Electric and Magnetic Field Assessment: The West Bartlett Substation

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Prepared for

GEI Consultants, Inc., P.C.
110 Walt Whitman Road, Suite 204
Huntington Station, NY 11746

Prepared by

Exponent®
420 Lexington Ave.
Suite 1740
New York, NY 10170

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Notice

At the request of Public Service Enterprise Group – Long Island (PSEG-LI) and GEI Consultants, Inc. P.C., Exponent modeled the magnetic-field levels associated with the proposed West Bartlett Substation in the Town of Brookhaven, New York. 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 PSEG-LI. We cannot verify the correctness of this input data, and rely on the client for the data's accuracy. 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. PSEG LI has confirmed to Exponent that the summary of data provided to Exponent contained herein is not subject to Critical Energy Infrastructure Information (CEII) restrictions.

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 readers of this report outside of the regulatory proceedings relating to this Project, and any re-use of this report or its findings, conclusions, or recommendations presented herein 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

Public Service Enterprise Group of Long Island (PSEG-LI) has proposed the construction of the West Bartlett Substation (The Project) fronting West Bartlett Road, 500 feet south of the existing Coram-Ridge transmission line right-of-way (ROW) in the Town of Brookhaven, NY. At the request of PSEG-LI, Exponent modeled the magnetic fields associated with the proposed substation equipment, existing overhead transmission line, and the proposed overhead interconnection to the existing transmission line.

The effect of the substation on existing magnetic-field levels was evaluated by modeling magnetic fields for pre- and post-Project conditions. For the pre-Project conditions, the loading on the existing overhead circuits was calculated without any of the proposed equipment in service. Exponent also measured background magnetic-field levels at the proposed substation site on March 30, 2016.

The post-Project condition includes magnetic-field contributions from the proposed substation equipment and a new 69-kilovolt (kV) loop in and out of the new substation yard. In the post-Project condition, two load cases were studied, corresponding to average load and peak load for the proposed equipment and overhead 69-kV transmission lines. Electric fields from the substation were not modeled because they are effectively blocked by the metal fence and landscaping around the substation yard.

The modeling shows that the substation equipment and proposed 69-kV interconnection have little effect on the calculated magnetic field levels at residences in the neighborhood. The overhead interconnection would be located on the eastern edge of the substation parcel, set back from existing residences by more than 300 feet. At dwellings on the east side of West Bartlett Road, for instance, the calculated magnetic field would increase on average by less than 0.3 mG with operation of the Project. These changes can be attributed to an increase in loading on the 69 kV transmission line on the existing ROW north of the West Bartlett Substation, and an increase in distribution loads along West Bartlett Road.

The greatest Project-related increase in calculated magnetic-field level would occur near the southwest corner of the proposed site, where proposed underground feeders pass below the substation fence. Directly over the proposed feeders, the calculated magnetic-field level would be 10 mG for average-load conditions and 21 milligauss (mG) for peak-load conditions. The region where the calculated magnetic fields would be elevated above background levels extends for approximately 50 feet on either side of the proposed underground feeders.

Overall, the calculated and measured magnetic field levels associated with the Project fall within the range of typical levels encountered within homes and businesses. The Project-related increases in the calculated magnetic field are small, and are on average within 0.3 mG at dwellings adjacent to the proposed substation.

Proposed Configuration

The proposed location for the West Bartlett Substation is located on a 3.9-acre property on the east side of West Bartlett Road between Park Lane and Rose Lane in the Town of Brookhaven, south of the existing Coram-Ridge 69 kV ROW. See Figure 1.

The proposed substation equipment includes positions for two 69-kV transmission circuits to terminate, three gas circuit breakers, two 69/13.8-kV transformers, and two metal-clad switchgear power centers with terminations for 13.8-kV feeders. In the proposed configuration, the 13.8-kV feeders exit the substation underground onto West Bartlett Road, and interconnect to the existing overhead distribution circuits in the surrounding community.

In addition to the new equipment inside the substation fence, the Project includes two overhead interconnections to the existing 69-kV transmission line located approximately 0.12 miles (600 feet) north of the proposed site. In the proposed configuration, the existing 69-kV transmission line between the Coram and Ridge Substations will be looped into and out of at the new West Bartlett Substation as follows:

1) The proposed western segment of the interconnection loop would extend the existing 69-kV Line "A" from Coram to a new dead-end structure on the existing ROW. The circuit would proceed overhead in the center of a new 50-foot wide, maintained ROW located along the eastern edge of the substation parcel. The conductors of Line "A" would be supported on the west side of a double-circuit structure. See Figure 2(c). The Line "A" overhead interconnection would turn west at the southeast corner of the parcel, and terminate within the substation fence at the eastern side of the yard.

2) The proposed eastern segment of the interconnection loop (Line "B") would begin at a terminal structure within the substation fence, near the southeast corner of the yard. Line "B" would proceed overhead as a three-phase circuit, having the same configuration as Line "A." The conductors of the Line "B" interconnection would be installed on the same double-circuit structures as Line "A" on the opposite set of insulators. The conductors of the Line "B" interconnection would proceed north to a new dead-end structure on the existing ROW, and turn east toward Ridge.

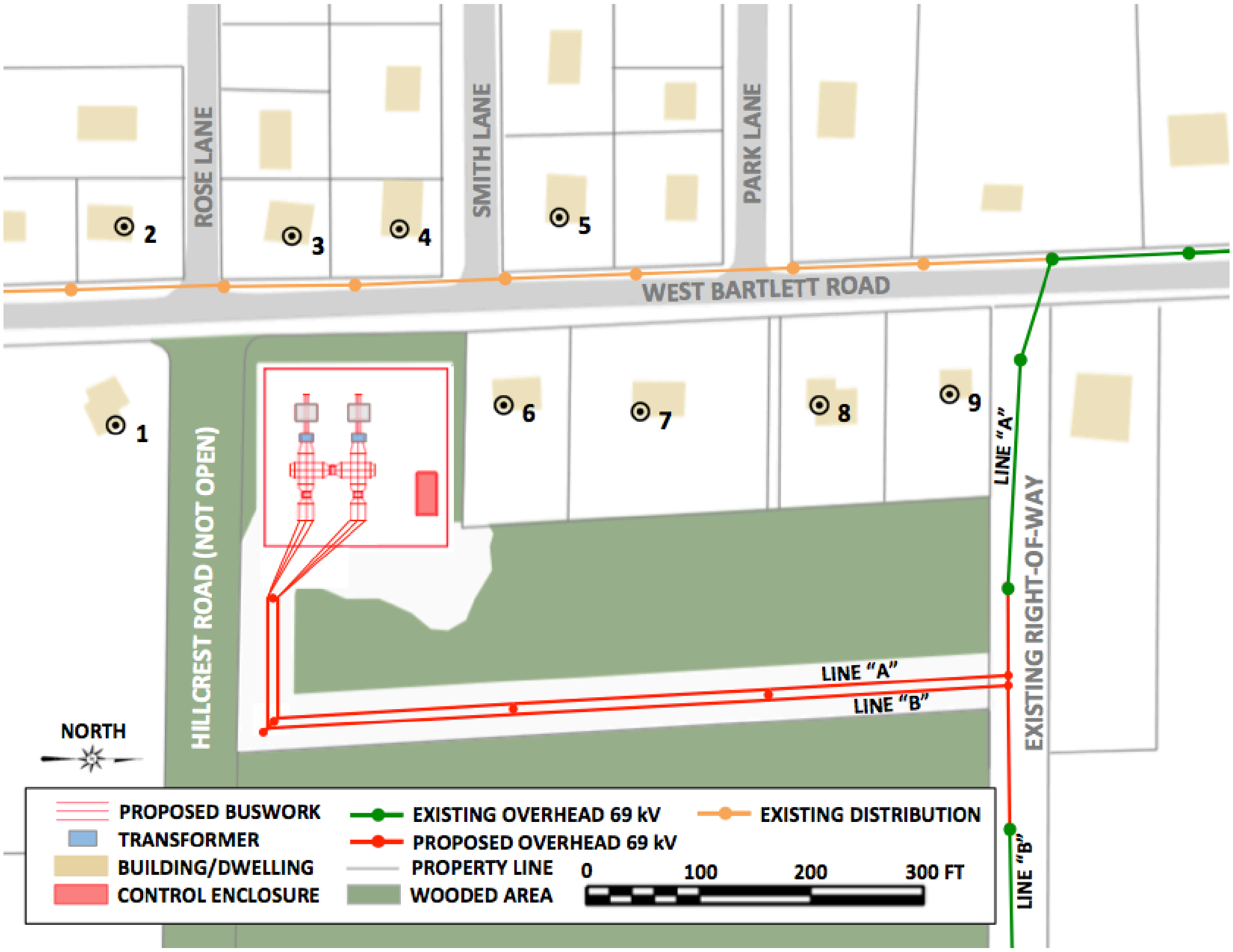

Figure 1. Proposed layout of the West Bartlett Substation and proposed overhead circuits in relation to the existing ROW and buildings in the vicinity of the Project

The numbered labels designate reporting locations for Project-related magnetic fields, which are summarized in Table 5.

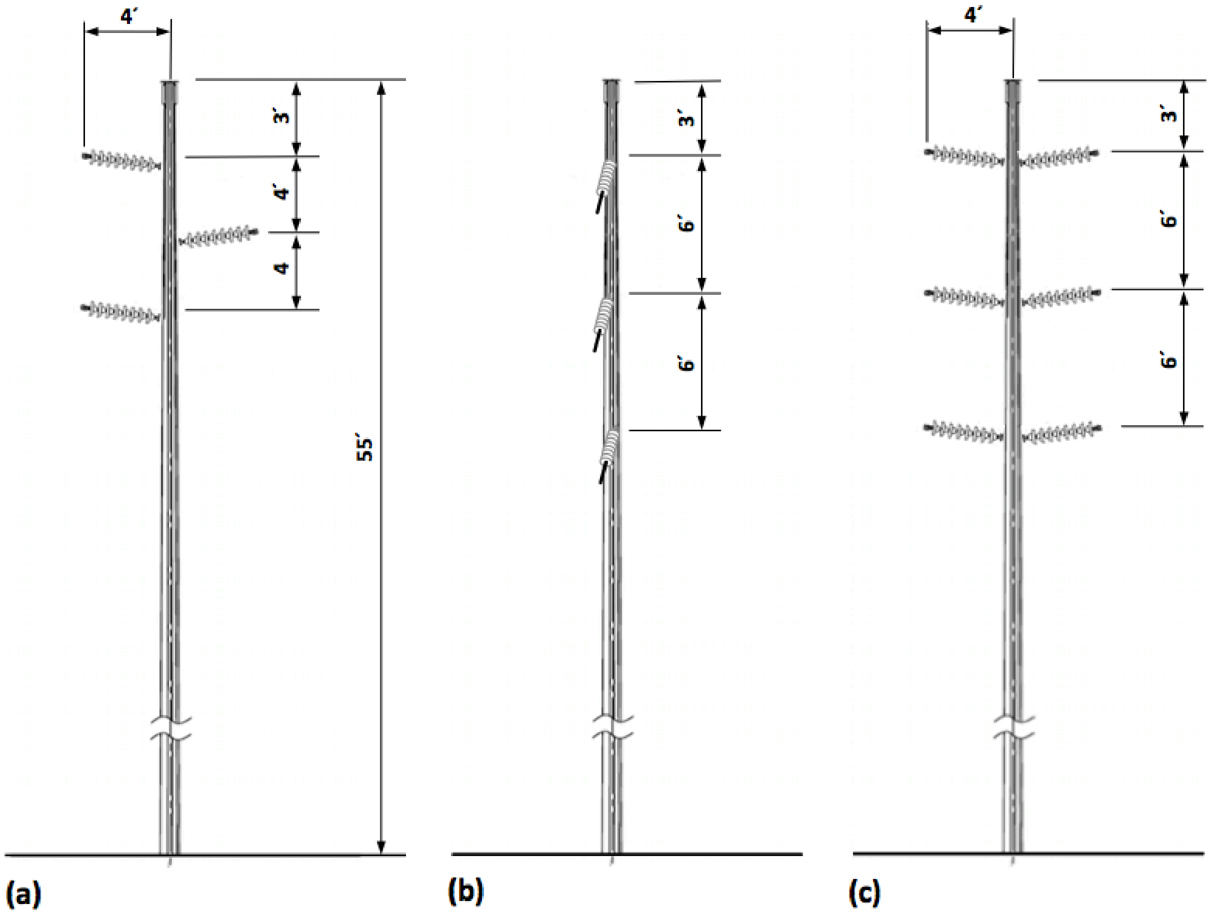

Figure 2. Structure dimensions used in SUBCALC model: (a) existing delta structure at tangent locations; (b) existing vertical single-circuit monopole at dead-end locations; and (c) double-circuit monopole for 69-kV interconnection.

Methods

Magnetic Field Modeling

The magnetic field around the perimeter of the proposed West Bartlett Substation and surrounding neighborhood was calculated using SUBCALC, which is part of the Enertech EMF Workbench Suite. SUBCALC models the magnetic fields in and around substations, accounting for the transformers and the three-dimensional arrangement of buswork and transmission-line interconnections (Figure 4). The SUBCALC model was built using the substation plan and profile data provide by PSEG-LI. The inputs to the program include data on the voltage, current flow, circuit phasing, and conductor configurations, which were also provided by PSEG-LI. [1]In particular, the SUBCALC model incorporates sag elevation data for each transmission line span and the elevation of conductor attachments. The short low-voltage underground connections from existing distribution lines into the substation were not included in the model.

Exponent calculated the anticipated magnetic field along four profiles perpendicular to the expanded substation perimeter, directed outward towards adjoining properties as shown in Figure 3:

Profile 1 is aligned with the transformer of Bank 1 in the substation yard, and proceeds west across West Bartlett Road.

Profile 2 starts 40 feet south of the northwest corner of the substation yard, and crosses West Bartlett Road.

Profile 3 begins near the control building on the north side of the substation yard, and proceeds north onto the adjoining property.

Profile 4 models the magnetic-field starting at the southern edge of the substation yard and proceeds south across Hillcrest Road (unopened) and onto the adjoining property.

Additional Profiles 5 – 7, shown in Figure 3, characterize the magnetic field along a transect perpendicular to the overhead route of the existing overhead 69 kV transmission line and proposed 69 kV interconnection. As described in greater detail below, measurements of background magnetic field levels were recorded along Profiles 1 – 2 and 4 – 7 on March 30, 2016. All magnetic fields were calculated at heights referenced to the elevation of the substation yard.

[1] The sources of the electric field within the substation are set back by 25 feet or more within the property line and their intensity diminishes quickly with distance. In addition, many objects are conductive—including fences, shrubbery, and buildings—and thus shield electric fields. Thus, the electric field from the West Bartlett Substation was not calculated since it will be effectively shielded by the substation fence and landscaping.

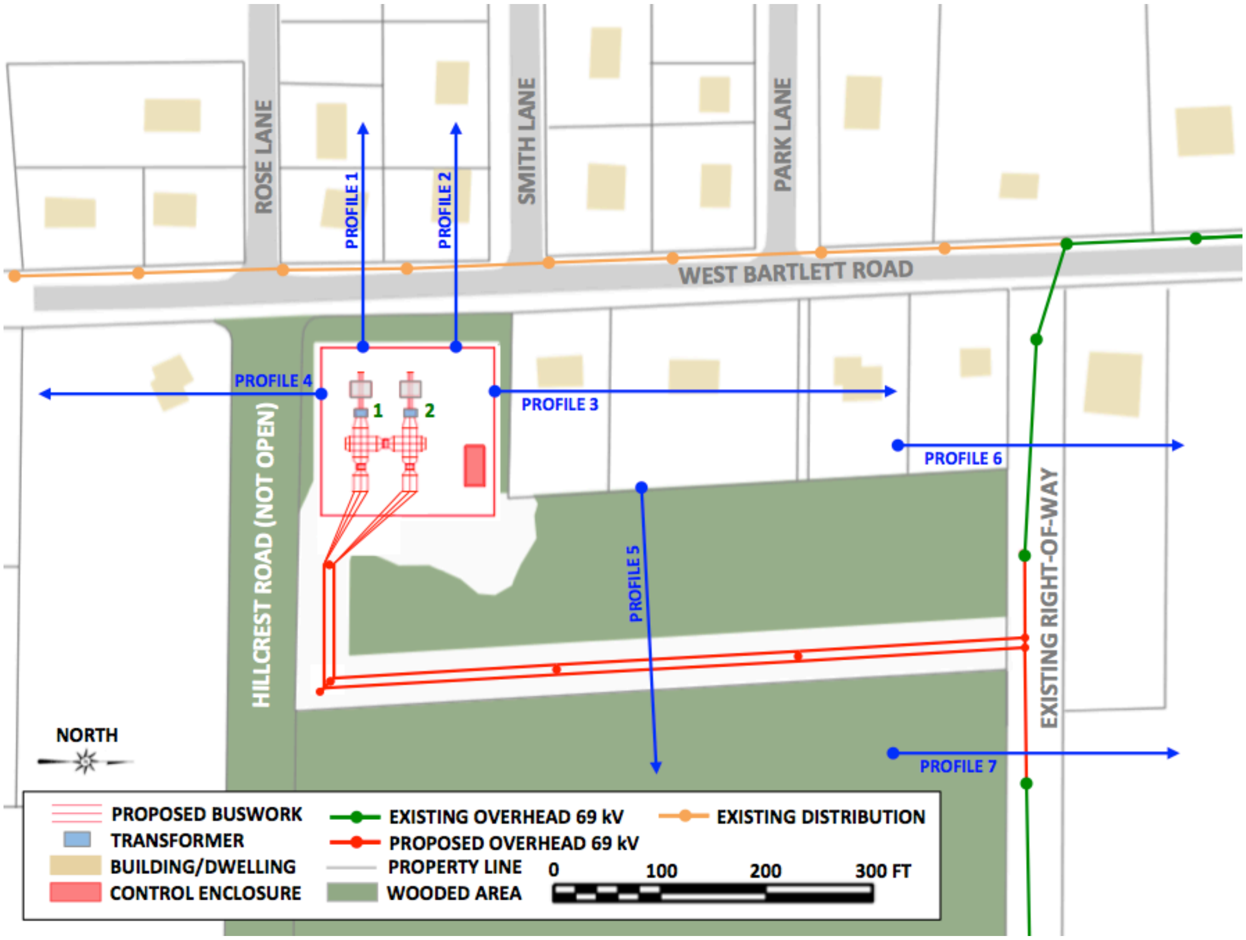

Figure 3. Plan view of the proposed West Bartlett Substation, showing the location of magnetic-field profiles and the proposed overhead route of Circuit A and Circuit B.

Along the fence line, perimeter of the property, and Profiles 1-7, the magnetic field was calculated at 1 meter (3.28 feet) above ground, in accordance with IEEE Std. C95.3.1-2010.[2] Calculated magnetic fields are reported as the resultant of x, y and z magnetic field vectors in units of milligauss (mG).[3]

Magnetic fields surrounding conductors depend on current, which increases with increasing load. The current flows (loadings) for the transmission lines, tie breaker, and transformers used in the model are summarized in Appendix A. Appendix A provides average loads for the in-service year of 2017, as well as a peak loads, corresponding to the highest load anticipated during the summer months in the year 2017.

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2 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 100 kHz. New York: IEEE. IEEE Std. C95.3.1™-2010.

3 The resultant magnetic field is the Euclidian norm (square root of the sum of the squares) of the component magnetic-field vectors calculated along vertical, transverse, and longitudinal axes.

Figure 4. Overview of the three-dimensional SUBCALC model used to calculate magnetic-field profiles in the vicinity of the proposed West Bartlett Substation for the average and peak loading cases in 2017.

Orange lines represent overhead transmission-line conductors, including the proposed 69 kV loop in and out of the West Bartlett Substation. The purple line along West Bartlett road represents overhead distribution conductors, which are proposed to be rebuilt as part of the reinforcement project in the surrounding community.

Measurements

In order to characterize background EMF levels at the proposed site of the West Bartlett Substation, magnetic fields were measured outside the proposed substation fence on March 30, 2016. The measurements were taken at a height of 1 meter (3.28 feet) above ground in accordance with the standard methods for measuring near power lines (IEEE Std. 644-1994a). Measured magnetic fields are expressed as the total field computed as the resultant of field vectors measured along vertical, transverse, and longitudinal axes.[4] The magnetic field was measured in units of mG by orthogonally-mounted sensing coils whose output was logged by a digital recording meter (EMDEX II) manufactured by Enertech Consultants. This instrument meets the Institute of Electrical and Electronics Engineers **(**IEEE) instrumentation standard for obtaining accurate field measurements at power line frequencies (IEEE Std.1308-1994b). The meter was calibrated by the manufacturer by methods like those described in IEEE Std. 644-1994a.

4 The resultant magnetic field is the Euclidian norm (square root of the sum of the squares) of the component magnetic-field vectors calculated along vertical, transverse, and longitudinal axes. Root mean square refers to the common mathematical method of defining the effective voltage, current, or field of an AC system.

Results and Discussion

The measured and calculated magnetic fields around the fence line of the proposed West Bartlett Substation are depicted in Figure 5. To characterize the existing sources around the proposed site, the "measured" profile in Figure 5 shows the magnetic-field levels recorded on March 30, 2016. The measured profile reflects pre-Project conditions at the site, in which no proposed facilities are constructed or in service.[5] The measured magnetic-field levels can be accurately modeled by two existing magnetic-field sources: (1) the overhead distribution circuit on the west side of West Bartlett Road, and (2) the overhead 69-kV transmission line on the existing ROW between Coram and Ridge. These sources were included in the calculated "pre-Project" profile in Figure 5, and in other calculated profiles in Figures 6 – 14. The measured magnetic fields from these sources were below 1 mG along the north, west, and south sides of the substation fence. At all locations on the east side of the proposed substation fence and in the adjacent wooded area, the measured magnetic field levels were below 0.2 mG.

The "post-Project" profile in in Figure 5 shows the magnetic field calculated by SUBCALC along the fence line of the proposed West Bartlett Substation for average-load conditions. The calculated field reflects the contribution of proposed substation equipment within the yard and the proposed overhead interconnection to the existing 69 kV transmission line to the north. The SUBCALC model also includes proposed underground distribution feeders exiting the substation onto West Bartlett Road, and interconnecting to overhead distribution lines in the surrounding community. Both the measured and calculated profiles in Figure 5 begin at the southwest corner of the substation yard, and continue counter clockwise along the fence to the southeast, northeast, and northwest corners of the yard.

Figure 6 shows the measured and calculated magnetic-field levels along the property line of the proposed West Bartlett Substation. The profile in Figure 6 begins at the southwest corner of the parcel, and continue counter clockwise along the fence to the southeast, northeast, and northwest corners of the L-shaped property. Figure 7 shows the calculated magnetic-field profile along the same path as in Figure 6, modeled using peak loading rather than average loading.

Figures 8 – 17 depict the calculated magnetic field levels along Profiles 1 – 7 for average-load conditions in 2017. All of these figures except Figure 10 include background magnetic-field measurements recorded in March 30, 2016. Table 1 summarizes calculated magnetic-field levels at various distances from the substation fence in Profiles 1 – 4, for average load conditions. Table 2 likewise summarizes calculated magnetic fields for Profiles 5 – 7, at various distances from the centerline of the overhead circuits, for average-load conditions. Tables 3 and 4 include the calculated magnetic fields at the same locations as Tables 1 and 2, but for peak-load rather than average-load conditions.

[5] The measured profile in Figure 5 provides a "snapshot" of background magnetic-field levels. On a given day, throughout a week, or over the course of months and years, the measured magnetic field can change depending upon the patterns of power demand within the surrounding community. In general, the measured magnetic will increase during summer months when power demand on Long Island is higher.

Referring to the calculated profiles in Figure 5 and Figure 6, operation of the Project elevates calculated magnetic field levels above existing background levels. The greatest Project-related increase in calculated magnetic-field levels would be on the eastern edge of the proposed substation yard (away from residences and West Bartlett Road), where the proposed overhead circuits pass above the substation fence. The calculated magnetic-field level on the eastern edge is 16 mG for average-load conditions and 33 mG for peak-load conditions. On West Bartlett Road, where the proposed underground feeders pass below the substation fence, the calculated magnetic-field level is 10 mG for average-load conditions and 21 mG for peak-load conditions. These results are consistent with IEEE Standard 1127-2013 that states "[i]n a substation, the strongest fields near the perimeter fence come from the transmission and distribution lines entering and leaving the substation. The strength of fields from equipment inside the fence decreases rapidly with distance, reaching very low levels at relatively short distances beyond substation fences." (IEEE Std. 1127-2013).

Referring to the southwest corner of the substation property in Figure 6 and Figure 7, the region where the calculated magnetic fields are elevated above the background level extends for approximately 50 feet on either side of the proposed underground feeders. As shown in Figure 8 (Profile 1), the calculated magnetic field is between 5-10 mG across West Bartlett Road, parallel to the path of the underground feeders exiting the substation. In Figure 9 (Profile 2), which is located 100 feet north of Profile 1, the calculated magnetic field reflects the loading of distribution lines on the west side of West Bartlett Road. These distribution loads are anticipated to increase with operation of the Project, since a greater proportion of load to the surrounding community will be served from the proposed West Bartlett Substation.

Extending north (Profile 3, Figure 10) and south (Profile 4, Figure 11) from the substation yard, the calculated magnetic field for average-load conditions remains nearly unchanged with operation of the Project. For peak-load conditions, the calculated increase is greater (0.5-1.0 mG, comparing pre-Project and post-Project cases). *See* Table 1 and

Table 3. This small increase reflects the fact that the substation equipment will be set back 25 to 90 feet from the substation fence.

The proposed 69-kV interconnection also has little effect on the calculated magnetic field levels at residences in the neighborhood. The overhead interconnection will be located on the eastern edge of the substation parcel, and set back from existing residences by more than 300 feet. Referring to Profile 5 (Figure 12), the calculated magnetic field 100 feet west of the 69 kV interconnection is 0.5 mG under average-load conditions and 0.9 mG under peak-load conditions. These magnetic-field levels represent an increase of 0.2-0.7 mG increase over the existing levels. *See* Table 2 and Table 4.

Across the existing ROW, the calculated magnetic field increases with operation of the Project, reflecting an increase in loading on the existing overhead transmission line. Referring to Profile 6 (Figure 13), the calculated magnetic field increases from 0.6 mG to 1.5 mG at locations 100 feet south of the existing centerline of the 69 kV circuit. The calculated increase is greater (2.4 mG pre-Project, versus 4.2 mG post-Project), for peak-load conditions. *See* Table 2 and Table 4.

Table 1. Summary of calculated magnetic fields (mG) for Profiles 1-4, average-load case

		Distance from Substation Fence (ft)			
Profile	**Condition**	**0**	**50**	**100**	**150**
1	Pre-Project	0.9	2.2	1.9	0.8
	Post-Project	9.0	5.7	2.8	0.8
2	Pre-Project	0.8	2.0	2.1	0.9
	Post-Project	0.8	3.1	3.3	0.9
3	Pre-Project	0.5	0.5	0.5	0.5
	Post-Project	0.5	0.5	0.5	0.5
4	Pre-Project	0.5	0.5	0.5	0.5
	Post-Project	0.8	0.5	0.5	0.5

* Underground distribution circuits are present at this location.

Table 2. Summary of calculated magnetic fields (mG) for Profiles 5-7, average-load case

		Offset from centerline of proposed circuits				
Profile	**Load case**	**100 ft west/south**	**50 ft west/south**	**0 ft**	**50 ft east/north**	**100 ft east/north**
5	Pre-Project	0.2	0.1	0.1	0.1	0.1
	Post-Project	0.5	1.2	4.0	0.7	0.1

6	Pre-Project	0.6	1.9	4.2	1.8	0.6
	Post-Project	1.4	2.8	7.1	2.8	1.0
7	Pre-Project	0.7	1.8	4.8	2.0	0.7
	Post-Project	1.0	2.9	8.0	3.5	1.2

Table 3. Summary of calculated magnetic fields (mG) for Profiles 1-4, peak-load case

Profile	Condition	Distance from Substation Fence (ft) 0	50	100	150
1	Pre-Project	0.9	2.2	1.9	0.8
	Post-Project	26.1*	16.1*	6.9	1.2
2	Pre-Project	0.8	2.0	2.1	0.9
	Post-Project	1.6	7.4	7.9	1.6
3	Pre-Project	0.5	0.5	0.5	0.5
	Post-Project	1.0	0.9	0.8	0.8
4	Pre-Project	0.5	0.5	0.5	0.5
	Post-Project	1.5	0.5	0.5	0.5

* Underground distribution circuits are present at this location.

Table 4. Summary of calculated magnetic fields (mG) for Profiles 5-7, peak-load case

Profile	Load case	Offset from centerline of proposed circuits: 100 ft west/south	50 ft west/south	0 ft	50 ft east/north	100 ft east/north
5	Pre-Project	0.2	0.2	0.2	0.2	0.2
	Post-Project	0.9	2.7	10.0	1.9	0.3
6	Pre-Project	2.4	6.5	14.4	6.4	2.4
	Post-Project	4.2	8.5	19.7	7.7	2.8
7	Pre-Project	2.2	6.5	16.6	7.0	2.6
	Post-Project	2.7	7.4	20.5	9.0	3.1

Structures and Buildings

Table 5 shows the magnetic field calculated at reporting locations 1 – 9 (see Figure 1), which are dwellings around the proposed site of the West Bartlett Substation. Table 5 provides the calculated magnetic field levels at both average and peak loading, before and after operation of the Project. The "average" column was calculated using the annual average loads provided in Appendix A. The "peak" column reflects the peak loads provided in Appendix A, and is anticipated to occur for a few days and hours during the year when power demand is highest in the surrounding community. Closest to the existing ROW (location 9), the average increase in calculated magnetic field is 0.2 mG for average-load conditions and 0.5 mG for peak-load conditions. This change reflects an increase in loading on the existing overhead transmission line with operation of the Project.

At other dwellings along the west side of West Bartlett Road, the Project-related increase in calculated magnetic fields is 0.2 mG or lower for average-load conditions and 1.4 mG or lower for peak-load conditions. This change reflects the increased peak loading of overhead distribution circuits along West Bartlett Road, as part of the overall reinforcement project in the surrounding community.

Table 5. Summary of calculated magnetic fields (mG) at designated structures

	2017 Average Load		2017 Peak Load	
Building designator*	**pre-Project**	**post-Project**	**pre-Project**	**post-Project**
1	0.3	0.3	0.3	0.3
2	0.5	0.6	0.5	0.7
3	1.0	1.1	1.0	2.1
4	1.2	1.2	1.2	2.6
5	1.1	1.2	1.1	2.4
6	1.1	1.3	1.1	2.4
7	0.6	0.7	0.6	1.0
8	0.5	0.5	0.5	0.8
9	0.5	0.7	0.8	1.3

* The location of each building is shown in Figure 1.

Comparison with Background Levels

Since electricity is such an integral part of our infrastructure (e.g., transportation systems, homes, and businesses), people living in modern communities are surrounded by sources of electric and magnetic fields. Figure 15 describes typical EMF levels measured in residential and occupational environments, compared to levels measured on or at the edge of transmission-line rights-of-way. While EMF levels decrease with distance from the source, any home, school, or office tends to have a "background" EMF level as a result of the combined effect of the numerous EMF sources. In general, the background magnetic-field level in a house away from appliances is typically less than 20 mG, while levels can be hundreds of mG in close proximity to appliances.

Little research has been done to characterize the general public's exposure to magnetic fields, although some basic conclusions are available from the literature. The vast majority of people in the United States have a *time-weighted average* (TWA) exposure to magnetic fields less than 2 mG.[6] The highest magnetic-field levels are typically found directly next to appliances.[7] For

[6] TWA is the average exposure over a given specified time period (i.e., an 8-hour workday or a 24-hour day) of a person's exposure to magnetic fields. The average is determined by sampling the exposure of interest throughout the time period. *See* Zaffanella LE and Kalton GW. Survey of Personal Magnetic Field Exposure Phase II: 1,000 Person Survey. EMF Rapid Program, Engineering Project #6. Lee, MA: Entertech Consultants, 1998.

example, Gauger (1985) reported the maximum AC magnetic field at 3 centimeters from a sampling of appliances as 3,000 mG (can opener), 2,000 mG (hair dryer), 5 mG (oven), and 0.7 mG (refrigerator).[8]

Overall, the calculated and measured magnetic field levels associated with the Project fall within the range of typical levels encountered within homes and businesses. The Project-related increases in the calculated magnetic field are small, and are on average within 0.3 mG at dwellings adjacent to the proposed West Bartlett Substation.

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[7] *See* Zaffanella LE. Survey of Residential Magnetic Field Sources. Volume 2: Protocol, Data Analysis, and Management. EPRI TR-102759-V2. Palo Alto, CA: EPRI, 1993.

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

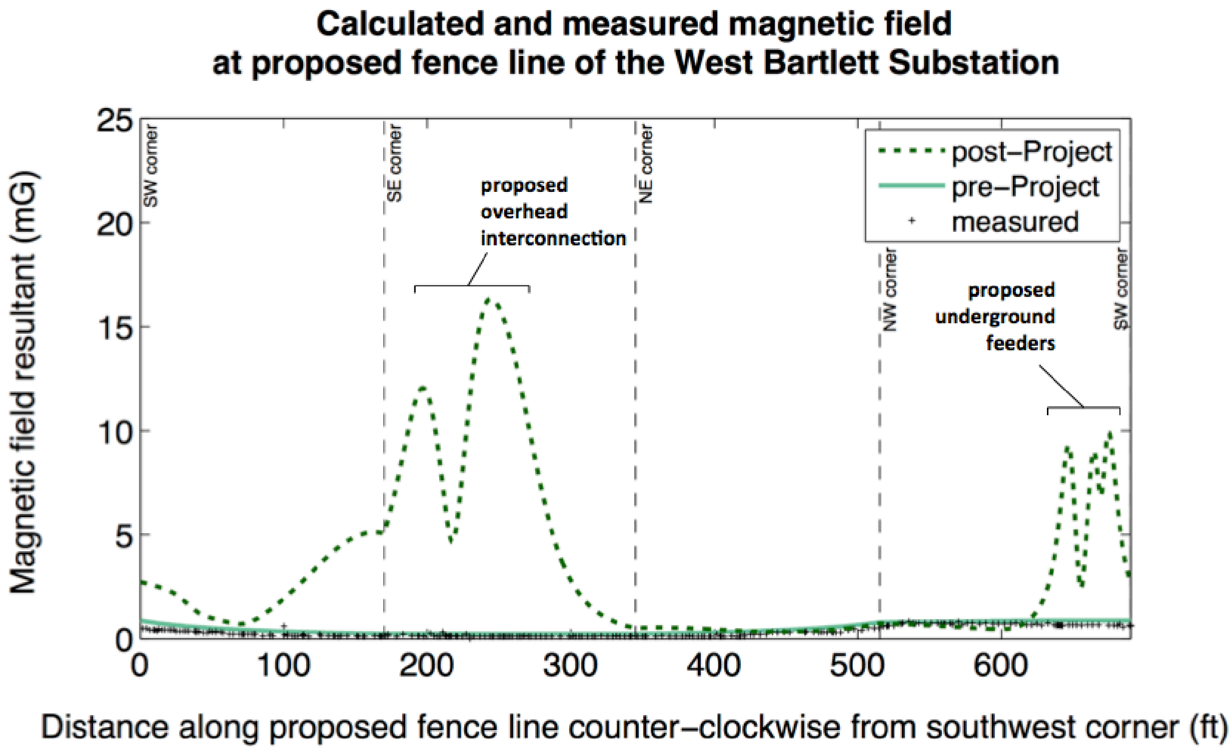
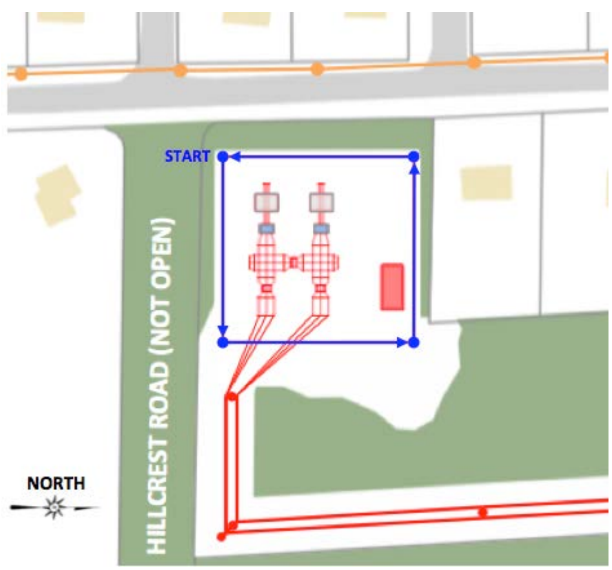


Figure 5. Calculated and measured magnetic-field profiles around the fence line of the proposed West Bartlett Substation for average-load conditions in 2017.

The measured profile shows the magnetic fields measured on March 30, 2016.



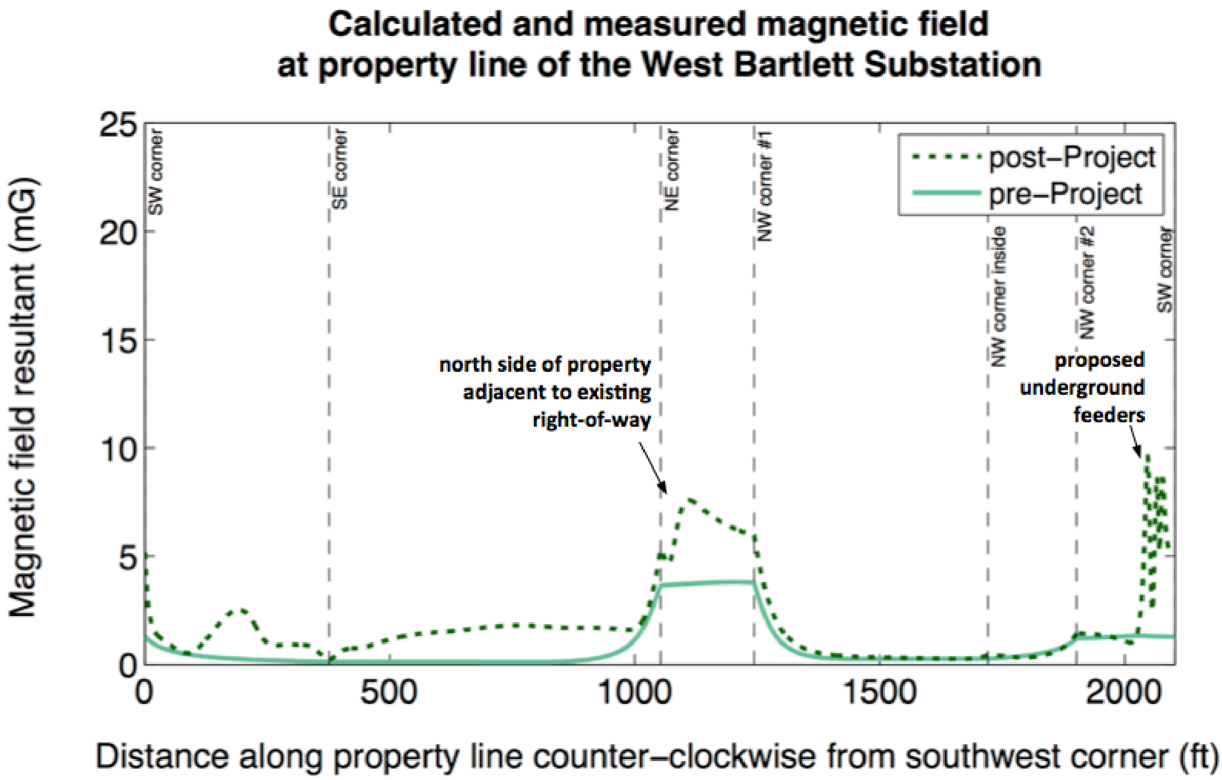
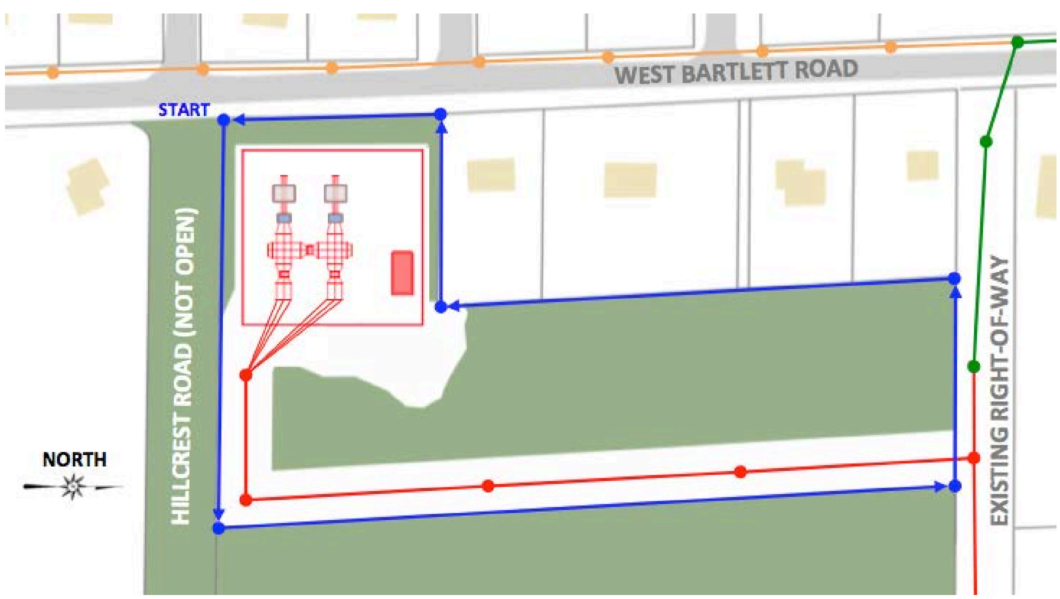


Figure 6. Calculated magnetic-field profile around the property line of the proposed West Bartlett Substation for average-load conditions in 2017.



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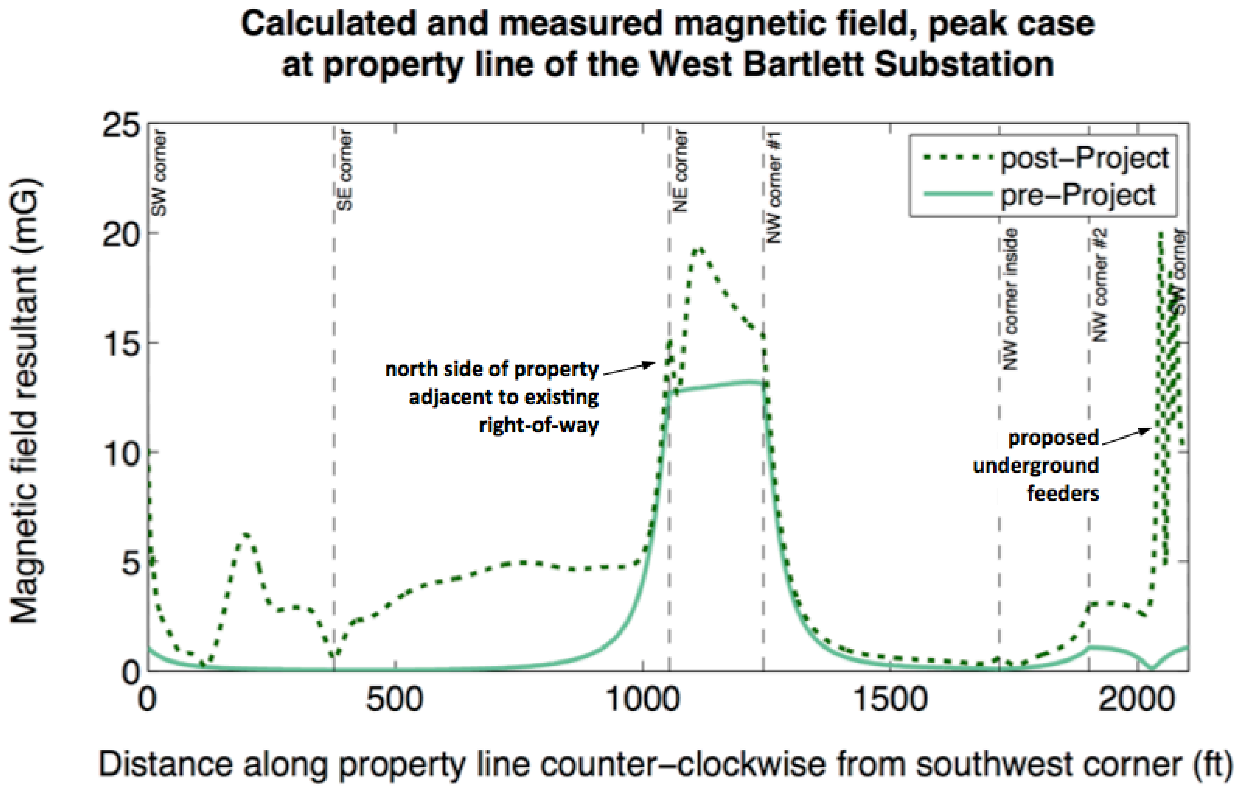

Figure 7. Calculated magnetic-field profile around the property line of the proposed West Bartlett Substation for peak-load conditions in 2017.

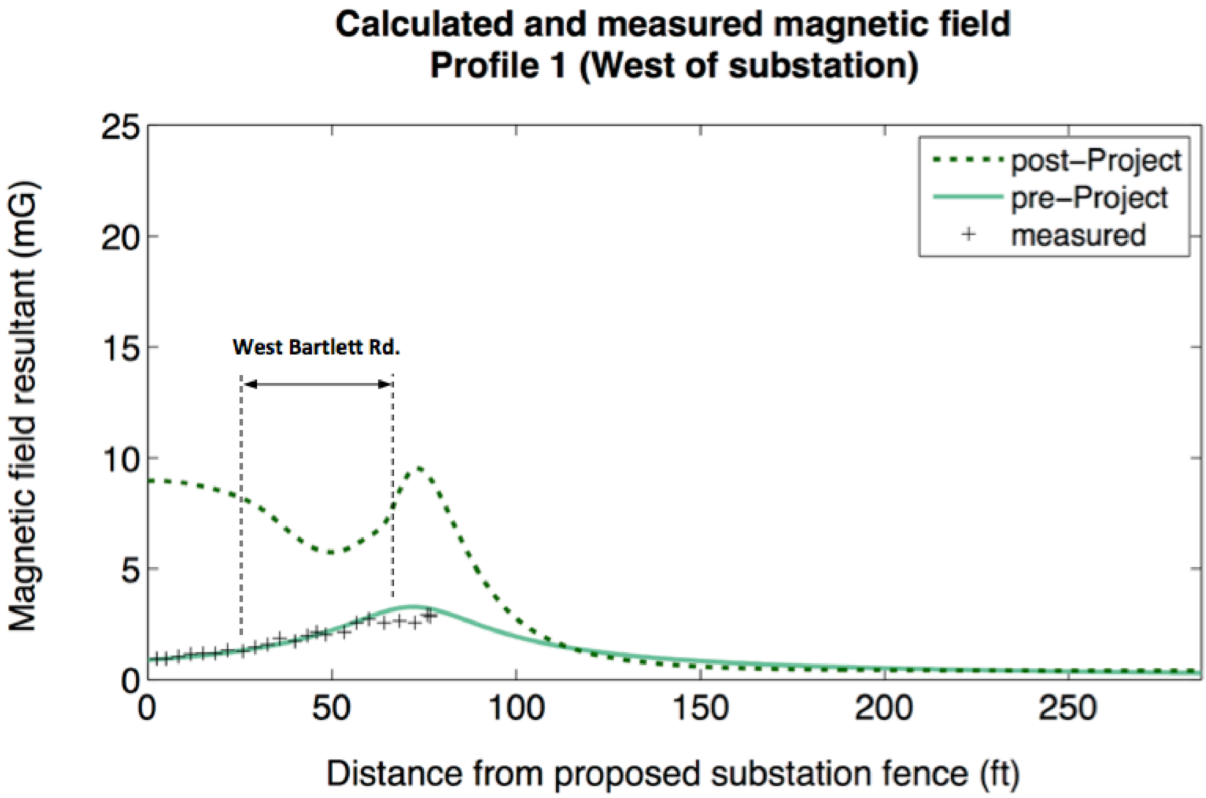

Figure 8. Measured and calculated magnetic-field levels along Profile 1 going to the west for average-load conditions in 2017.

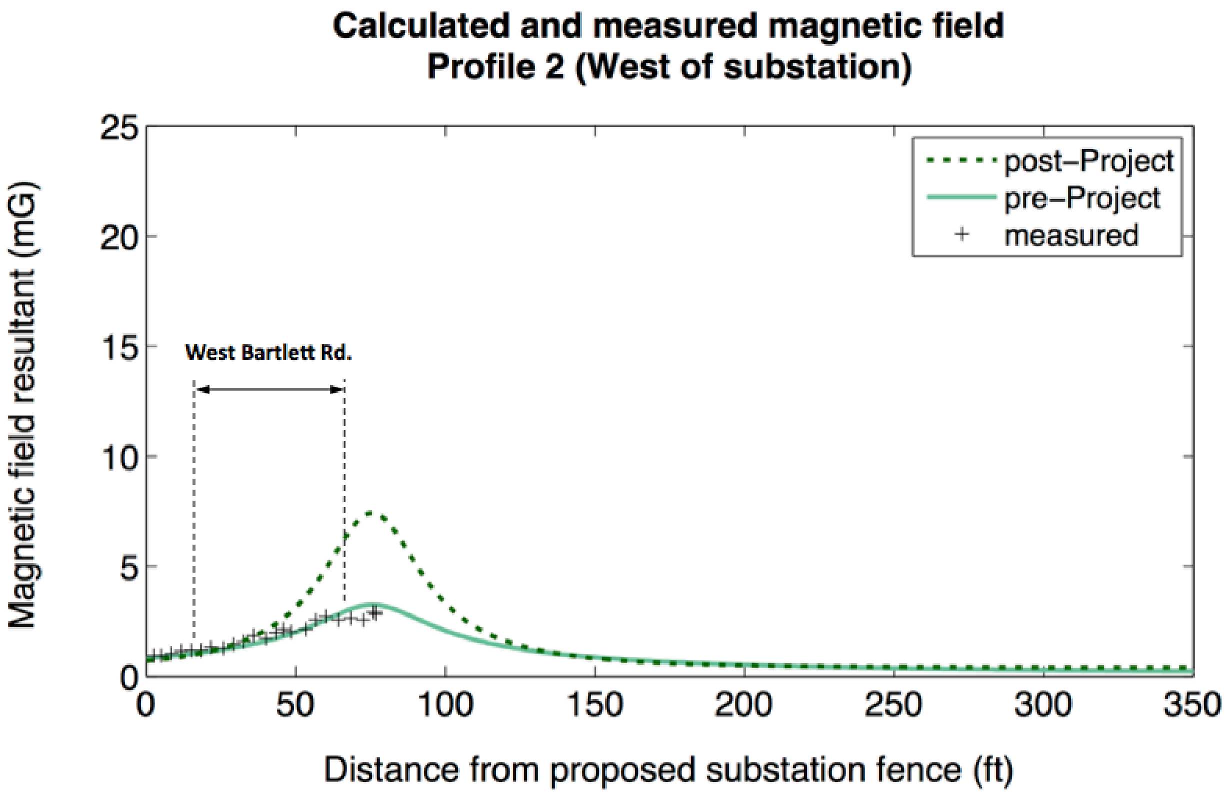

Figure 9. Measured and calculated magnetic-field levels along Profile 2 going to the west for average-load conditions in 2017.

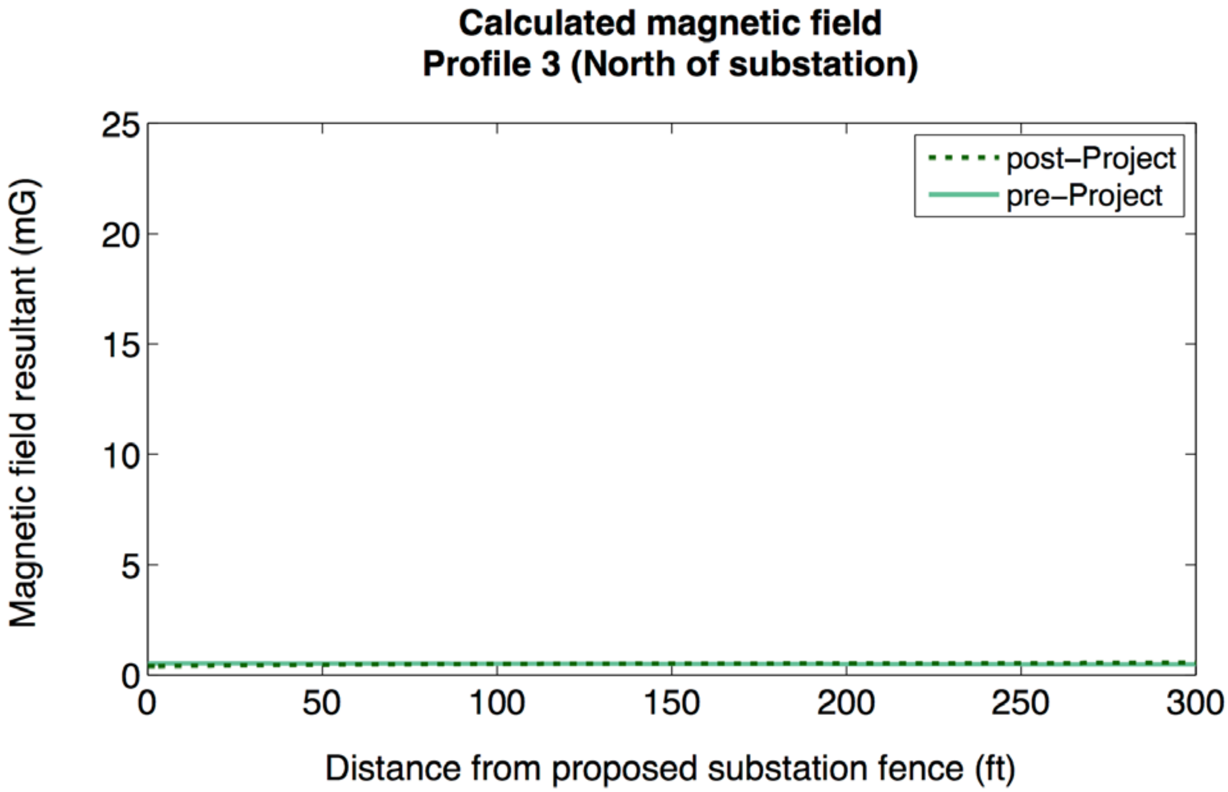

Figure 10. Calculated magnetic-field levels along Profile 3 going to the north for average-load conditions in 2017.

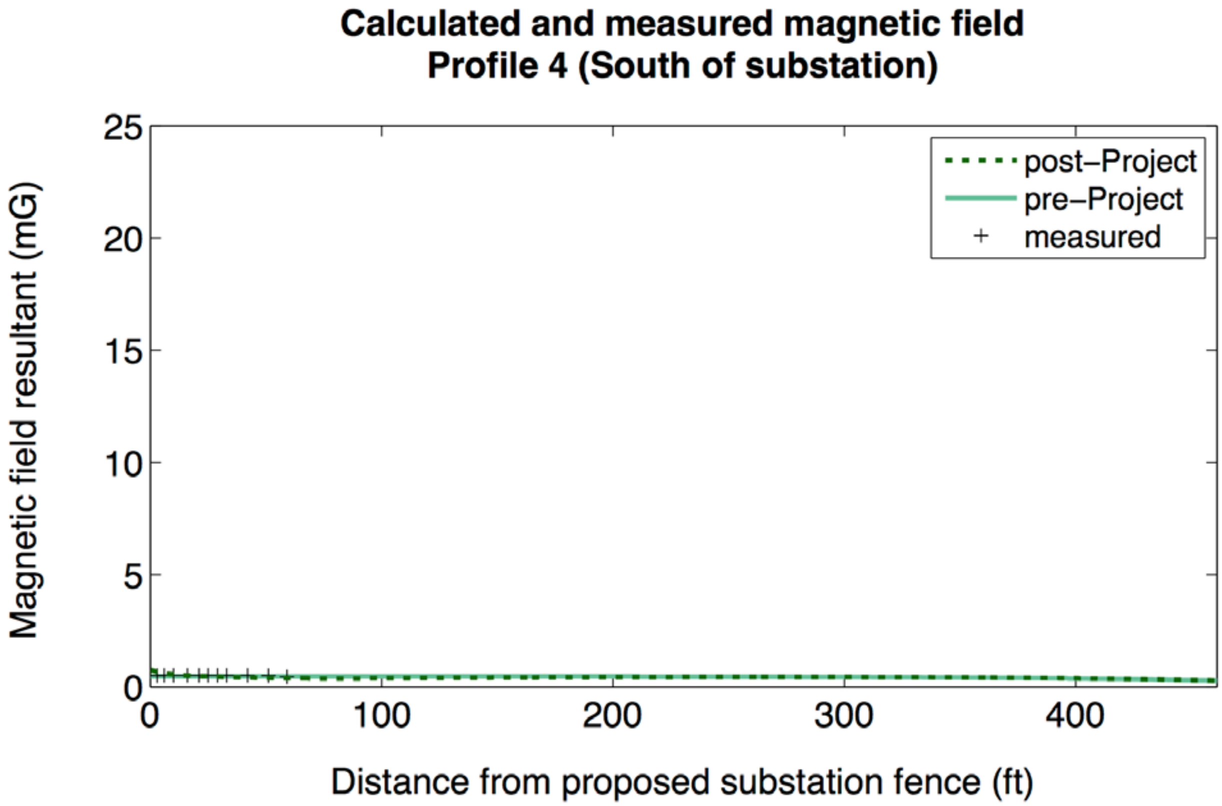

Figure 11. Measured and calculated magnetic-field levels along Profile 4 going to the south for average-load conditions in 2017.

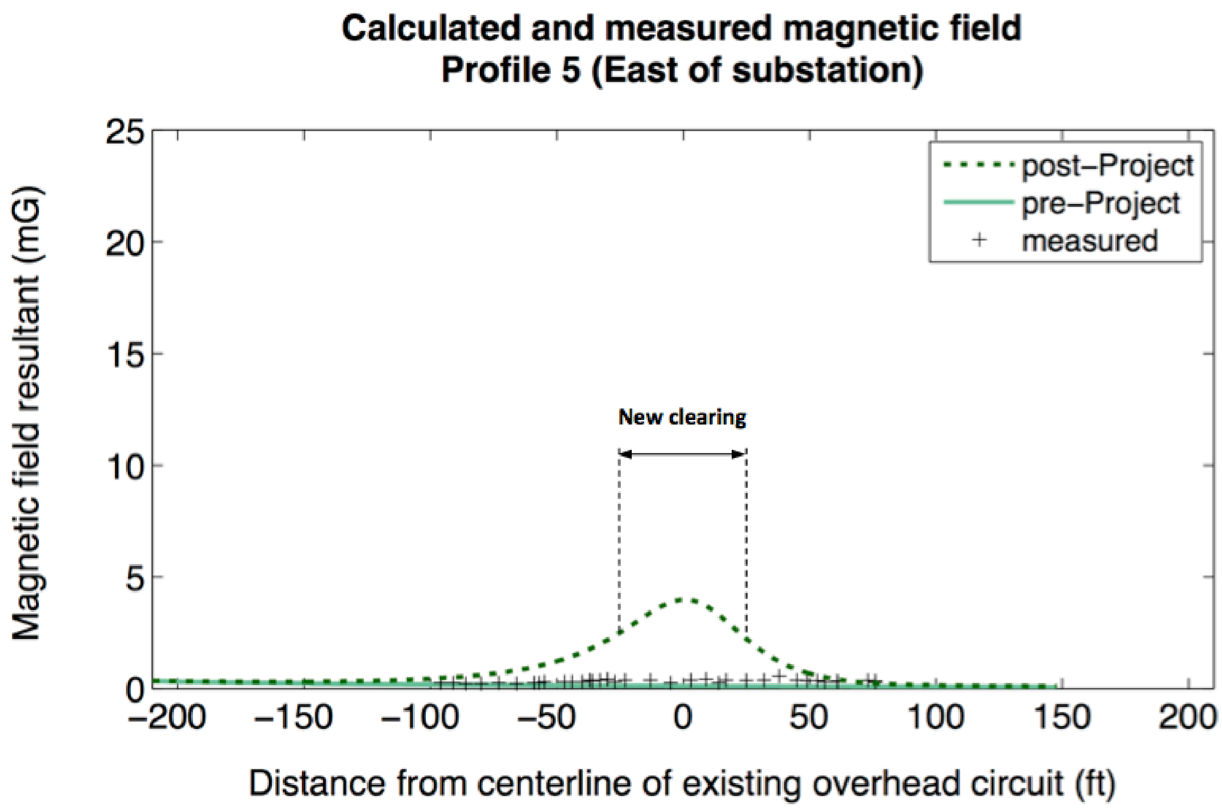

Figure 12. Measured and calculated magnetic-field levels along Profile 5 for average-load conditions in 2017. View looking north.

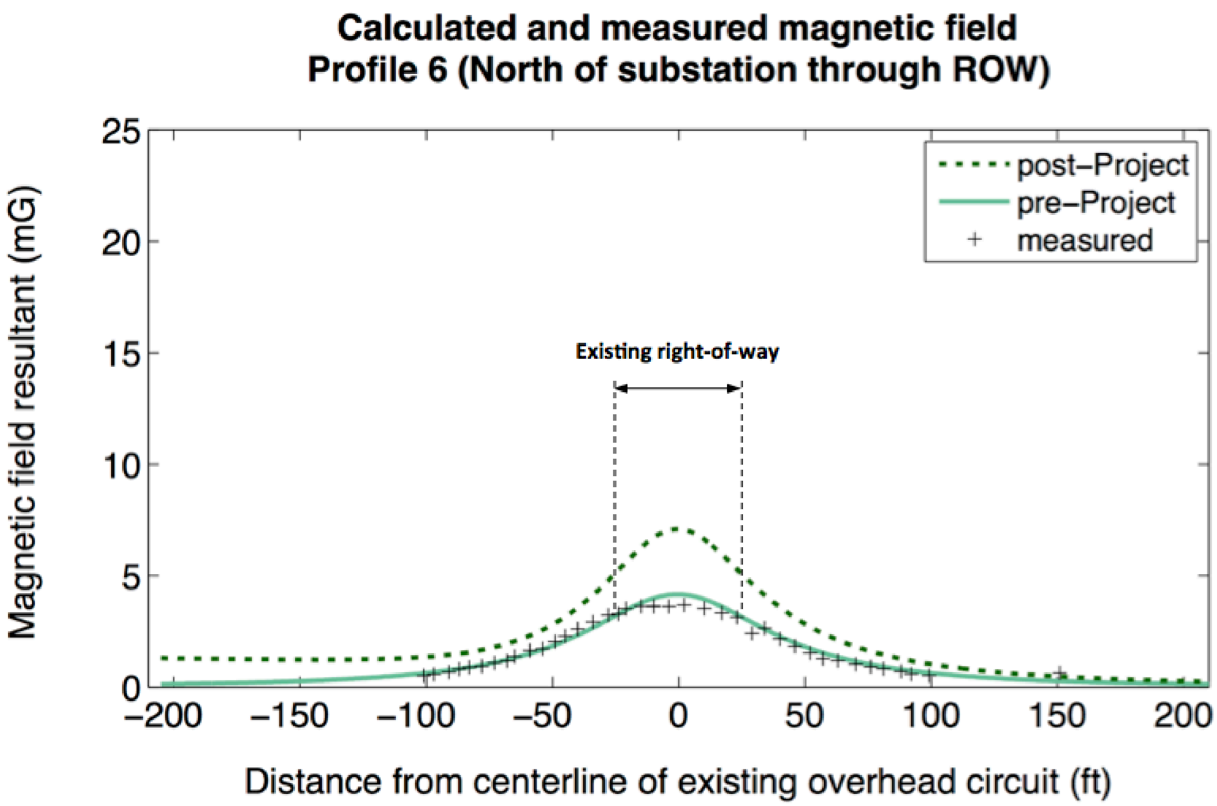

Figure 13. Measured magnetic-field levels along Profile 6 going to the north

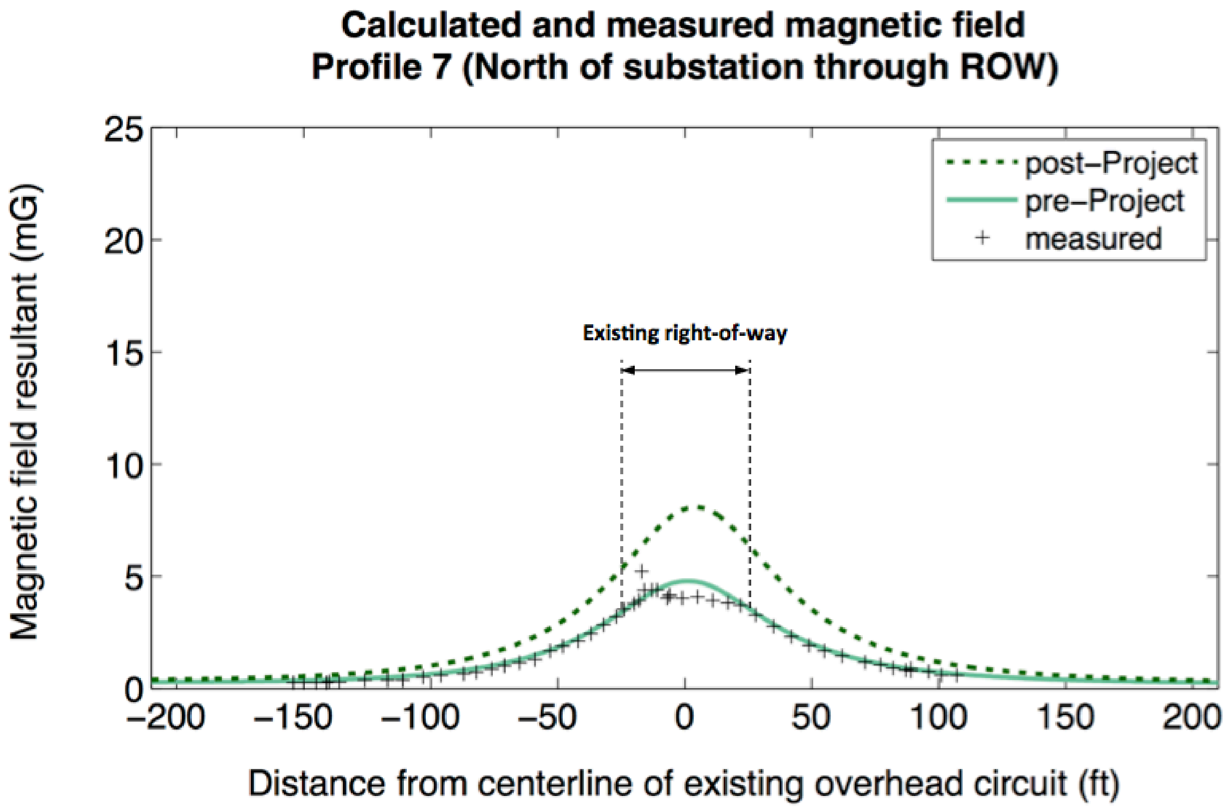

Figure 14. Measured magnetic-field levels along Profile 7 going to the north

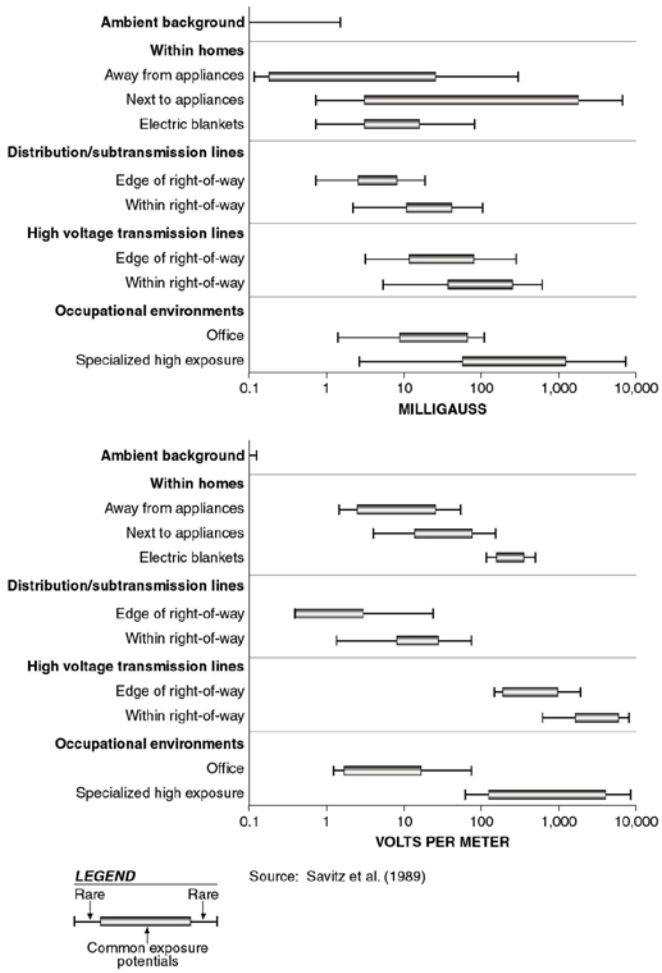

Figure 15. Electric- and magnetic-field strengths in the environment.

Appendix A

Magnetic fields surrounding conductors depend on current, which increases with increasing load. The current flows (loadings) for transmission lines, tie breaker, and transformers used in the model are summarized in Table A1 and Table A2. The loadings in Table A1 correspond to the average load for the in-service year of 2017. Loadings for modeled transmission lines for a peak loading case are provided in Table A2, and correspond to the annual peak load anticipated during the summer months in the year 2017.

Table A1. Circuit loading for average-load case in 2017

Circuit or Equipment	Voltage (kV)	Condition	MW	MVAR	MVA	Current Magnitude (A)	Current Angle (degrees)
Circuit A	69	Pre-Project	13.0	1.1	13.1	109	5.0
		Post-Project	22.0	1.9	22.1	184	5.0
Circuit B	69	Pre-Project	13.0	1.1	13.1	109	5.0
		Post-Project	18.0	1.6	18.1	151	5.0
Transformer Bank 1	69/13.8	Pre-Project	—	—	—	—	—
		Post-Project	4.0	0.3	4.0	165	5.0
Tie breaker	69	Pre-Project	—	—	—	—	—
		Post-Project	22.0	1.9	22.1	184	5.0

Table A2. Circuit loading for peak-load case in 2017

Circuit or Equipment	Voltage (kV)	Condition	MW	MVAR	MVA	Current Magnitude (A)	Current Angle (degrees)
Circuit A	69	Pre-Project	46.0	4.0	46.2	384	5.0
		Post-Project	57.0	5.0	57.2	477	5.0
Circuit B	69	Pre-Project	46.0	4.0	46.2	384	5.0
		Post-Project	50.0	4.4	50.2	418	5.0
Transformer Bank 1	69/13.8	Pre-Project	—	—	—	—	—
		Post-Project	7.0	0.6	7.0	295	5.0
Tie breaker	69	Pre-Project	—	—	—	—	—
		Post-Project	57.0	5.0	57.2	477	5.0