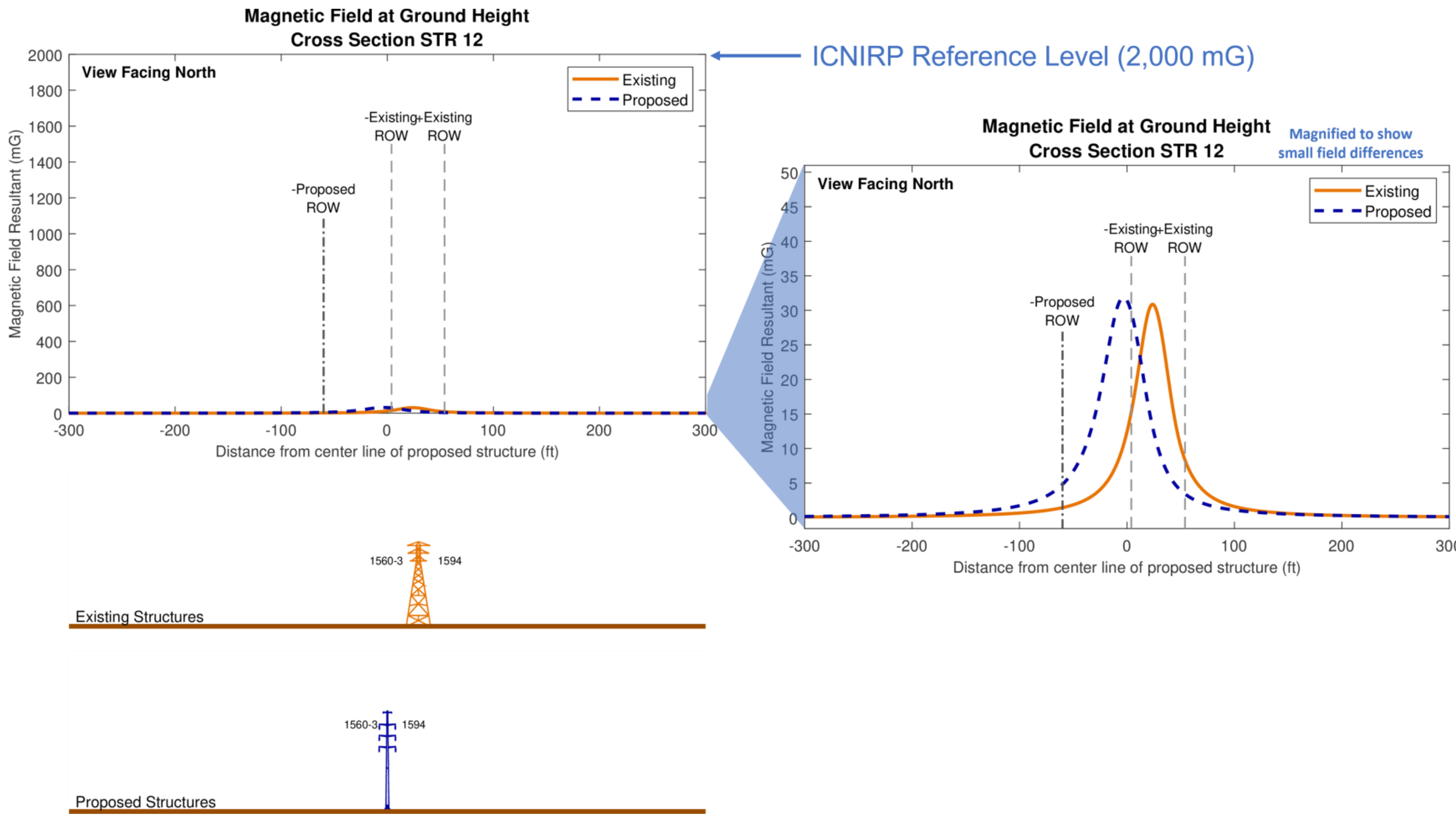

Figure C-12. Magnetic-field profile across Structure 12 (between Indian Well and Ansonia substations) at average loading.

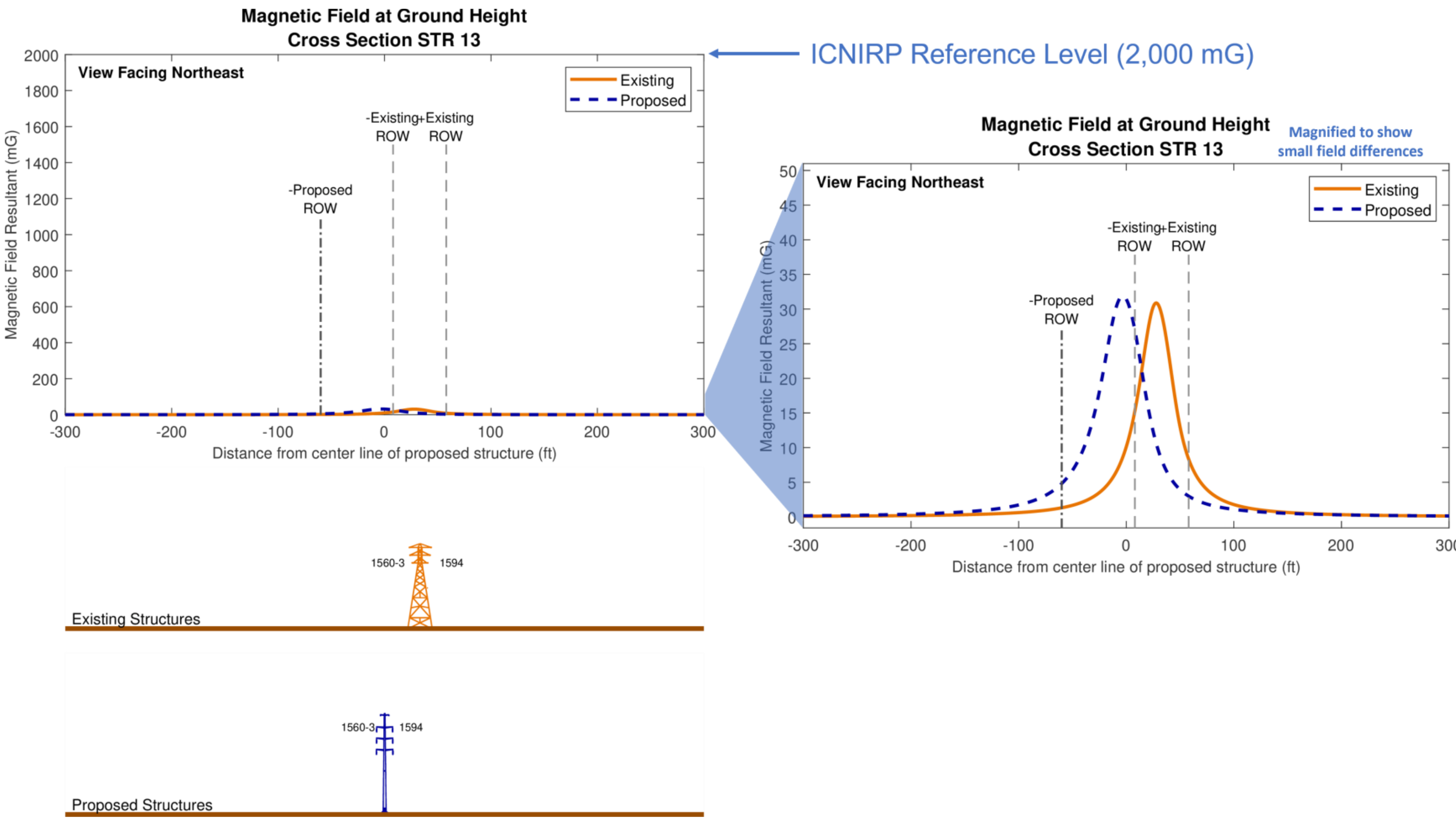

Figure C-13. Magnetic-field profile across Structure 13 (between Indian Well and Ansonia substations) at average loading.

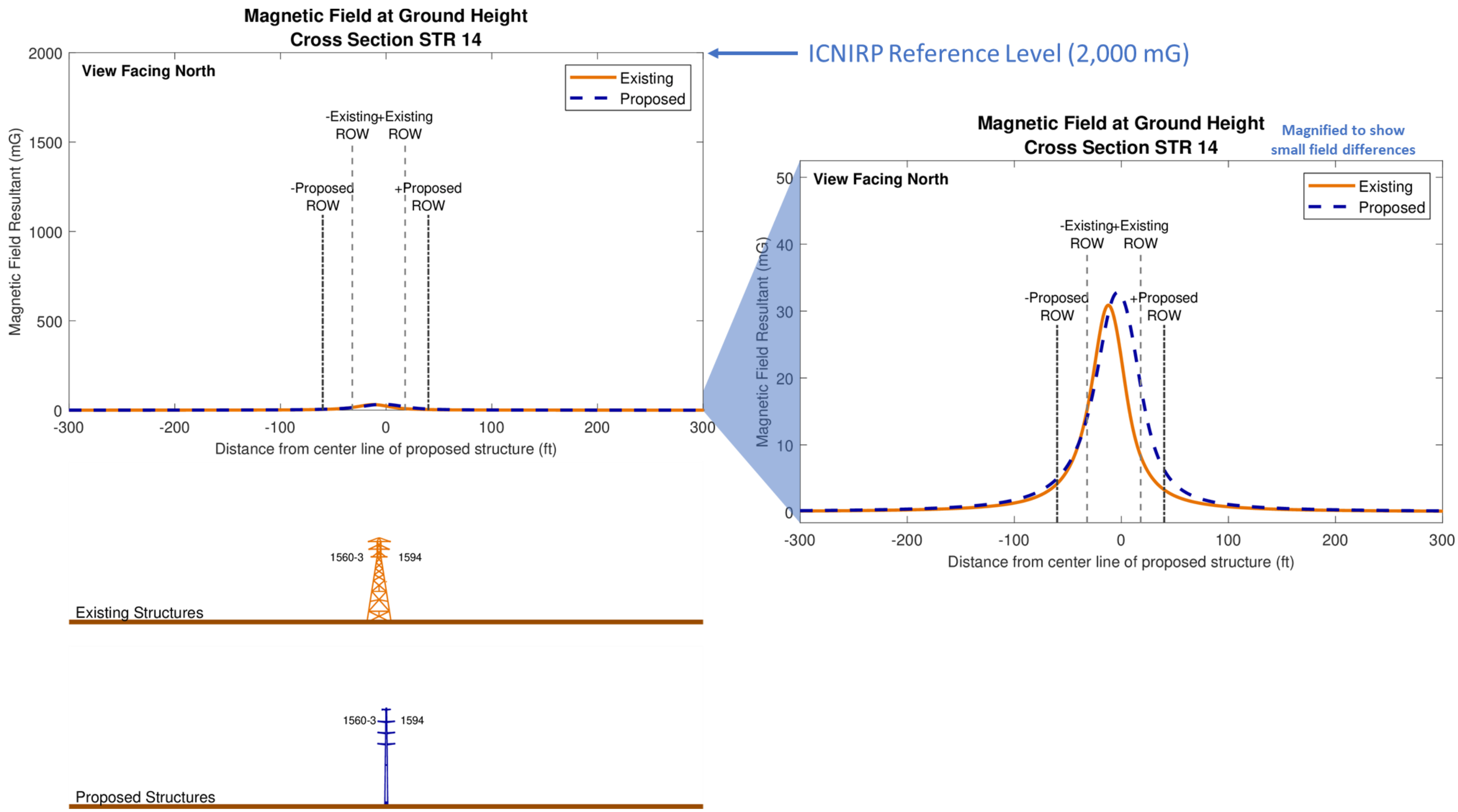

Figure C-14. Magnetic-field profile across Structure 14 (between Indian Well and Ansonia substations) at average loading.

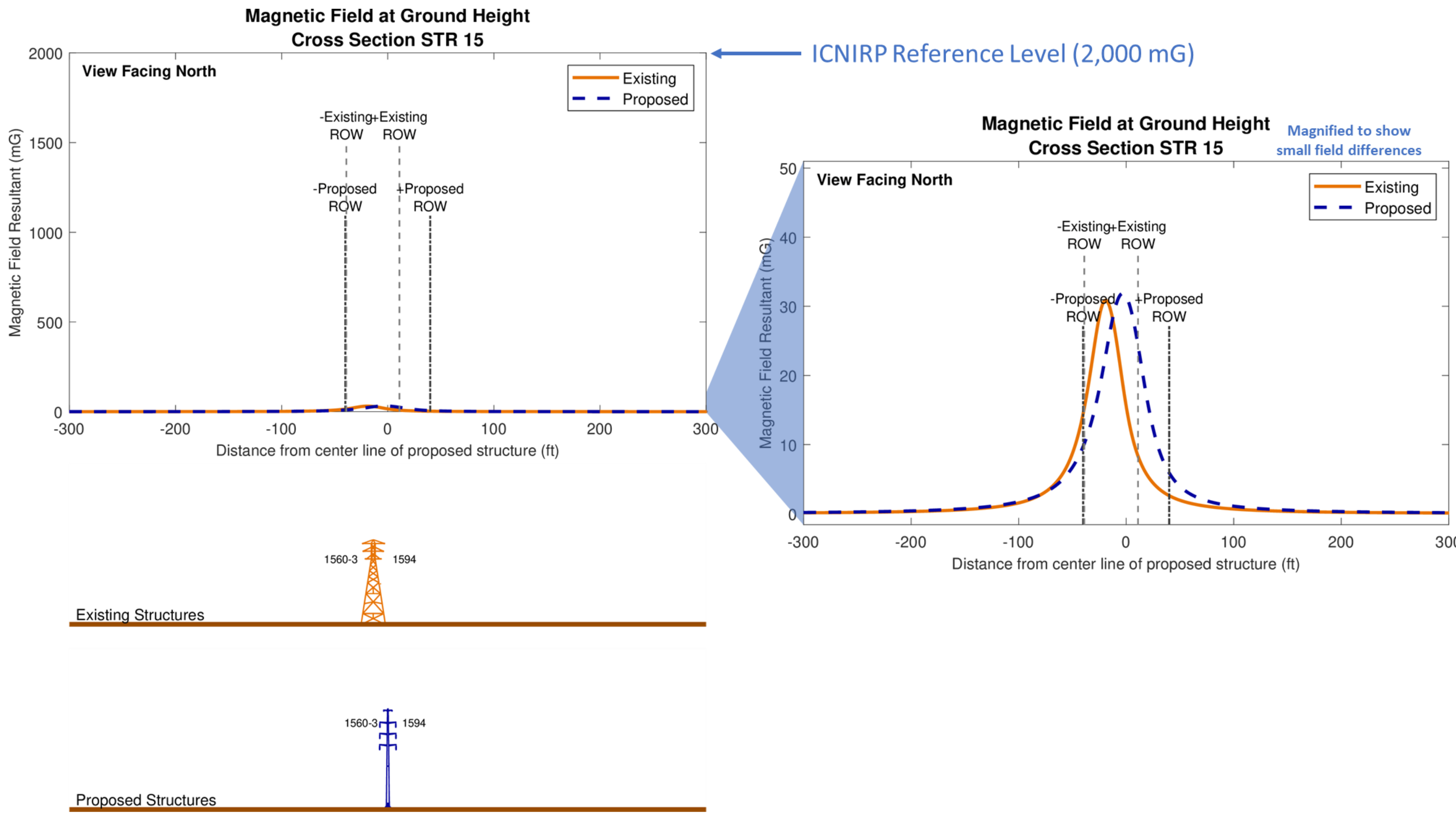

Figure C-15. Magnetic-field profile across Structure 15 (between Indian Well and Ansonia substations) at average loading.

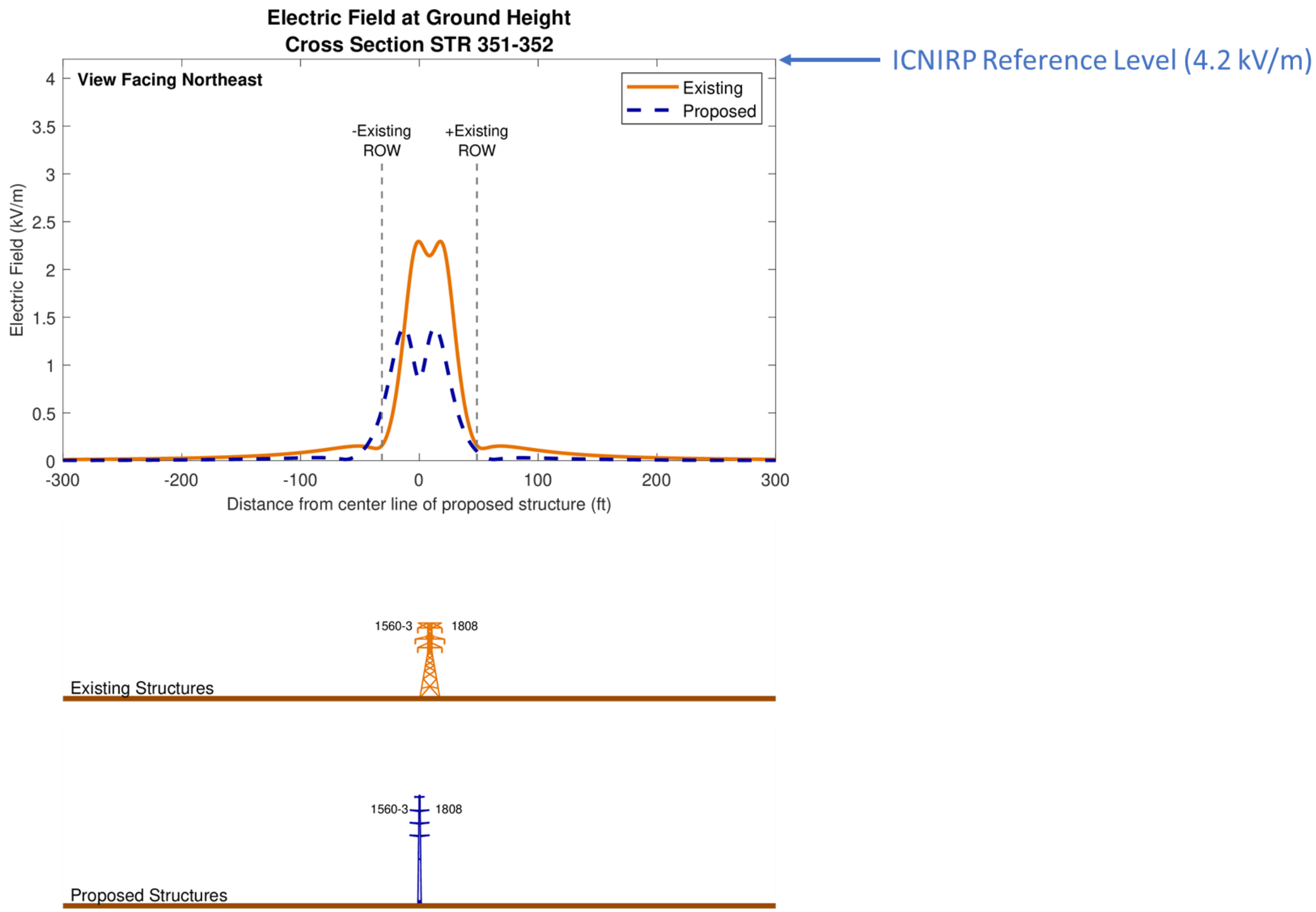

Figure C-16. Electric-field profile across Structures 351 and 352 (between Derby Junction and Indian Well Substation).

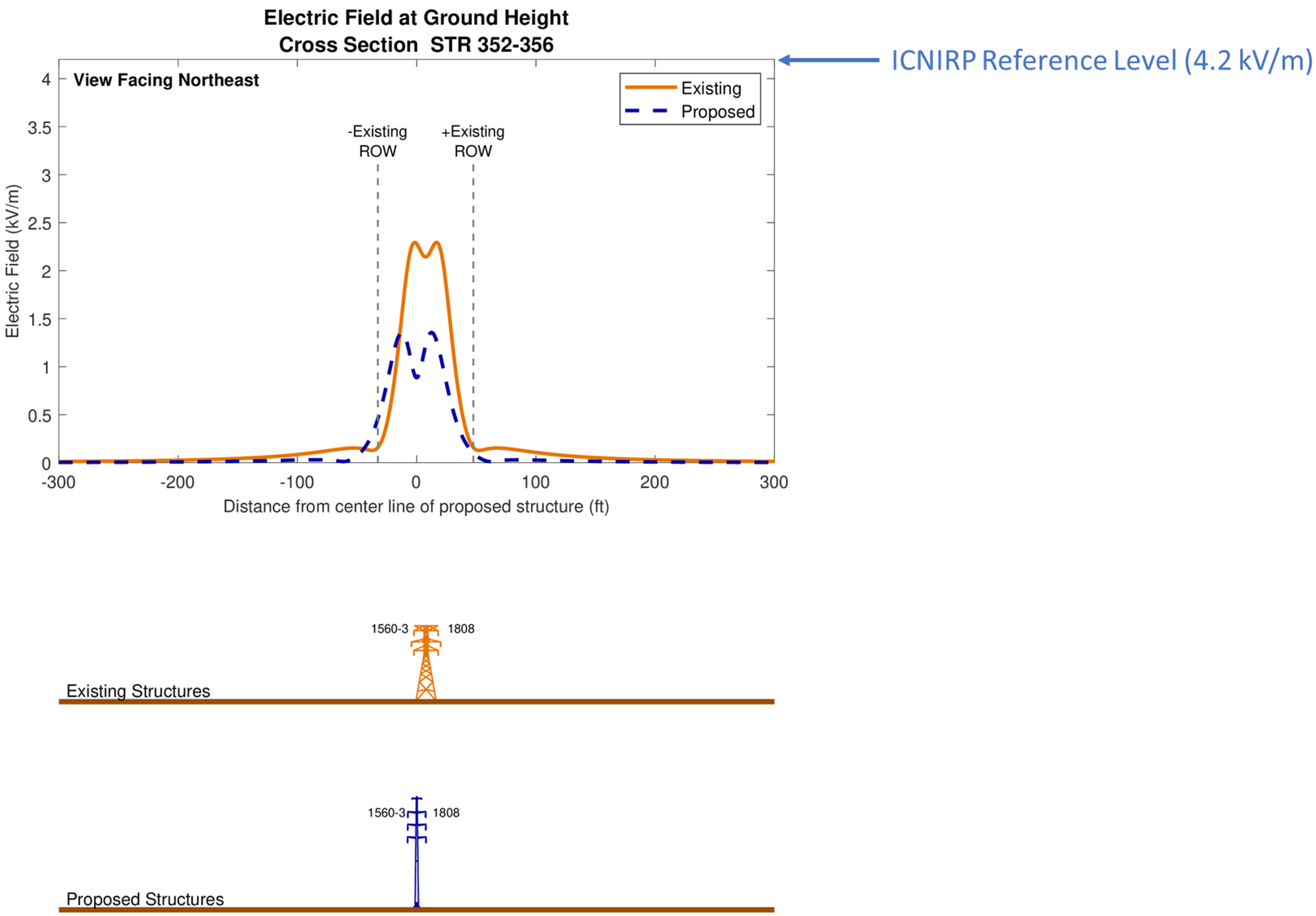

Figure C-17. Electric-field profile across Structures 352 to 356 (between Derby Junction and Indian Well Substation).

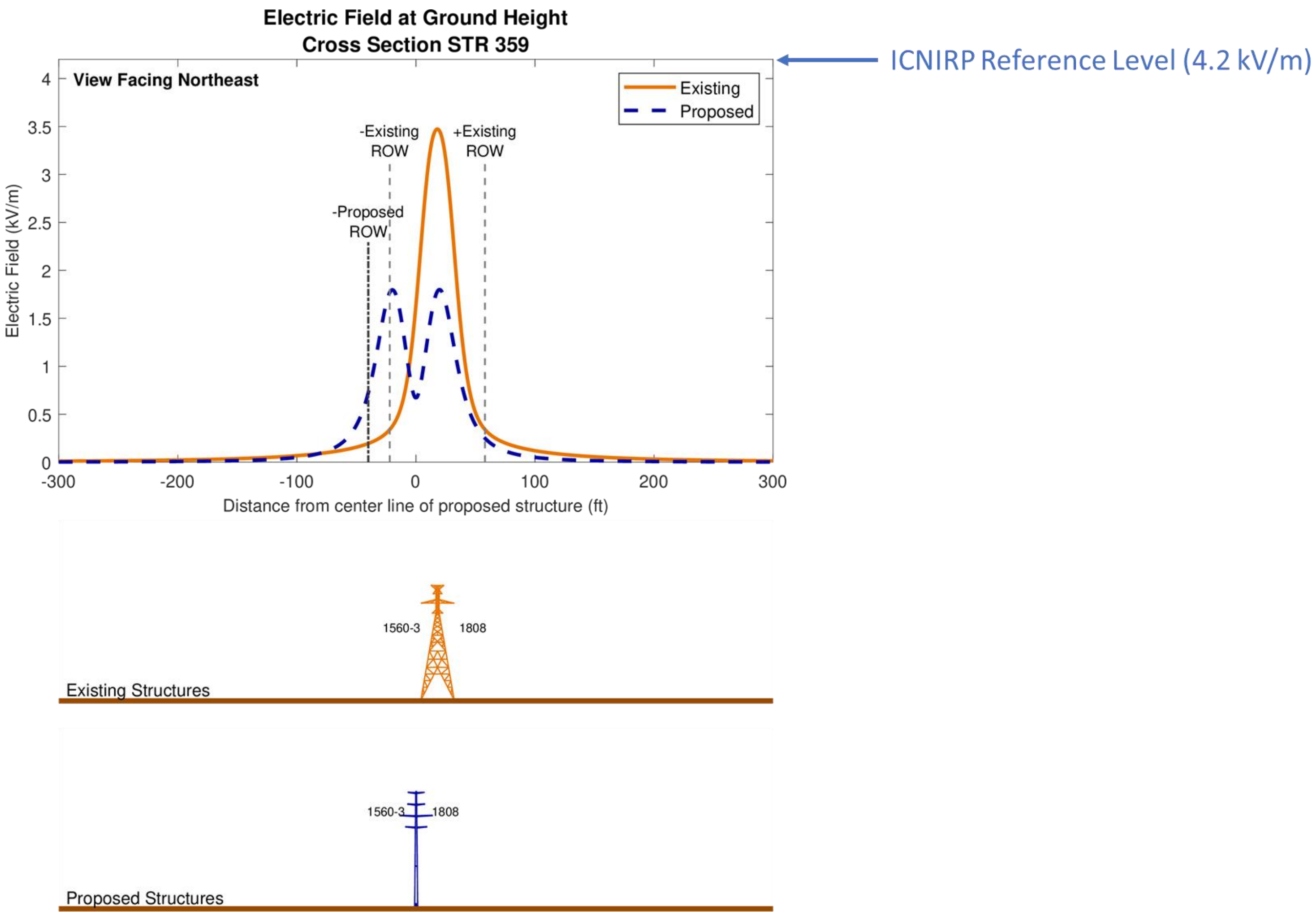

Figure C-18. Electric-field profile across Structure 359 (between Derby Junction and Indian Well Substation).

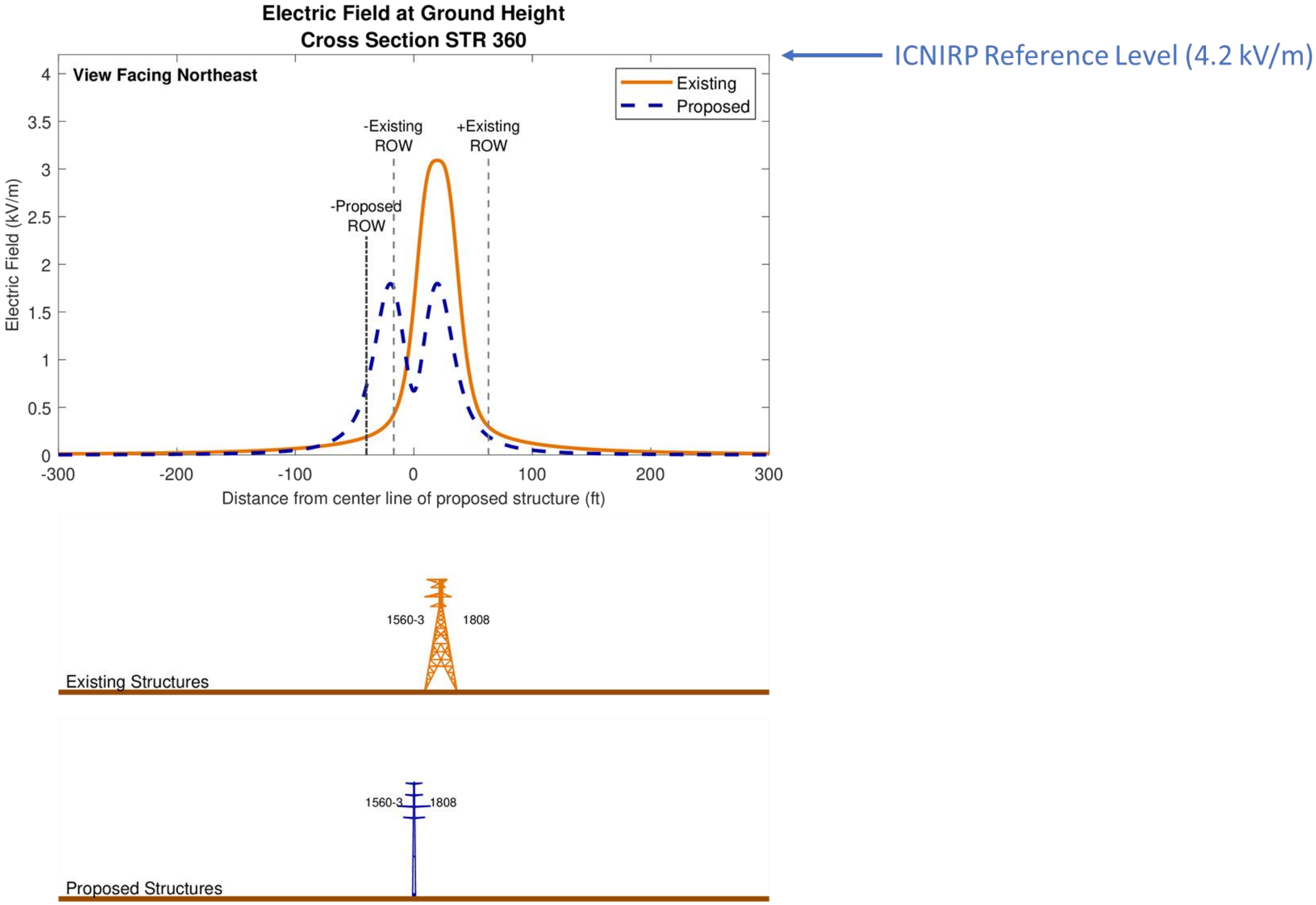

Figure C-19. Electric-field profile across Structure 360 (between Derby Junction and Indian Well Substation).

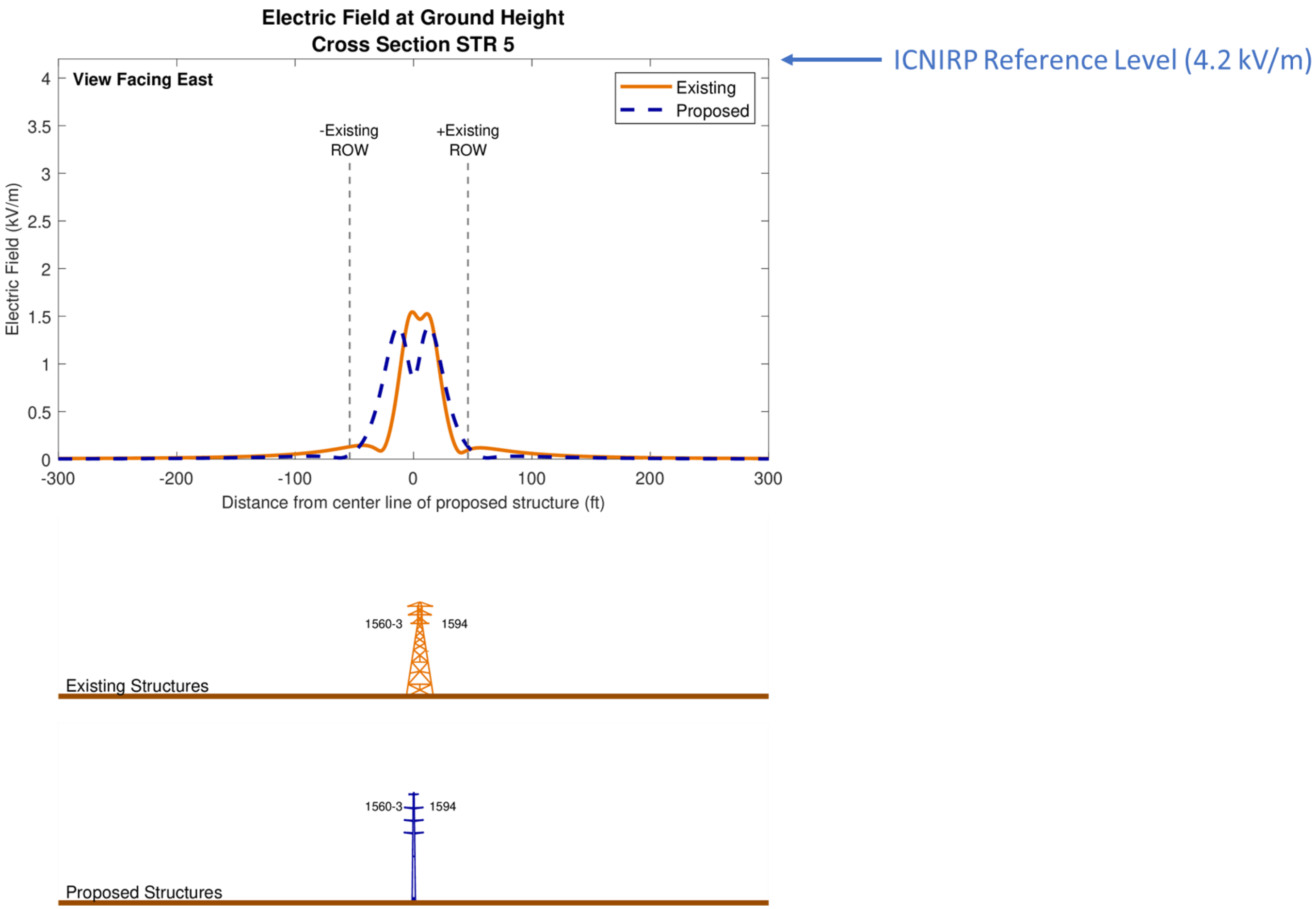

Figure C-20. Electric-field profile across Structure 5 (between Indian Well and Ansonia substations).

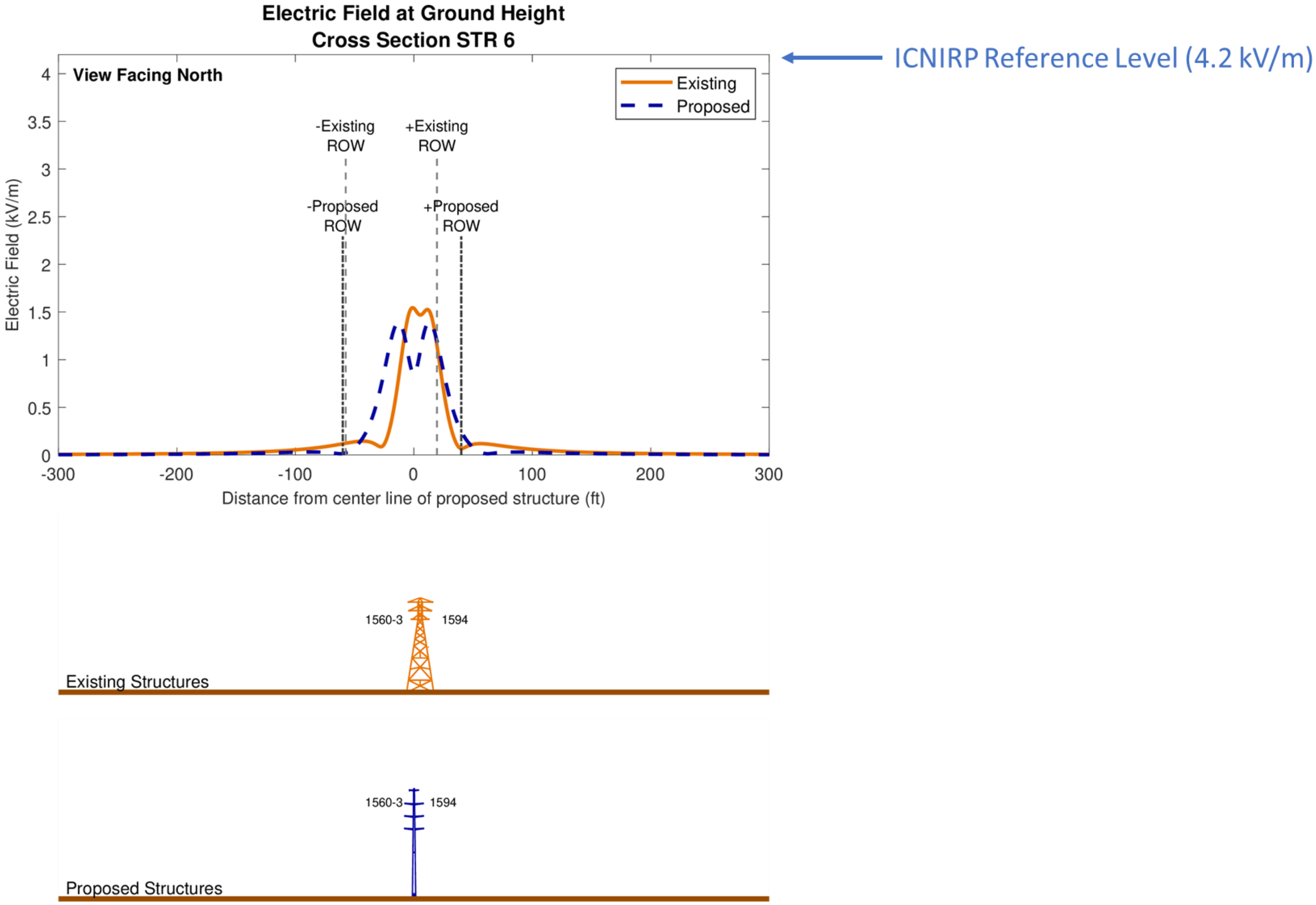

Figure C-21. Electric-field profile across Structure 6 (between Indian Well and Ansonia substations).

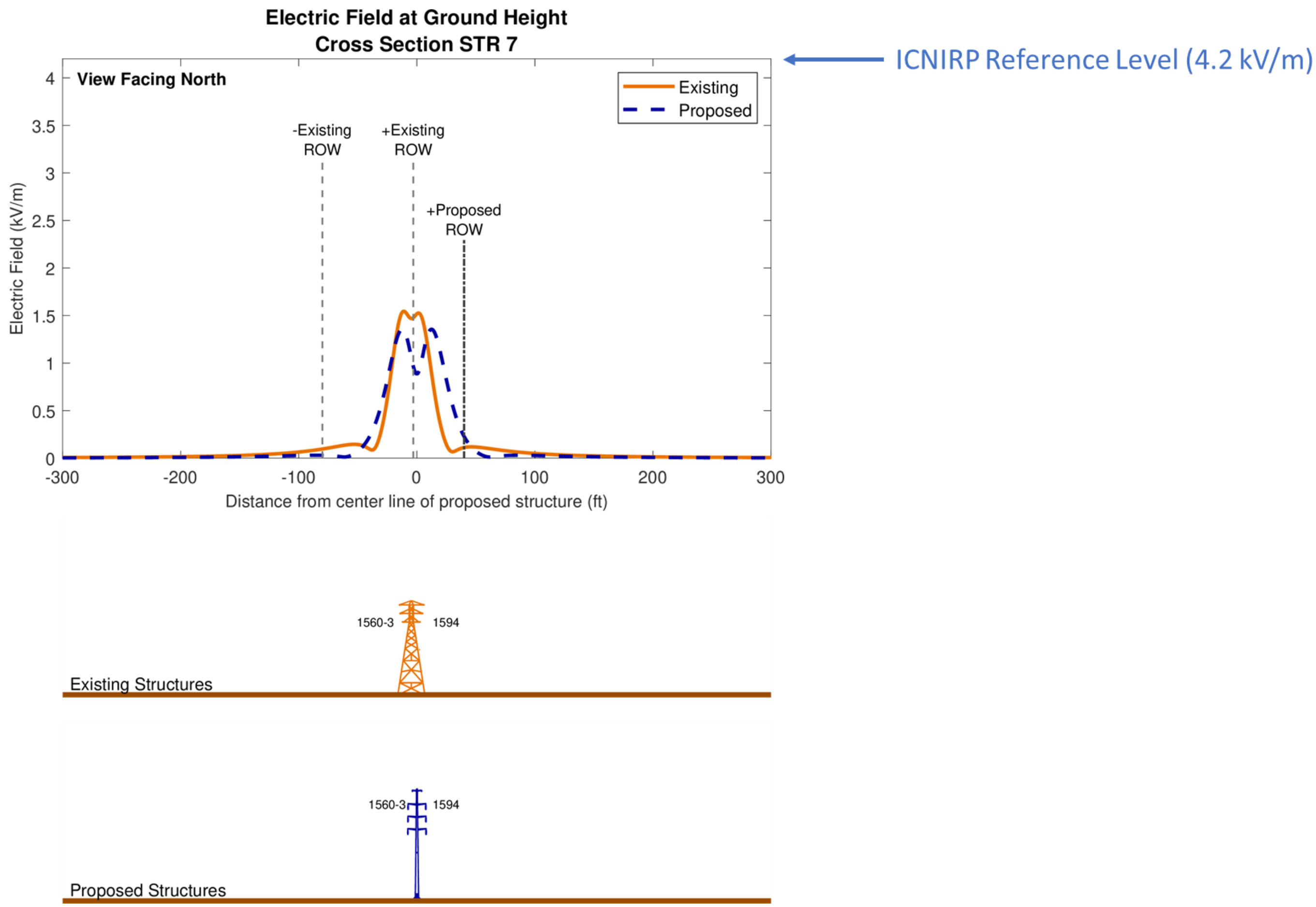

Figure C-22. Electric-field profile across Structure 7 (between Indian Well and Ansonia substations).

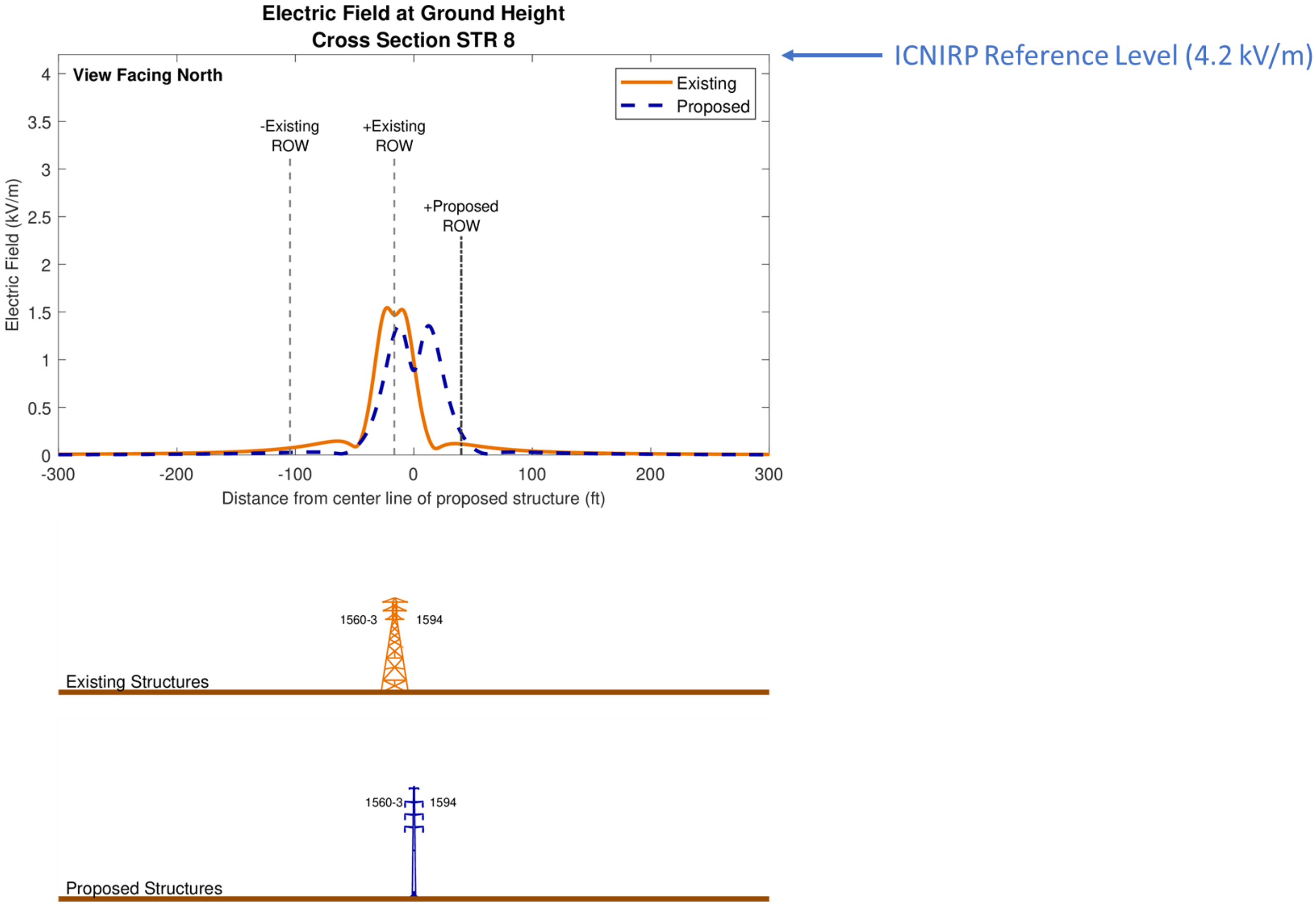

Figure C-23. Electric-field profile across Structure 8 (between Indian Well and Ansonia substations).

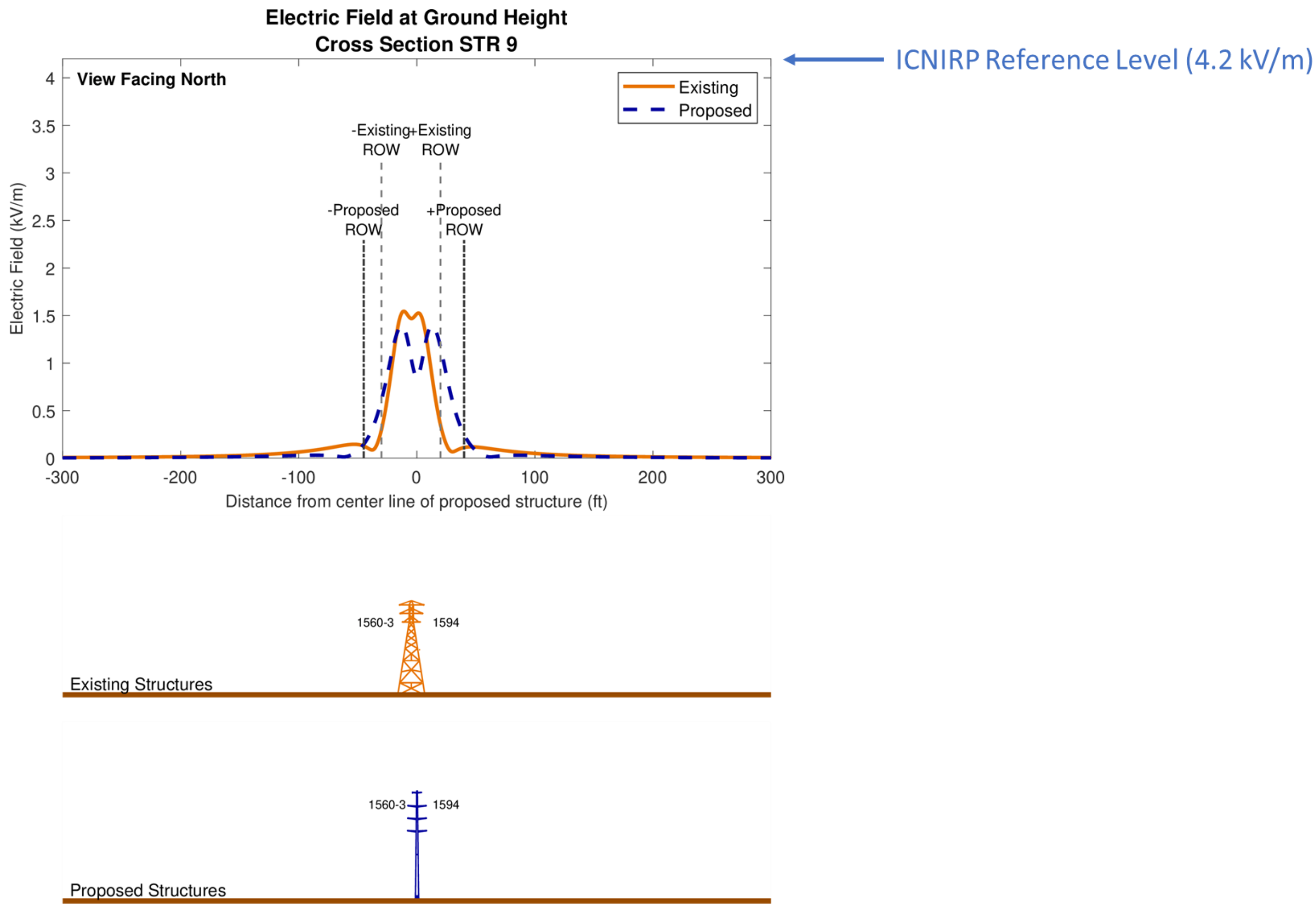

Figure C-24. Electric-field profile across Structure 9 (between Indian Well and Ansonia substations).

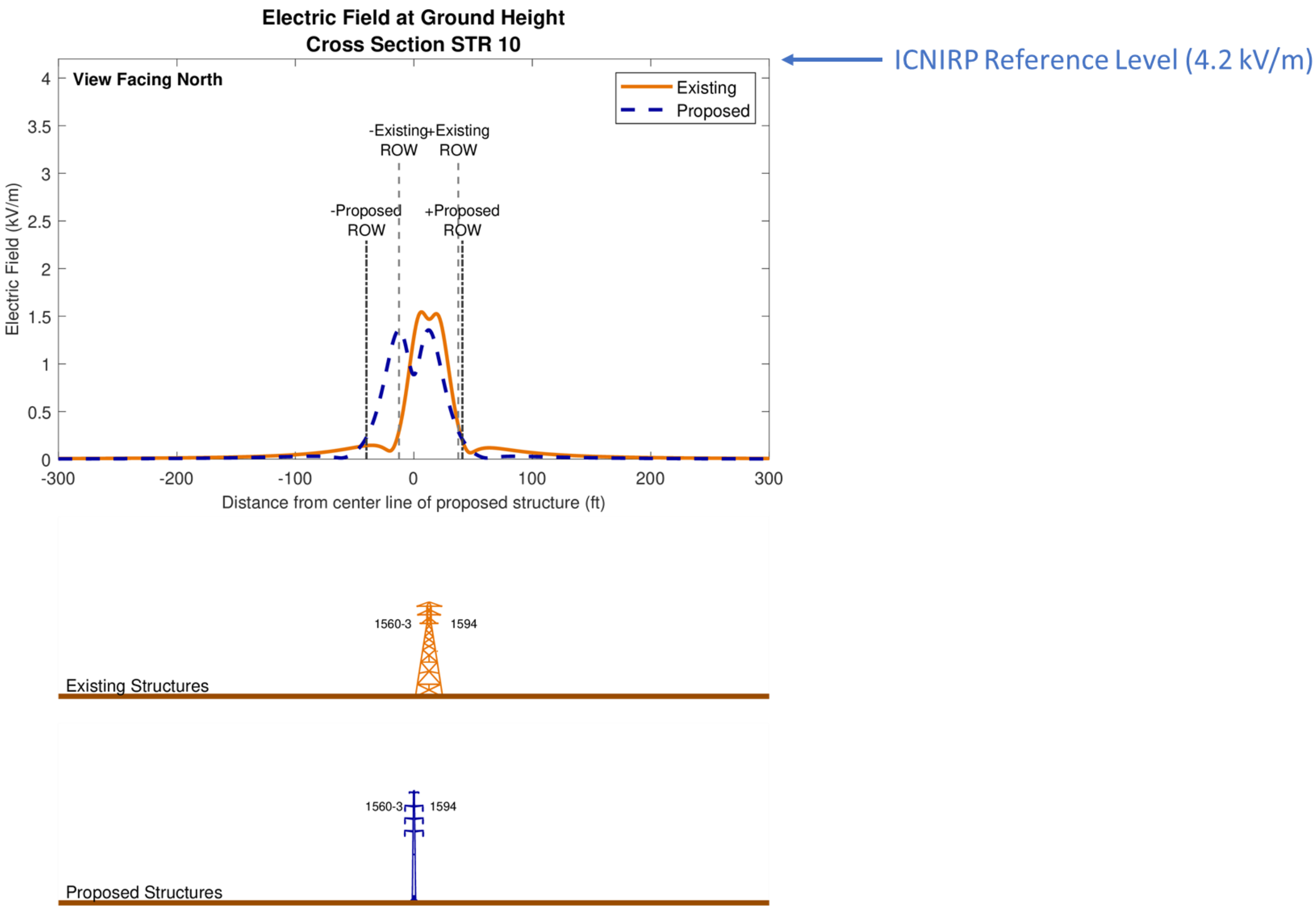

Figure C-25. Electric-field profile across Structure 10 (between Indian Well and Ansonia substations).

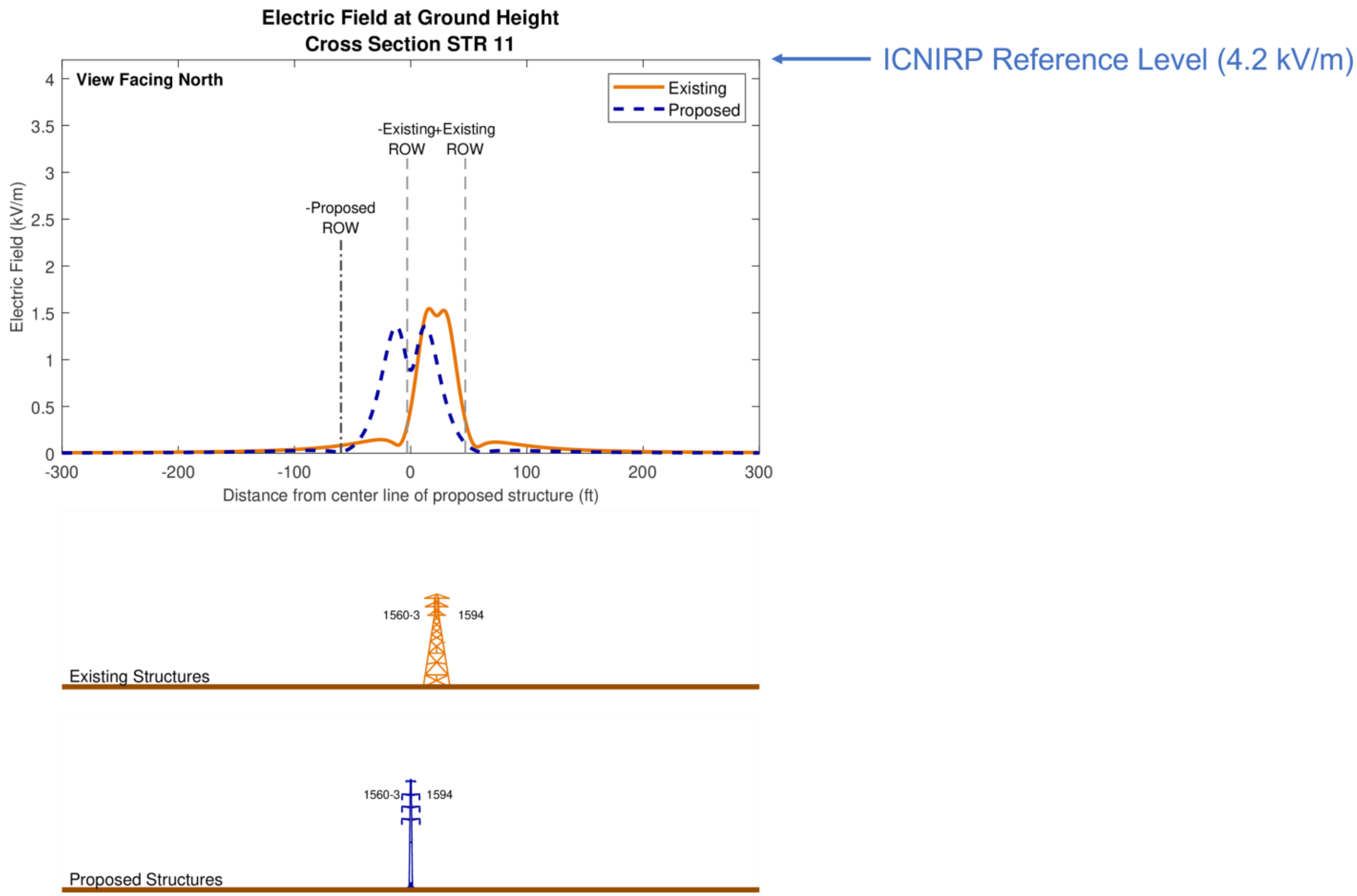

Figure C-26. Electric-field profile across Structure 11 (between Indian Well and Ansonia substations).

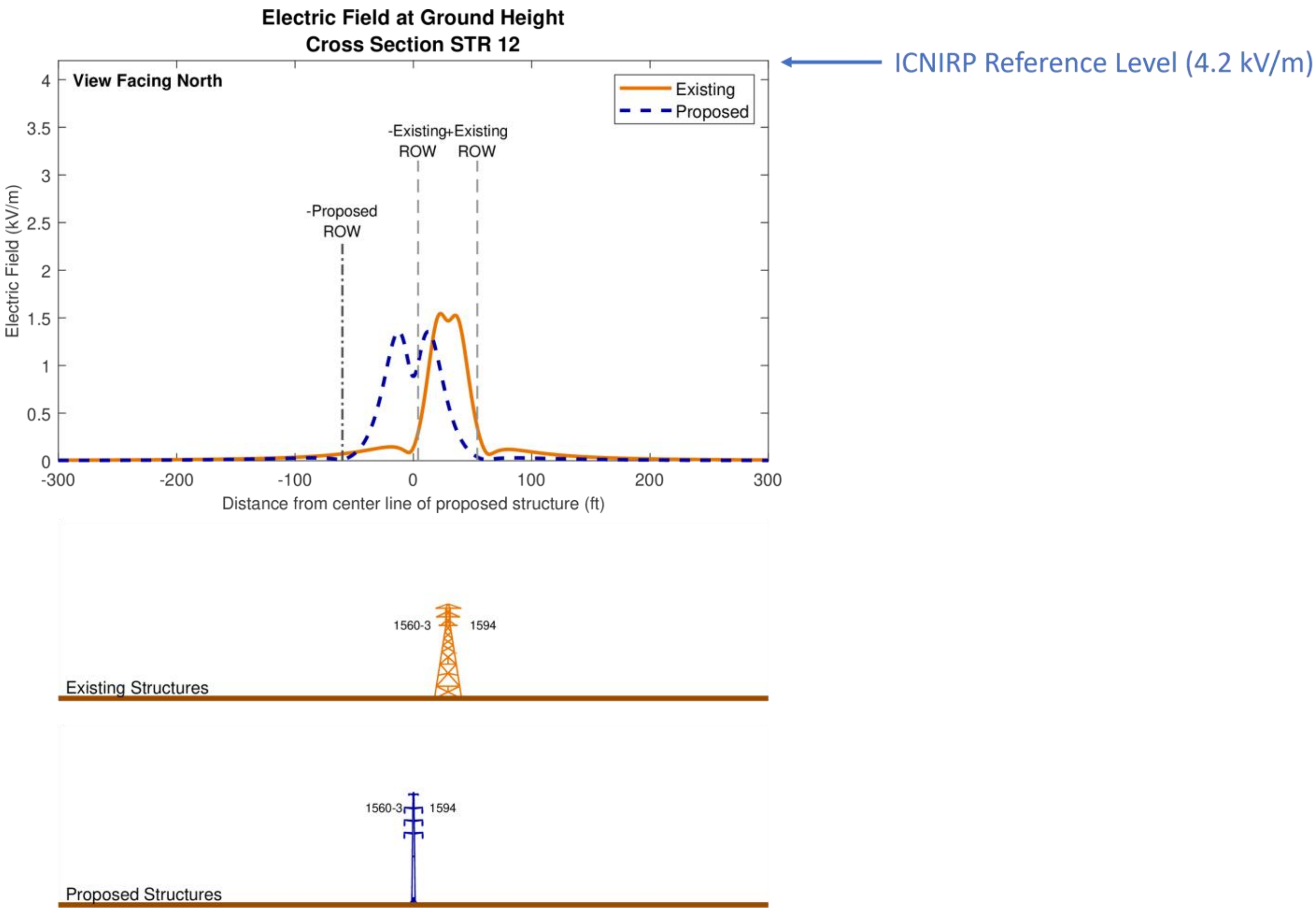

Figure C-27. Electric-field profile across Structure 12 (between Indian Well and Ansonia substations).

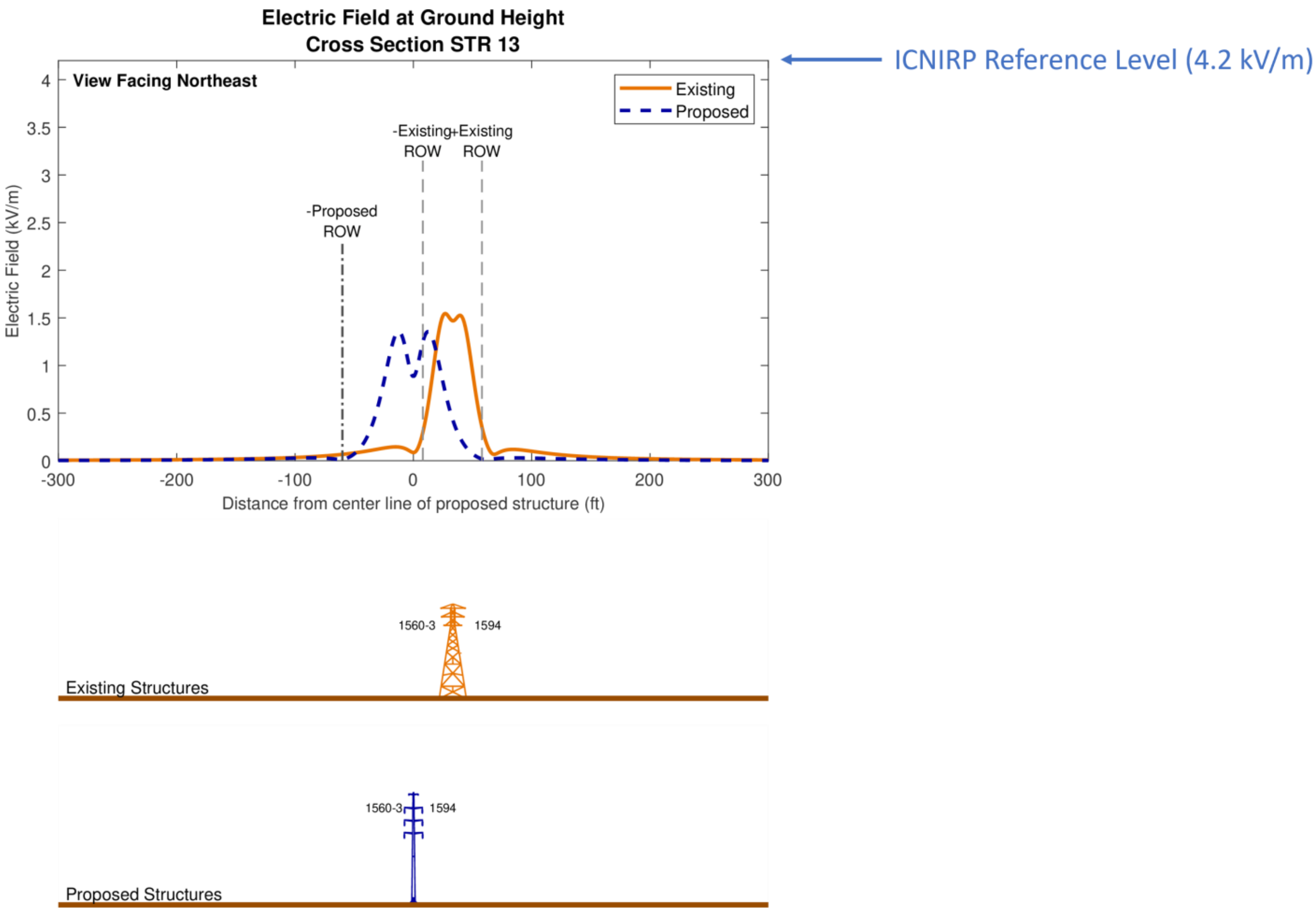

Figure C-28. Electric-field profile across Structure 13 (between Indian Well and Ansonia substations).

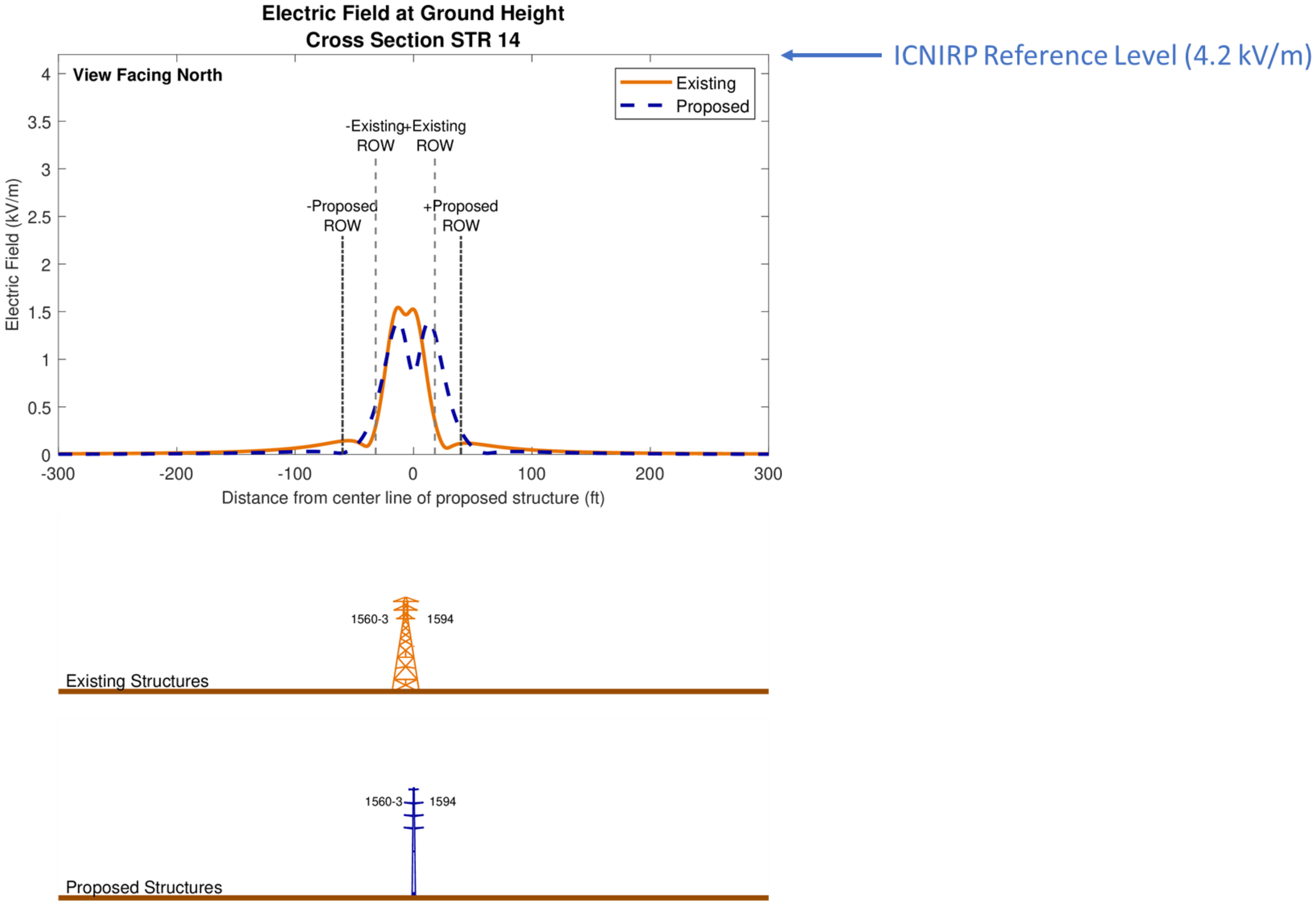

Figure C-29. Electric-field profile across Structure 14 (between Indian Well and Ansonia substations).

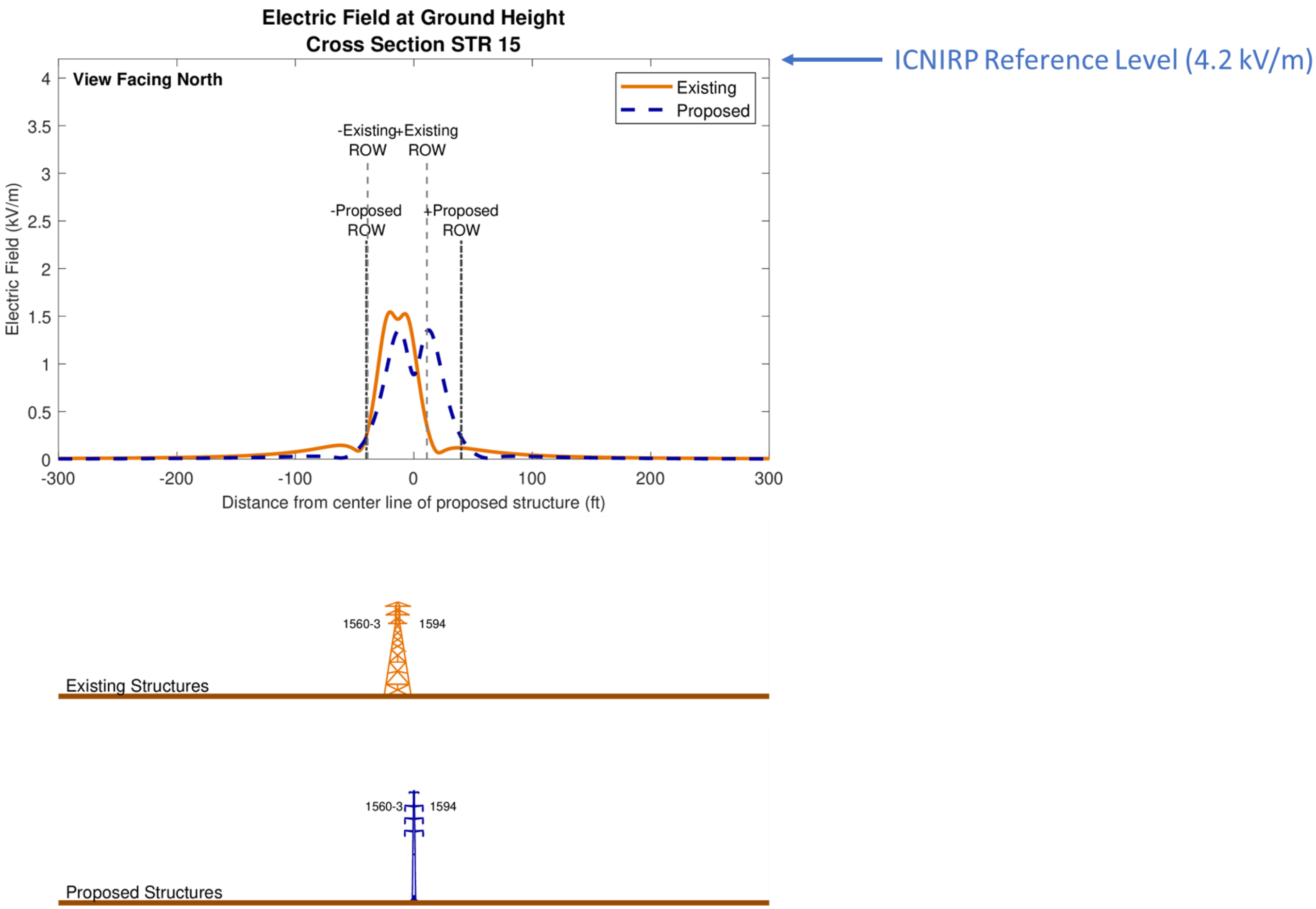

Figure C-30. Electric-field profile across Structure 15 (between Indian Well and Ansonia substations).

Existing

Proposed

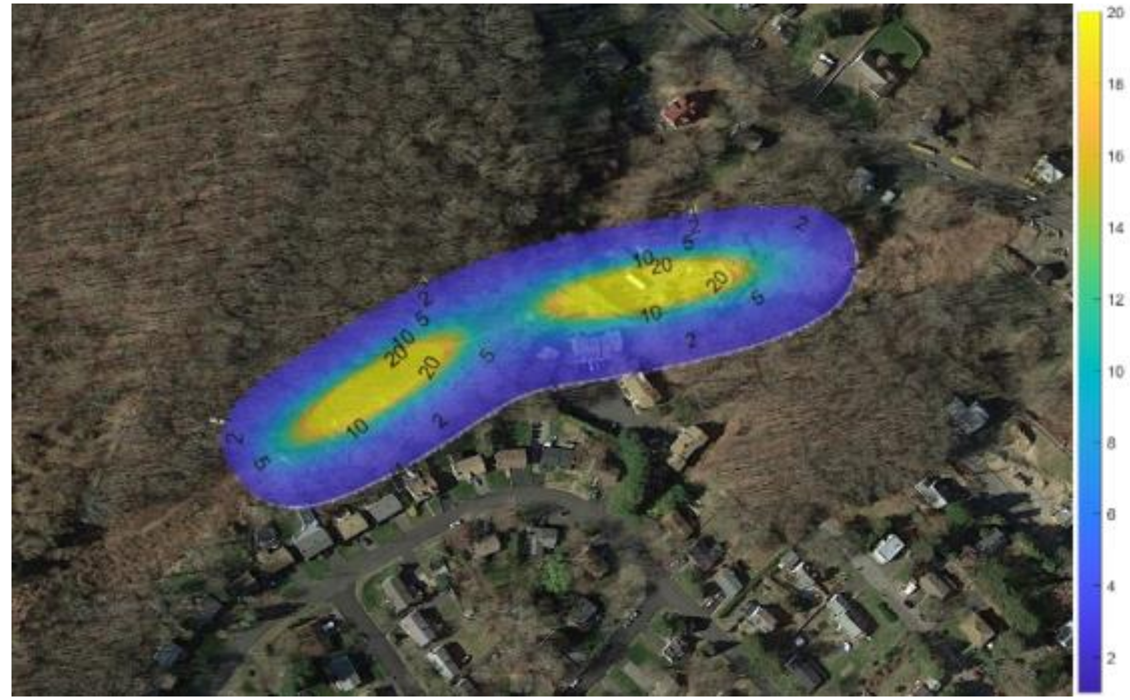

Figure C-31. 3-dimensional magnetic-field (mG) modeling results for Structures 356 to 358 (between Derby Junction and Indian Well Substation). Field levels decrease below 1 mG outside colored areas.

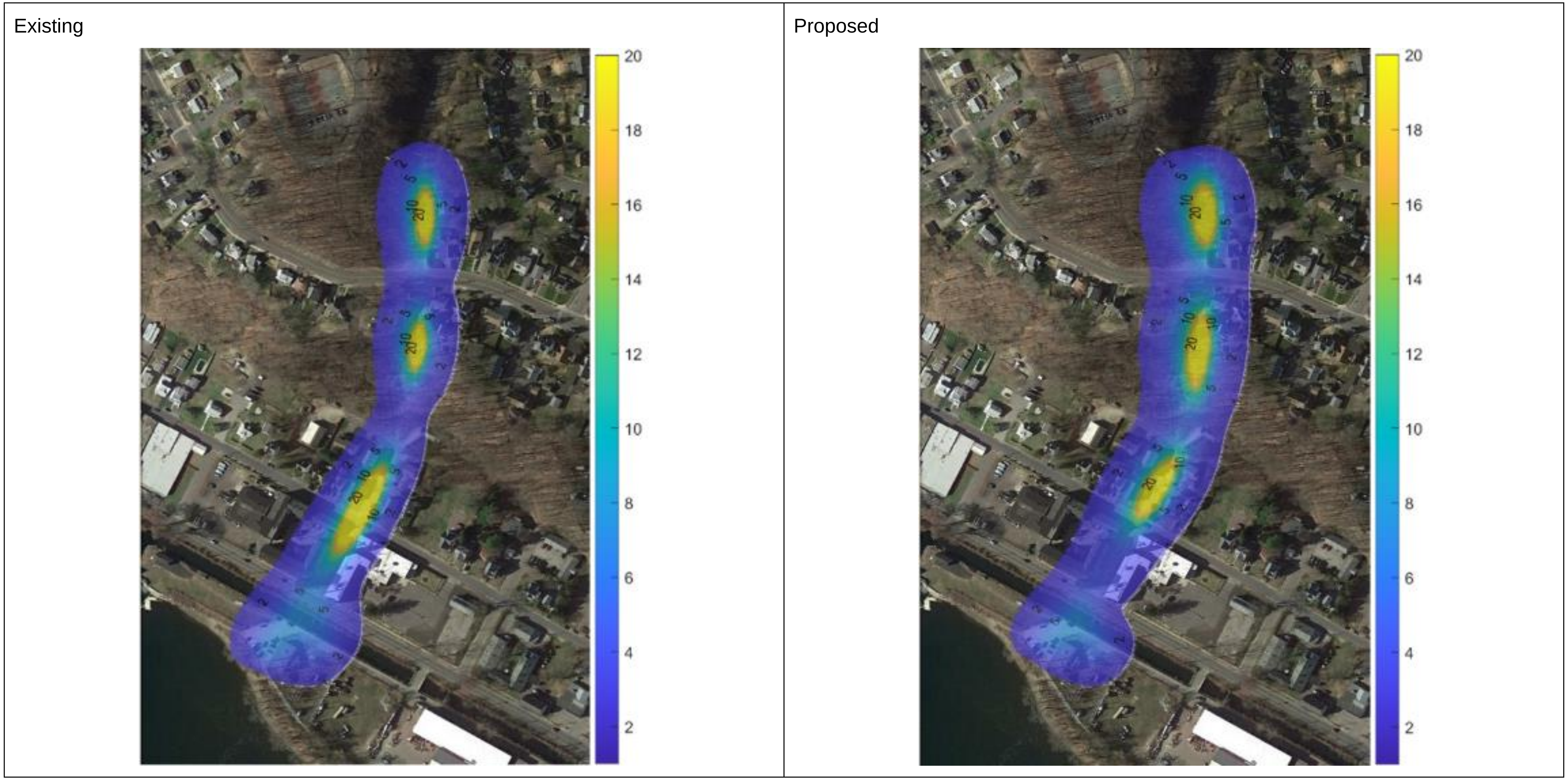

Figure C-32. 3-dimensional magnetic-field (mG) modeling results between Indian Well Substation and Structure 5 (between Indian Well and Ansonia substations). Field levels decrease below 1 mG outside colored areas.

Existing	Proposed
	

Figure C-33. 3-dimensional magnetic field (mG) modeling results between Structure 15 and Ansonia Substation (between Indian Well and Ansonia substations). Field levels decrease below 1 mG outside colored areas.

Attachment D

Pre-Construction EMF Measurements

Pre-Construction Magnetic-Field Measurements

In accordance with CSC guidance measurements of magnetic fields were taken at or near the edges of property boundaries, which included “adjacent schools, daycare facilities, playgrounds, and hospitals (and any other facilities described in Conn. Gen. Stat. § 16-50l)” (CSC, 2016). Existing EMF levels were measured (including at locations as close to the edges of the existing ROW as possible) on February 24, March 2, and March 25, 2022. The measurements were taken at a height of approximately 1 meter (3.28 feet) above ground in general accordance with the standard methods for measuring EMF near power lines (IEEE Std. 644-2019). EMF levels were expressed as the total field computed as the resultant of field vectors measured along vertical, transverse, and longitudinal axes.[16] The magnetic field was measured in units of mG by orthogonally-mounted sensing coils whose outputs were logged by a digital recording meter (EMDEX II) manufactured by Enertech Consultants, which meets the requirements of IEEE Standard (1308-1994) for obtaining accurate field measurements at power line frequencies. Electric-field levels were measured using an accessory electric-field probe using the EMDEX II meter. These instruments meet the IEEE instrumentation standard for obtaining accurate field measurements at power line frequencies. The meters were calibrated by the EMDEX LLC by methods like those described in IEEE Std. 644-2019. A calibration certificate is provided in Attachment E.

The locations identified by UI for measurements are summarized in Table D-1, and were grouped together for ease of measurements (non-residential areas are highlighted in blue). Figure D-1 depicts the existing transmission line ROW and an indication of the 300-foot distance from the existing transmission line centerline. Along this route, Exponent made EMF measurements along the existing ROW where safely accessible. Close-up depictions of these route sections are provided in Figure D-2 and Figure D-3.

[16] Measurements along the vertical, transverse, and longitudinal axes were recorded as root-mean-square magnitudes. Root mean square refers to the common mathematical method of defining the effective voltage, current, or field of an alternating-current system.

Table D-1. Locations identified for measurements by UI

Location Name	Category	Location Address	Route Segment (See Figure 4)	Model
Public Area 1 (Gilder Boathouse)	School	280 Roosevelt Dr Derby, CT	Between Indian Well and Ansonia substations	STR 360
Public Area 2 (Derby High School)	School	75 Chatfield St. Derby, CT	Between Indian Well and Ansonia substations	STR 7
Public Area 3 (Dog Park)	Parks & Recreation	Coon Hollow Rd Derby, CT	Between Indian Well and Ansonia substations	STR 8 STR 9
Public Area 4 (Nolan Athletic Complex)	Parks & Recreation	Ansonia, CT	Between Indian Well and Ansonia substations	3-D modelling
Residential Area 1	Residential	Shelton, CT	Between Derby Junction and Indian Well Substation	STR 352-356
Residential Area 2	Residential	Shelton, CT	Between Derby Junction and Indian Well Substation	STR 352-356
Residential Area 3	Residential	Shelton, CT	Between Derby Junction and Indian Well Substation	3-D Modelling
Residential Area 4	Residential	Derby, CT	Between Indian Well and Ansonia substations	3-D Modelling
Residential Area 5	Residential	Derby, CT	Between Indian Well and Ansonia substations	STR 5; STR 6
Residential Area 6	Residential	Derby, CT	Between Indian Well and Ansonia substations	STR 10 STR 11
Residential Area 7	Residential	Ansonia, CT	Between Indian Well and Ansonia substations	STR 12 STR 13 STR 14
Residential Area 8	Residential	Ansonia, CT	Between Indian Well and Ansonia substations	3-D Modelling

Measurements in each of the areas identified in Table D-1 are identified graphically in Figure D-4 through Figure D-6. .

Table D-2 provides a statistical summary of the magnetic-field measurements. Table D-3 provides extrapolated values based on scaling the measured magnetic-field levels to average and peak loading.

Exponent also measured magnetic-field levels across a transect of the transmission line approximately 1,000 feet from Derby Junction. Figure D-2 depicts this transect measurement path in pink overlayed on Google Earth satellite imagery. The EMF transect measurement results are provided in Figure D-7.

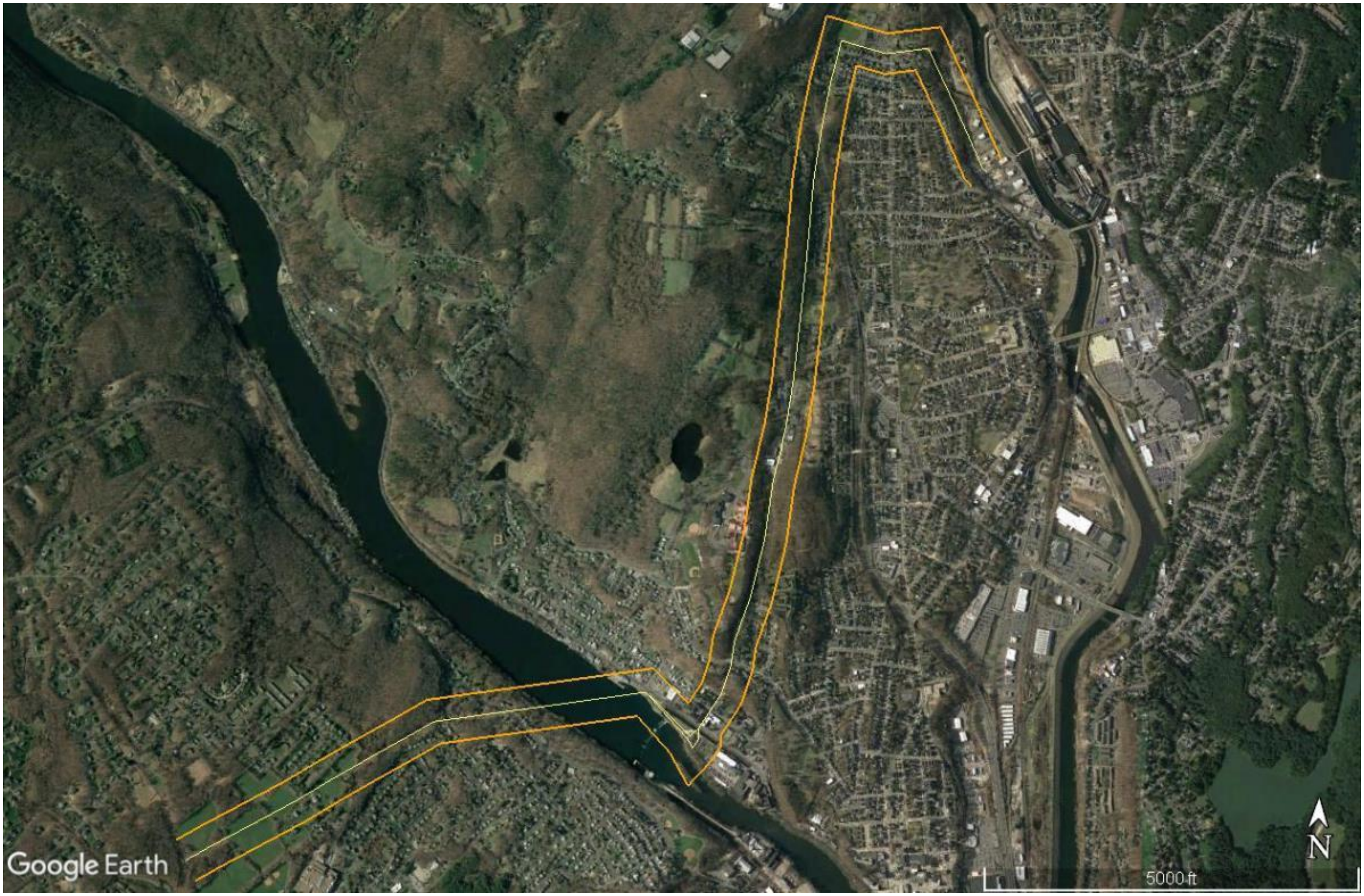

Figure D-1. Google Earth satellite mapping of the transmission line route. Orange lines show the distance of 300 feet from the existing transmission line.

Figure D-2. Google Earth satellite mapping showing areas where magnetic-field measurements were obtained along approximately 0.9 miles of the portion of the route between Derby Junction and the Housatonic River (in Shelton) and on both sides of the ROW edges where possible. Residential areas within 300 feet of the route are represented with yellow polygons and indicated as residential areas R1, R2, and R3. The pink line represents the 300-foot transect. Measurement results for the transect are shown below in Figure D-7.

Figure D-3. Google Earth satellite mapping showing areas where magnetic-field measurements were obtained within residential area R4 and public area A1 (light-blue region). Orange lines show the distance of 300 feet from the existing transmission line.

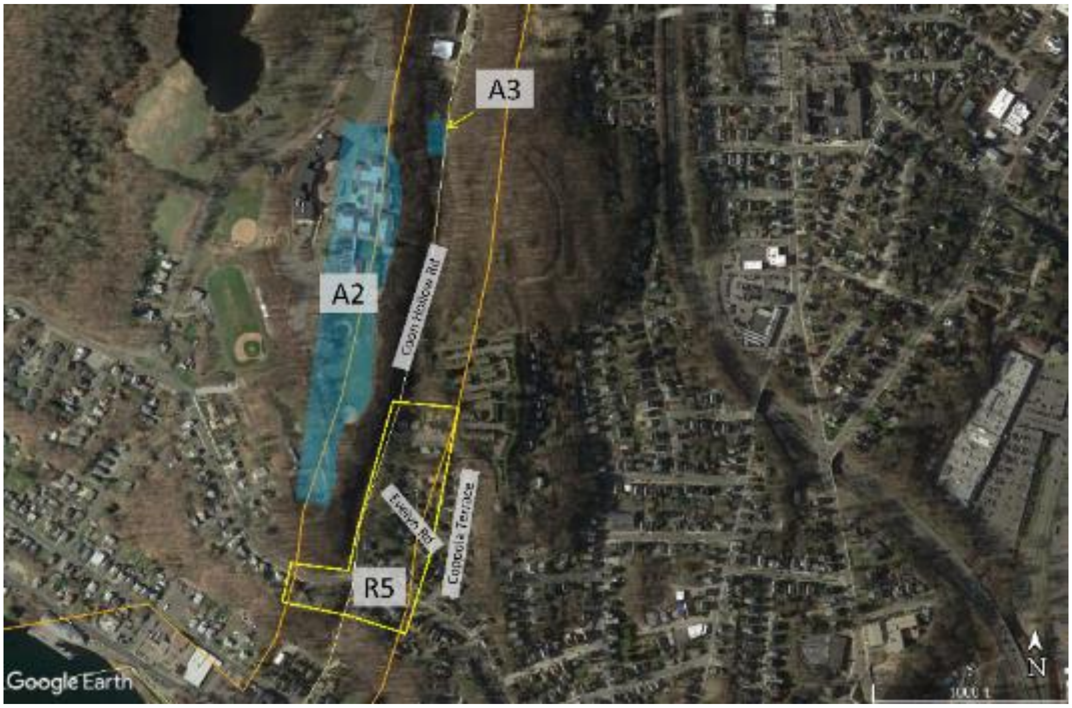

Figure D-4. Google Earth satellite mapping showing areas where magnetic-field measurements were obtained within residential area R5 and public areas A2 and A3 (light-blue regions).

Figure D-5. Google Earth satellite mapping showing areas where magnetic-field measurements were obtained within residential areas R6 and R7.

Figure D-6. Google Earth satellite mapping showing areas where magnetic-field measurements were obtained within residential area R8 and public area A4.

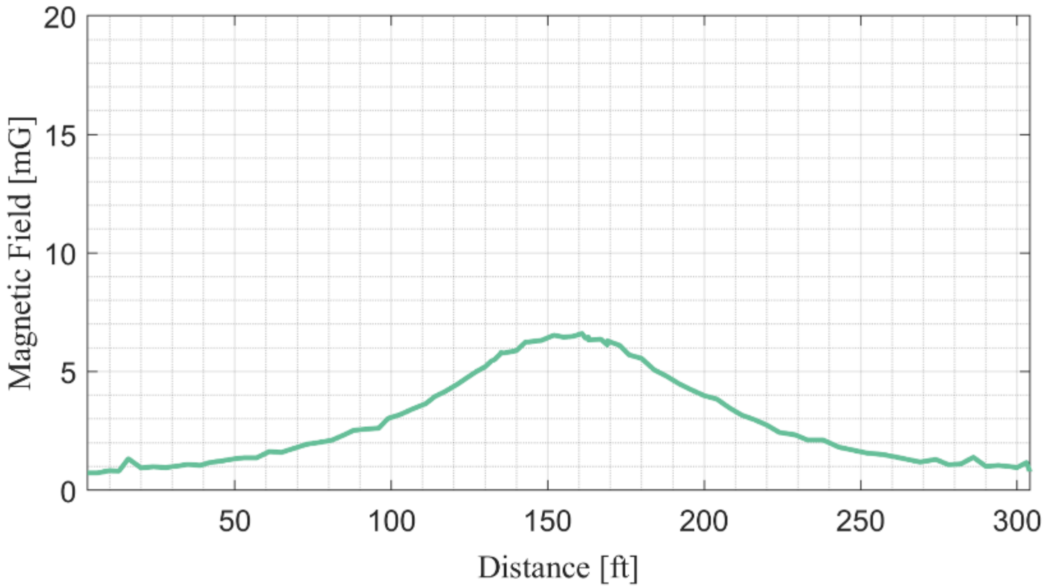

Figure D-7. Magnetic-field measurements collected along the transect path depicted in Figure D-2.

Table D-2. Measured EMF levels along the Project route

Location	Measured magnetic field (mG)			Measured electric field (kV/m)		
	Minimum	Mean	Maximum	Minimum	Mean	Maximum
Public Area 1 (Gilder Boathouse)	1.4	1.4	1.8	0.007	0.023	0.053
Public Area 2 (High School)	<0.1	<0.1	0.9	0	0.007	0.028
Public Area 3	1.8	1.8	2.4	0.005	0.088	0.199
Public Area 4	0.1	0.1	2.6	0.037	0.150	0.476
Residential Area 1	0.3	0.3	4.9	0	0.045	0.157
Residential Area 2	0.5	0.5	5.9	0.010	0.057	0.101
Residential Area 3	0.5	0.5	3.5	0	0.041	0.141
Residential Area 4 (B St)	1.3	1.3	3.5	0.010	0.039	0.065
Residential Area 5 (Coon Hollow Road, Evelyn, & Coppola Terrace)	0.1	0.1	2.3	0	0.042	0.130
Residential Area 6 (Hawking & W Roads)	0.1	0.1	0.5	0.005	0.039	0.086
Residential Area 6 (Silver Hill Road)	0.1	0.1	0.8	0	0.102	0.246
Residential Area 7 (Adanti Avenue)	<0.1	<0.1	0.2	0	0.046	0.075
Residential Area 7 (Reichelt Terrace)	<0.1	<0.1	0.5	0.005	0.011	0.022
Residential Area 8 (Hart Lane)	0.2	0.2	1.3	0.027	0.027	0.027
Residential Area 8 (Willow Street)	0.9	0.9	1.8	0.027	0.080	0.145
Residential Area 8 (Hull Street)	0.4	0.4	1.8	0.005	0.054	0.145
Residential Area 8 (Scotland Street)	0.2	0.2	1.8	0.022	0.044	0.068
Residential Area 8 (Franklin Street)	1.8	1.8	6.1	0.011	0.014	0.017

Table D-3. Measured magnetic-field levels extrapolated to average and peak loading

Location	Measured magnetic field (mG)			Magnetic fields extrapolated to peak loading			Magnetic fields extrapolated to average loading		
	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum
Public Area 1 (Gilder Boathouse)	1.4	1.8	2.3	4.7	6.1	7.8	4.7	6.1	7.8
Public Area 2 (High School)	0.05	0.9	7.5	0.2	2.9	24	0.2	2.8	23
Public Area 3 (Dog Park)	1.8	2.4	3.1	5.8	7.8	10	5.6	7.4	9.6
Public Area 4 (Nolan Ball Field)	0.1	2.6	6	0.3	7.9	18	0.3	7.5	17

Attachment E

Calibration Certificate

Certificate of Calibration

The calibration of this instrument was controlled by documented procedures as outlined on the Certificate of Testing Operations and Accuracy Report using equipment traceable to N.I.S.T., ISO/IEC 17025:2017(E), and ANIZ540-1 COMPLIANT.

Instrument Model: EMDEX II - Standard

Frequency: 60 Hz

Serial Number: 1134

Date of Calibration: 03/19/2021

Re-calibration suggested at one year from above date.

EMDEX LLC

Calibration Inspector: H. Christopher Hooper

EMDEX LLC
1356 Beaver Creek Drive
Patterson, California 95363
(408) 866-7266

Certificate of Calibration

The calibration of this instrument was controlled by documented procedures as outlined on the Certificate of Testing Operations and Accuracy Report using equipment traceable to N.I.S.T., ISO/IEC 17025:2017(E), and ANIZ540-1 COMPLIANT.

Instrument Model: EMDEX II - Standard

Frequency: 60 Hz

Serial Number: 1134

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