The latest revision date of Appendix FF to the Empire Offshore Wind COP is July 2023. This appendix was not revised as part of the November 2023 submittal; therefore, the date on the Appendix FF cover sheet remains as July 2023.

Empire Offshore Wind: Empire Wind Project (EW 1 and EW 2)
Construction and Operations Plan

APPENDIX FF

Onshore Electric and Magnetic Field Assessment

Prepared for
equinor

TETRA TECH

JULY 2023

Exponent Engineering P.C.

Electrical Engineering and Computer Science Practice

Empire Offshore Wind: Empire Wind Project (EW 1 and EW 2)

Updated Onshore Magnetic-Field Assessment

Empire Offshore Wind: Empire Wind Project (EW 1 and EW 2)

Updated Onshore Magnetic-Field Assessment

Prepared for

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June 22, 2023

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Acronyms and Abbreviations

A	Ampere
AC	Alternating current
COP	Construction and Operations Plan
DC	Direct current
EMF	Electric and magnetic fields
Empire	Empire Offshore Wind LLC
EW 1	Empire Wind 1
EW 2	Empire Wind 2
ft	Feet
Hz	Hertz
ICES	International Committee on Electromagnetic Safety
ICNIRP	International Commission on Non-Ionizing Radiation
IEEE	Institute of Electrical and Electronics Engineers
JTB	Joint Transition Bay
km	Kilometer
kV	Kilovolt
Lease Area	designated Renewable Energy Lease Area OCS-A 0512
m	Meter
mG	Milligauss
mi	Statute mile
mm	Millimeter
MW	Megawatt
nm	Nautical mile
POI	Point of Interconnection
Project	The offshore wind project for OCS A-0512 proposed by Empire Offshore Wind LLC consisting of Empire Wind 1 (EW 1) and Empire Wind 2 (EW 2).
Project Area	The area associated with the build out of the Lease Area, submarine export cables, interarray cables, and all onshore Project facilities.
WHO	World Health Organization
XLPE	Cross-linked polyethylene

Executive Summary

Empire Offshore Wind LLC (Empire) proposes to construct and operate two separate offshore wind facilities in the designated Renewable Energy Lease Area OCS-A 0512 (Lease Area) located approximately 14 statute miles (mi) (12 nautical miles [nm], 22 kilometers [km]) south of Long Island, New York, and 19.5 mi (16.9 nm, 31.4 km) east of Long Branch, New Jersey. Empire proposes to develop the Lease Area with two wind farms, known as Empire Wind 1 (EW 1) and Empire Wind 2 (EW 2) (collectively referred to hereafter as the Project). EW 1 and EW 2 will be electrically isolated and independent from each other. Each wind farm will connect via offshore substations to separate onshore Points of Interconnection at onshore locations by export cables and onshore substations. The Project includes two onshore locations where the renewable electricity generated will be transmitted to the electric grid. In this report, Exponent summarizes calculations of the magnetic fields associated with the operation of the onshore export and interconnection cables planned for installation and operation in Brooklyn, New York, and Long Beach and/or Oceanside, New York.

In this updated report, the primary change is that the voltage of the EW 2 export cable (and interconnection cable) has been updated to reflect (1) the new 345-kilovolt (kV) design of the onshore export and interconnection cables, and (2) the reduction in the number of EW 2 export cables from three to two.

Magnetic-field levels for EW 1 were calculated in this report for three representative configurations of the proposed 345 kV onshore interconnection cables constructed in underground duct banks. For EW 2 magnetic-field levels were calculated for two representative configurations of the proposed 345 kV onshore export cables and onshore interconnection cables in underground duct banks or steel pipes corresponding to operation at average and peak electricity generation levels. All magnetic field calculations were performed using an optimal phasing of cables to minimize magnetic field levels associated with each underground configuration. The magnetic-field levels associated with the operation of the Project's onshore cables in all of these representative configurations (both for EW 1 and EW 2) at average and peak current flows were calculated to be well below exposure limits published by the

International Committee on Electromagnetic Safety and the International Commission on Non-Ionizing Radiation Protection, which were designed to protect the health and safety of the general public.

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 at all times the controlling document.

Introduction

Project Description

Empire Offshore Wind LLC (Empire) proposes to construct and operate the Project located in the designated Renewable Energy Lease Area OCS-A 0512 (Lease Area). The Lease Area covers approximately 79,350 acres (32,112 hectares) and is located approximately 14 statute miles (mi) (12 nautical miles [nm], 22 kilometers [km]) south of Long Island, New York, and 19.5 mi (16.9 nm, 31.4 km) east of Long Branch, New Jersey. Empire proposes to develop the Lease Area with two wind farms, known as Empire Wind 1 (EW 1) and Empire Wind 2 (EW 2) (collectively referred to hereafter as the Project). EW 1 and EW 2 will be electrically isolated and independent from each other. Each wind farm will connect via offshore substations to separate Points of Interconnection (POIs) at onshore locations by way of export cable routes and onshore substations. In this respect, the Project includes two separate onshore locations in New York where the renewable electricity generated will be transmitted to the electric grid.

This report summarizes the calculated levels of alternating current (AC) magnetic fields at representative cross-sections of the underground export cables and interconnection cables in the onshore portion of the Project. In this updated report, the primary change is that the voltage of the EW 2 export cable (and interconnection cable) has been updated to reflect the new 345-kilovolt (kV) design of the onshore export and interconnection cables and the number of EW 2 export cables was reduced from three to two. The assessment of the offshore portion of the Project is provided in a companion report titled *Empire Offshore Wind: Empire Wind Project (EW 1 and EW 2) - Offshore Electric and Magnetic Field Assessment*.

EW 1

EW 1 will connect to an existing substation POI near the Gowanus neighborhood in Brooklyn, New York. An overview of the offshore Project is shown in Figure 1. The routes of the interconnection cables proposed for EW 1 are shown in Figure 2.

Electricity generated in the EW 1 windfarm area will be transmitted to the POI as AC on the following Project components:

1) Two submarine export cables, operating as separate circuits, with a voltage of 230 kV will exit the offshore substation and traverse independently approximately 40 nautical miles (46 miles, 74 kilometers) to a landing site in Brooklyn, New York, where the submarine export cable will connect directly to the onshore substation;

2) At the onshore substation, the voltage of the electricity will be stepped up to 345 kV for connection to the electrical grid; and

3) Two 345-kV interconnection cable circuits in a dual-circuit duct bank will connect the onshore substation to the POI.

EW 2

In this updated design, the voltage of the EW 2 project is proposed to be 345-kV for all primary onshore project components, and with the higher voltage, EW 2 will require only two 345 kV cables, instead of three 230-kV cables. EW 2 will connect to an existing substation at the Oceanside POI in Oceanside, New York via one of two proposed EW 2 Onshore Substations. Figure 3 shows the locations of the two proposed EW 2 Onshore Substations A and C, the four considered landfall locations (EW 2 Landfall A, B, C, and E), and the proposed routes of the onshore export and interconnection cables proposed for EW 2. The colored lines between the EW 2 landfall locations and the onshore substations show the potential 345-kV onshore export cable routes. The colored lines between the onshore substations and the EW 2 POI at Oceanside show the potential 345-kV interconnection cable routes.

Electricity generated in the EW 2 windfarm area will be carried to shore as AC on the following Project components:

1) Two submarine export cables, each operating as a separate circuit, will exit the offshore substations as individual cable circuits at a voltage of 345 kV and traverse the 26 nautical mile (30-mile, 48 kilometer) distance to the cable landfall in Long Beach, New York.

2) At landfall, the submarine export cables will enter the joint transition bays (JTB) where each of the three conductors within the cable will be spliced to corresponding conductors

of the onshore export cables. These 345 kV onshore export cables will continue in a double-circuit underground duct bank to the proposed onshore substation.

3) Where the onshore cable route may pass under roads or railway lines, short segments of the onshore export cables will be constructed in a double-circuit underground Road Crossing configuration.

4) At the onshore substation the 345-kV onshore export cables will transition to 345 kV interconnection cables with nominally identical cable specifications.

5) The two 345 kV interconnection cable circuits will be contained in a double-circuit underground duct bank and will connect the onshore substation to the POI.

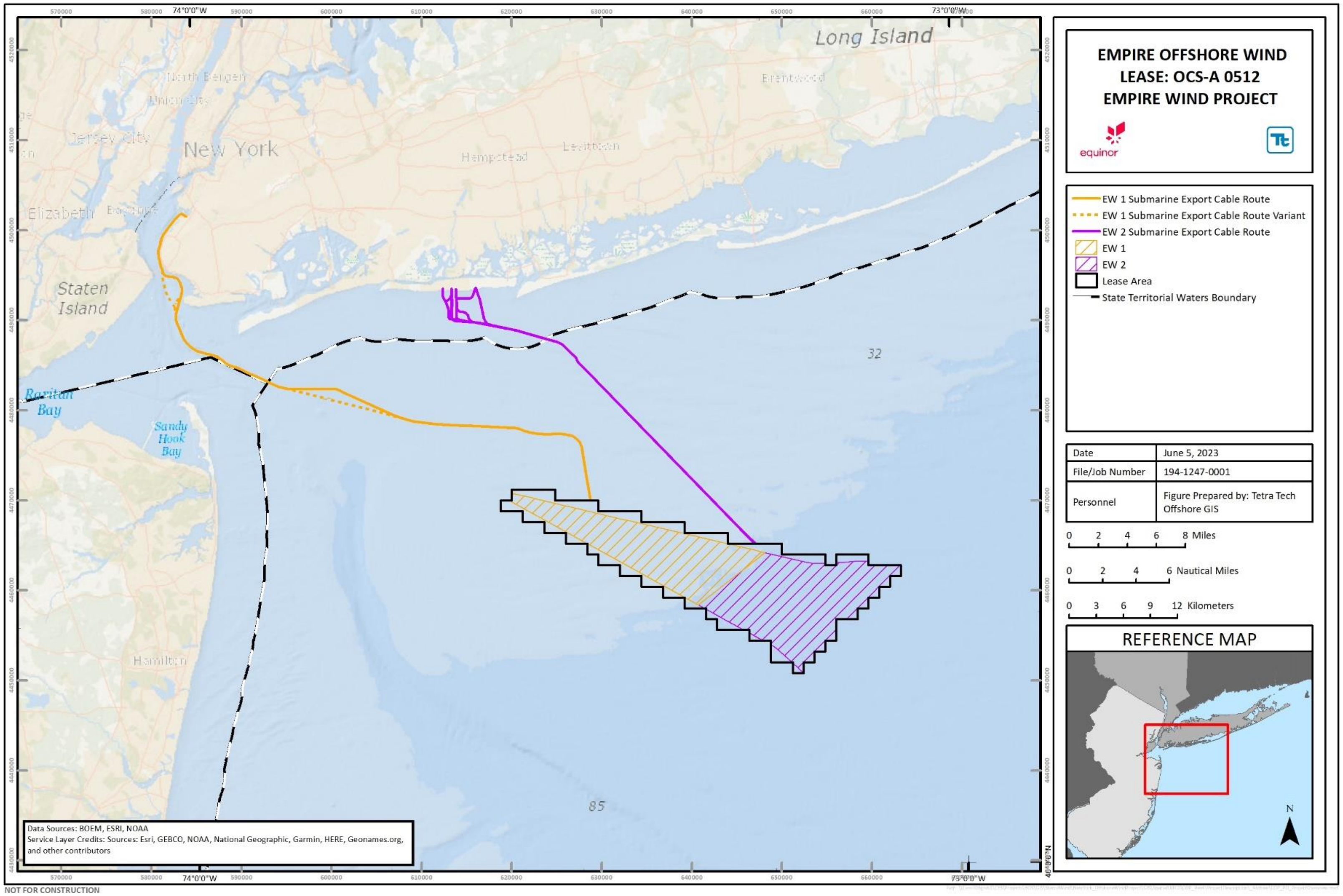

Figure 1. Overview of the Lease Area and submarine export cable routes for EW 1 and EW 2.

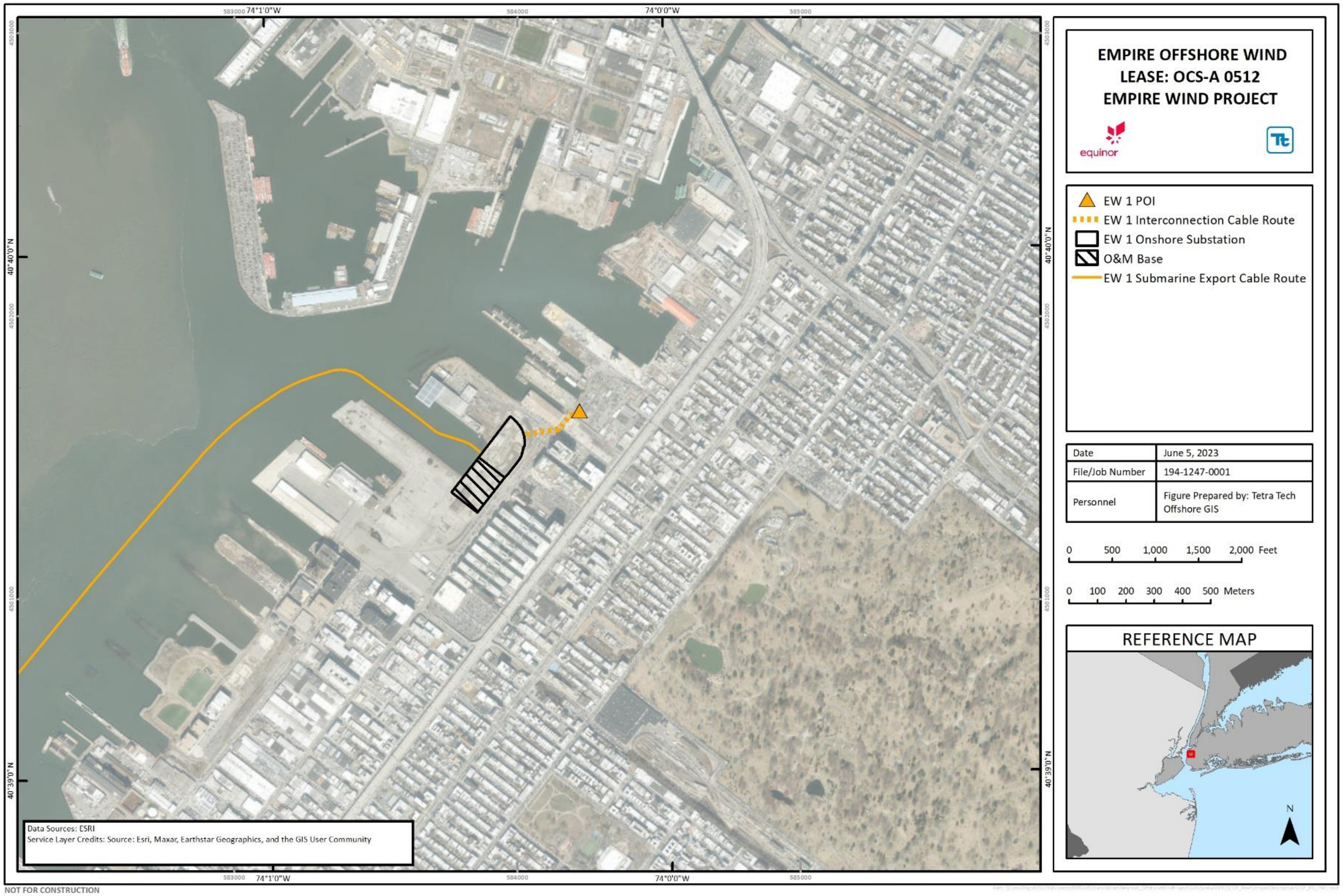

Figure 2. Overview of the proposed EW 1 submarine export cable route at landfall and respective interconnection cable.

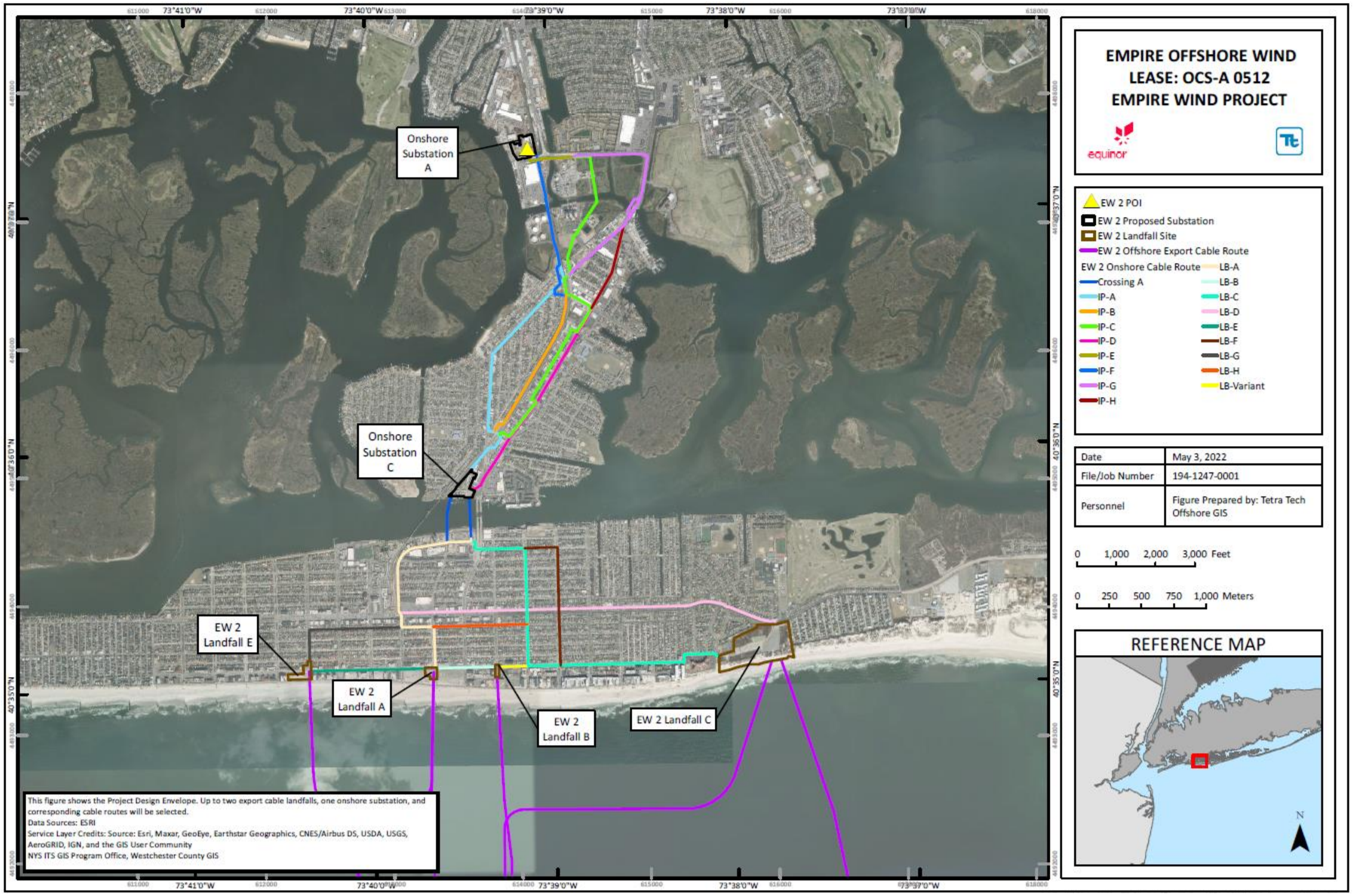

Figure 3. Overview of the proposed EW 2 submarine export cable route options at landfall, the respective onshore export cable route options, and the interconnection cable route options.

Magnetic Fields

The flow of electric currents on the onshore export cables and interconnection cables will create magnetic fields above ground. These magnetic-field levels will be highest near the cables and decrease rapidly with distance, generally in proportion to the square of the distance from the cables. In this report, magnetic fields were reported as root-mean-square magnetic flux density in units of milligauss (mG), where 1 Gauss is equal to 1,000 mG.[1]

The onshore export cables and interconnection cables also will create electric fields underground inside the cable insulation and sheath due to the voltage applied to the conductors located within the cables. However, since the conductors are to be encased within conductive metallic sheathing, these electric fields will not be present above ground because they are entirely blocked by this shielding (CSA Ocean Sciences Inc., and Exponent, 2019).[2]

The levels of magnetic fields will vary depending on the magnitude of electric current—reported in units of Amperes (A)—carried on the cables at any one time. Therefore, calculations of magnetic fields represent only a snapshot at one moment due to the varying power generated by the turbines, which depends both on operational status and wind speed. To account for the variability of current, calculations of magnetic fields were performed for the peak current at which the windfarm can operate, which will indicate the highest magnetic-field levels that can occur, and for the annual average current that represents more typical field levels over time. Additional discussion of the AC fields associated with offshore windfarm submarine cables in general is provided in a report issued by the Bureau of Ocean Energy Management (CSA Ocean Sciences Inc., and Exponent, 2019).

[1] Magnetic fields also are commonly reported in units of microtesla, where 0.1 microtesla is equal to 1 mG.

[2] An approximately 300-ft (91-m) segment of the interconnection cable route at the crossing of Barnum's Channel may be located aboveground via a cable bridge. The cable construction will likewise block the electric field outside the cable. The bridge will be inaccessible to members of the general public and therefore was not included in this assessment.

Assessment Criteria

The State of New York has an interim policy for magnetic fields at edges of rights-of-way for new AC transmission lines and at winter normal conductor rating, which is the maximum load (and hence maximum magnetic field) that the transmission line can continuously sustain. The Article VII report (Exponent, 2023) to be submitted to the New York State Public Service Commission has demonstrated compliance with the New York interim magnetic-field standard.

There are no federal standards that limit magnetic fields produced by electric system infrastructure, but two international organizations provide guidance on limiting exposure to magnetic fields, which is based on extensive review and evaluation of relevant research of health and safety issues—the International Committee on Electromagnetic Safety (ICES), which is a committee under the oversight of the Institute of Electrical and Electronics Engineers (IEEE), and the International Commission on Non-Ionizing Radiation (ICNIRP), an independent organization providing scientific advice and guidance on electromagnetic fields. Both organizations have recommended limits designed to protect the health and safety of persons in occupational settings and for the general public. The ICES exposure reference level for the general public to 60-Hertz (Hz) magnetic fields is 9,040 mG, and ICNIRP determined a reference level limit for whole-body exposure to 60-Hz magnetic fields at 2,000 mG (ICES, 2019, ICNIRP, 2010). The World Health Organization (WHO), a scientific organization within the United Nations system with the mandate to provide leadership on global health matters; shape health research agendas; and set norms and standards, views these standards as protective of public health (WHO, 2007). The WHO assessment also states "[g]iven the weakness of the evidence for a link between [long-term] exposure to ELF magnetic fields" and health effects at levels below these standards, "the benefits of exposure reduction on health are unclear and thus the cost of reducing exposure should be very low" (p. 372).

Cable Configurations and Calculation Methods

Exponent calculated the 60-Hz magnetic fields associated with the operation of the onshore export and interconnection cables proposed to be installed as part of the Project. The cables are to be installed predominantly in duct banks onshore and the methods used for calculating the magnetic-field levels above ground are described below.

EW 1: Onshore 345-kV Interconnection Cables

The EW 1 offshore submarine export cables will terminate directly at the onshore substation, so there is no onshore export cable for EW 1. At the onshore substation, the voltage will be stepped up from 230 kV to 345 kV. From the onshore substation, interconnection cables installed in a double-circuit underground duct bank will transmit power to the POI. A cross-sectional drawing of the components of a representative individual single-conductor cross-linked polyethylene (XLPE) cable is shown in Figure A-1 in Attachment A. At 345-kV, each circuit will carry an average current of 618 A and a peak current of 727 A.

The dominant installation configuration for the proposed cables, referred to here as the Typical configuration, has the two circuits in a trefoil arrangement side-by-side at a minimum target burial depth of 3 feet (ft) (0.9 m) to the top of the duct bank,[3] and a minimum separation distance between duct banks of 0.0 ft (0.0 m). The Typical configuration will represent the preferred and most likely installation scenario for the majority of the interconnection cable route between the onshore substation and the POI. A cross-sectional drawing of the Typical configuration is shown in Figure 4.

A circuit spacing greater than the preferred value will only be used for short distances when installation conditions require greater separation such as at JTBs or splice vaults, at locations using horizontal directional drilling, or to accommodate existing utilities. For each of these

[3] For greater burial depth, magnetic-field levels would be lower.

locations it is anticipated that the horizontal separation between the two circuits will be up to 10 ft (3 m).

Other alternative cable installation configurations, such as at road crossings or where deeper burial is not possible, also may be required for limited distances, as discussed in greater detail in Attachment A.

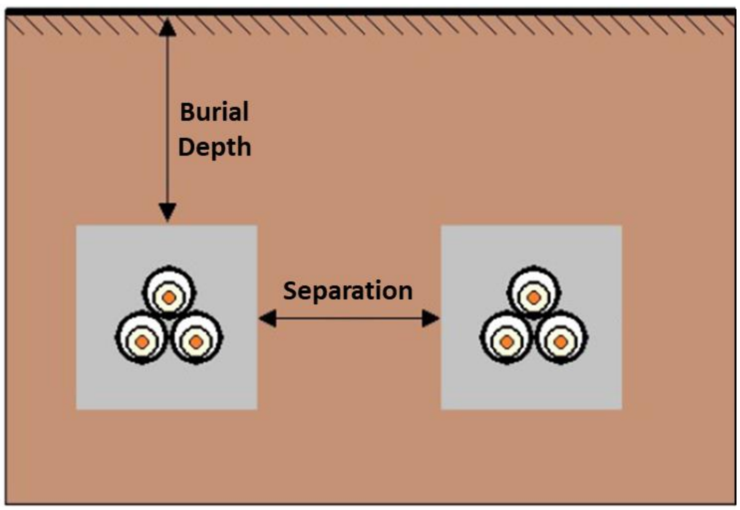

Figure 4. Representative cross-section of the Typical configuration of interconnection cables in 345-kV duct banks for EW 1.

EW 2: Onshore 345-kV Export Cables

At landfall for EW 2, the two submarine export cable circuits will enter JTBs where each submarine cable will be spliced to three individual onshore single-core, cross linked polyethylene (XLPE) export cables (three for each circuit, six cables total). Along a majority of the route between the JTB and the selected EW 2 onshore substation, the onshore export cables will be constructed in a double-circuit underground duct bank configuration, as shown in Figure 5, wherein the three conductors of each circuit are arranged in a trefoil configuration. A more detailed schematic of this configuration is provided in Attachment A (see Figure A-5). The duct bank configuration will be installed at a minimum target burial depth of 3 feet (ft) (0.9 meters [m]) below ground level and will be constructed at the center of a 25-ft (7.6-m) wide cable corridor (i.e., a ROW) during operation. Each of the two circuits will operate at 345 kV and will carry an average current of 703 Amperes (A) and a peak current of 1,153 A (i.e., average and peak loading, respectively).

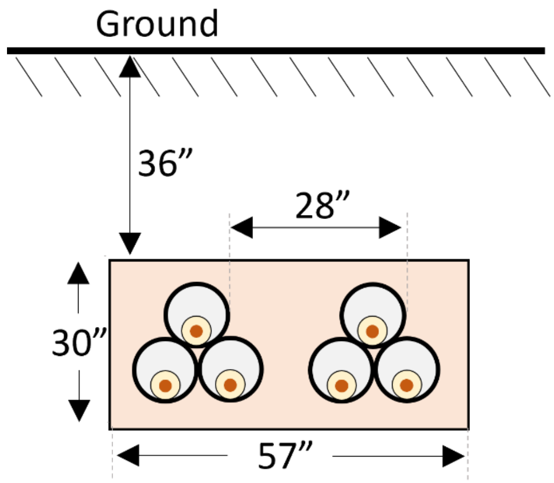

Figure 5. The double-circuit underground duct bank configuration for the 345-kV export cables or 345-kV interconnection cables showing two circuits, each in a trefoil configuration.

Where the onshore cable route may pass under roads or railway lines, short segments the onshore export cables will be constructed in a double-circuit underground Road Crossing configuration, as shown in Attachment A, Figure A-6. The three conductors of each circuit in the Road Crossing configuration will be arranged in a trefoil configuration within a 30” steel pipe. The center-to-center spacing of the two circuits will be 17.5 ft (5.3 m). Each of the two circuits will operate at 345-kV and was modeled with an average current of 703 A and a peak current of 1153 A. Further details of the onshore export cables and the respective duct bank configurations are discussed in Attachment A.

EW 2: Onshore 345-kV Interconnection Cables

At the onshore substation, the Project cables will transition from the 345 kV onshore export cables to the 345 kV onshore interconnection cables, which will carry power from the onshore substation to the existing POI on two 345-kV underground interconnection cable circuits. Along a majority of the route, the onshore interconnection cables will be constructed in the same underground duct bank configuration as the Export Cable, as shown above in Figure 5. For short segments of the route, the onshore interconnection cables will be constructed in the Road Crossing configuration, as shown in Attachment A, Figure A-6. The geometrical configurations and loading values proposed for the 345-kV onshore export cables in the duct bank and Road Crossing configurations are nominally identical to those proposed for the onshore export cable discussed above.

Calculation Methods

Magnetic-field levels were calculated for each cable configuration using conservative assumptions to ensure that the calculated field levels overestimate the field levels measured at any specified current flow. Magnetic-field levels were calculated using computer algorithms developed by the Bonneville Power Administration, an agency of the U.S. Department of Energy (BPA, 1991). All calculations were made assuming that the conductors of the transmission line are parallel to one another and infinite in extent. Although these assumptions simplify the calculations, they do not decrease the accuracy of the model, and the BPA algorithms have been shown to accurately predict magnetic-field levels measured near transmission lines (Chartier and Dickson, 1990; Perrin et al., 1991). Field levels were calculated at a height of 3.3 ft (1 m) above ground and reported as the resultant root mean square field level of the three orthogonal field components in accordance with IEEE Std. C95.3.1-2010 (IEEE, 2010) and IEEE Std. 644-2019 (IEEE, 2019).[4] Although the routes of the onshore export cables and surrounding infrastructure (e.g., existing transmission or distribution lines, substations, etc.) will differ for each landing site, the magnetic-field levels from the proposed duct banks will not vary by location, and the calculations provided are representative of export cable installations along each onshore route.

Phase Optimization

The particular configuration of the phase conductors among the different circuits can significantly change the magnetic-field level above the cables for each of the EW 1 or EW 2 onshore cable installation configurations. This is due to the mutual cancellation of magnetic

[4] For an Article VII filing in New York, magnetic-field levels are required to be reported as the maximum of the field ellipse, which is similar to the resultant root mean square field, but may not be exactly the same.

fields from adjacent cables and circuits. Phase optimization is one of the low-cost measures to reduce magnetic-field levels, consistent with recommendations of the World Health Organization (WHO, 2007). At the request of Empire, Exponent performed a phase optimization analysis for both the EW 1 and EW 2 onshore export and interconnection cables to determine which of all possible phase permutations of the cables in each configuration would minimize the calculated magnetic-field levels at a horizontal distance of 25 ft (7.6 m) from the center of the model. The arrangement of the phase optimized conductors for each of the five modeled configurations are indicated by the letters adjacent to each phase conductor in Figure A-2 through Figure A-6. The results of the calculations performed using these phase optimized arrangements for each of the five model configurations are provided in Attachment B.

Calculated Magnetic Fields

Magnetic-field levels were calculated for the proposed onshore cables of EW 1 and EW 2 at average and peak current flows, and using the optimal phasing calculated as described above. For EW 1, calculated field levels for the Typical configuration in the preferred arrangement for average current flows are summarized below and represent field levels expected to occur along proposed routes. Similarly, for EW 2, the calculated magnetic-field levels for the duct bank configuration at average loading are summarized below and represent magnetic-field levels expected to typically occur along proposed routes. Calculated field levels for all configurations and current flows are summarized in Attachment B.

EW 1: Onshore 345-kV Interconnection Cable Duct Banks

Magnetic-field levels for the Typical configuration of the EW 1 interconnection cable between the onshore substation and the POI calculated at 3.3 ft (1 m) above ground, are plotted as a function of horizontal distance from the midpoint between the two duct banks for a representative cross-section of the Typical configuration (Figure 6).

Table 1 summarizes the calculated magnetic-field values for the EW 1 interconnection cable. The highest calculated magnetic-field level at average loading is 37 mG directly over either of the two duct banks, decreasing rapidly to 5 mG or less beyond a horizontal distance of 30 ft (9.1 m) from the center of the two duct banks. All calculated magnetic-field levels for this and short portions of the route in which alternative spacings and configurations are proposed (including at peak loading) are included in Attachment B. All calculated magnetic-field levels are well below the ICNIRP reference level of 2,000 mG and the ICES exposure reference level of 9,040 mG for exposure of the general public.[5]

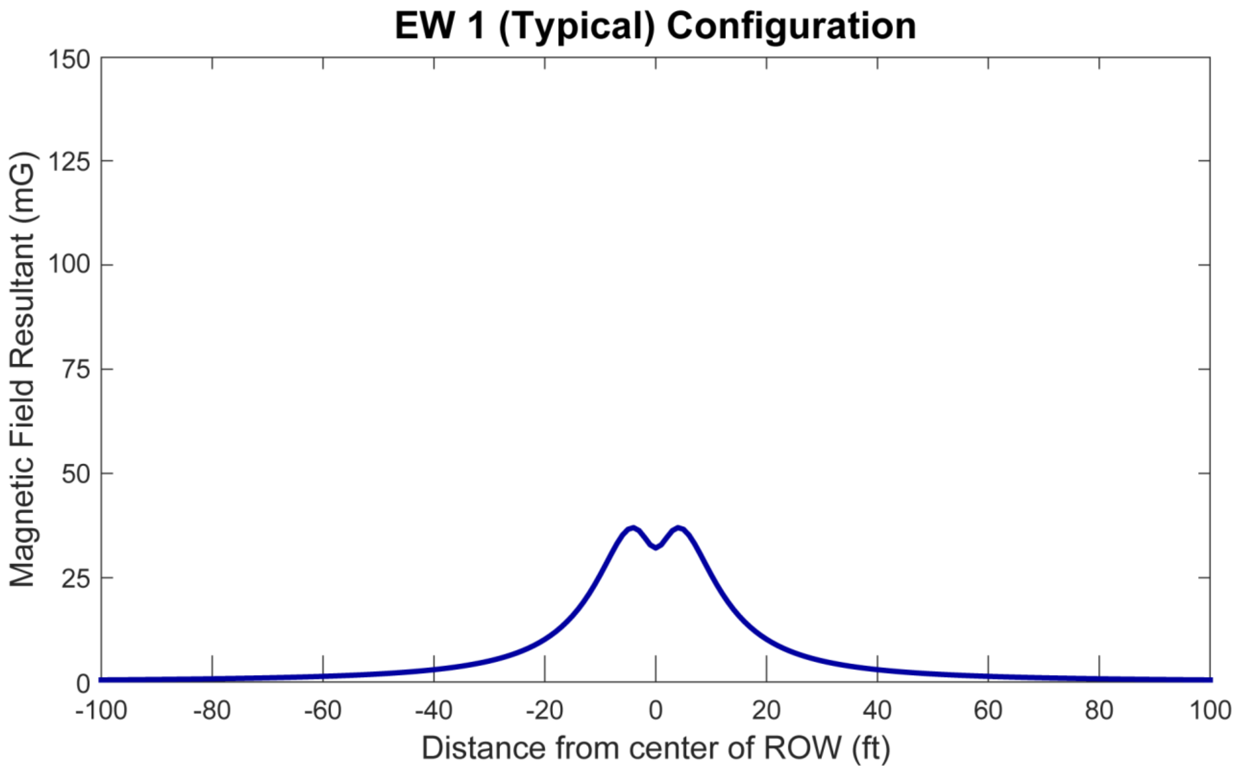

Figure 6. Calculated magnetic-field levels at 3.3 ft (1 m) above ground for the Typical configuration of EW 1 345-kV interconnection cable at average loading.

Table 1. Calculated magnetic-field levels (mG) at 3.3 ft (1 m) above ground for the Typical configuration of the EW 1 345 kV interconnection cable at average loading

	Distance from Center of Configuration						
Cable	**–50ft (–15 m)**	**–25ft (–7.6 m)**	**–10ft (–3 m)**	**Max**	**+10ft (+3 m)**	**+25ft (+7.6 m)**	**+50ft (+15 m)**
EW 1 (Typical) Interconnection	1.9	7.0	26	37	26	7.0	1.9

5 The Article VII report (Exponent, 2023) to be submitted to the New York State Public Service Commission demonstrates compliance with the New York interim magnetic-field standard.

EW 2: Onshore 345-kV Export/Interconnection Cable Duct Bank

Calculated magnetic-field levels for the EW 2 onshore export cables and onshore interconnection cables in the underground duct bank configuration at average current flow are plotted as a function of horizontal distance from the center of the duct bank – i.e., the midpoint between the two trefoils, as shown in Figure 7. With the change from 230-kV design for the export cables to 345 kV, the calculated magnetic field values for the export and interconnection configurations are now the same.

Table 2 summarizes the calculated magnetic-field values for this duct bank configuration of the EW 2 onshore/interconnection cable. The highest calculated magnetic-field level at average loading is 37 mG directly over either of the two circuits, decreasing rapidly to 5.8 mG or less beyond a horizontal distance of 25 ft (7.6 m) from the center of the double-circuit bank. Tabular summaries of the calculated magnetic-field levels for this configuration and the alternative Road Crossing configuration, at both average and peak loading, are included in Attachment B.

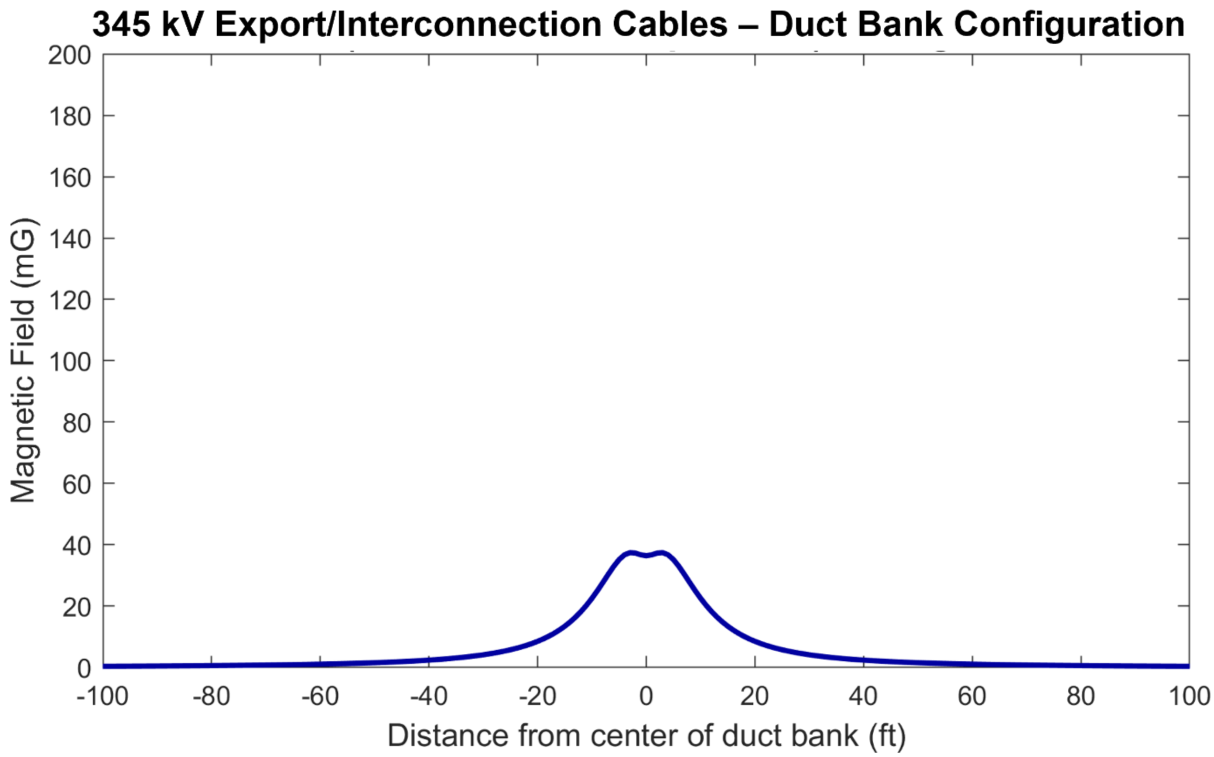

Figure 7. Calculated magnetic-field levels at 3.3 ft (1.0 m) above ground for EW 2, 345 kV onshore export and interconnection cable in double-circuit duct bank configuration at average loading.

Table 2. Calculated magnetic-field levels (mG) at 3.3 ft (1.0 m) above ground for the duct bank configuration of EW 2 345 kV onshore export/interconnection cables at average loading.

	Distance from Center of Configuration						
Configuration	**–50ft (–15 m)**	**–25ft (–7.6 m)**	**–10ft (–3 m)**	**Max**	**+10ft (+3 m)**	**+25ft (+7.6 m)**	**+50ft (+15 m)**
EW 2 Duct Bank (Export Cable and Interconnection Cable)	1.6	5.8	23	37	23	5.8	1.6

All calculated magnetic-field levels for were well below the ICNIRP reference level of 2,000 mG and the ICES exposure reference level of 9,040 mG for exposure of the general public.

Conclusions

The change in the voltage of the EW 2 export and interconnection cables from 230 kV to 345-kV has led to new calculations of the magnetic fields from those elements. The magnetic-field levels generated by the Project's onshore export and interconnection cables (for both EW 1 and the updated design of EW 2) were calculated to be well below limits published by the International Commission of Non-Ionizing Radiation Protection (ICNIRP) (2,000 mG) and International Committee on Electromagnetic Safety (ICES) (9,040 mG) that are designed to protect the health and safety of the general public (ICES, 2019; ICNIRP, 2010).[6] The highest magnetic-field levels were calculated over the duct banks but decrease rapidly with distance.

For EW 1 the calculated magnetic-field level for the Typical interconnection cable configuration (proposed for the majority of the respective onshore cable routes) at 25 ft (7.6 m) at average current flow was 7.0 mG, which is more than 280 to 1200 times lower than ICNIRP or ICES reference levels for exposure of the general public. For short distances along the EW 1 route where the cable may be installed in alternate configurations at road crossings or to avoid buried infrastructure, the magnetic fields were slightly higher and lower respectively.

For EW 2, at a distance of 25 ft (7.6 m) from the duct bank centerline, the magnetic-field levels of the onshore export and interconnection cables in any configuration were calculated to be 9.8 mG or less at average loading, more than 200 to 900 times lower than ICNIRP or ICES reference levels for exposure of the general public.

For all cable configurations, the magnetic field at peak current flow will be higher than at average current; however, the magnetic fields from all configurations and all current levels will remain well below the ICNIRP and ICES limits.

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[6] The Article VII report (Exponent, 2023) to be submitted to the New York State Public Service Commission demonstrates compliance with the New York interim magnetic-field standard

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Limitations

At the request of Empire, Exponent modeled the magnetic-field levels associated with the operation of the onshore underground cables that will transport electricity generated by the Project from the shore to the proposed points of interconnection.

This report summarizes the analysis performed to date and presents the findings resulting from that work. In the analysis, we have relied on cable design geometry, usage, specifications, and various other types of information provided by Empire. We cannot verify the correctness of this input data and rely on Empire 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. Empire has confirmed to Exponent that the data contained herein are not subject to Critical Energy Infrastructure Information restrictions.

The results 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 for purposes other than intended for permitting of the proposed 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.

Benjamin R.T. Cotts, Ph.D., P.E. (Licensed Electrical Engineer, New York, #103209-01), employed by Exponent, performed and reviewed calculations of the magnetic fields associated with the operation of the proposed Project.

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Benjamin Cotts, Ph.D., P.E.

Attachment A

Cable and Duct Bank Details

Table A-1. Summary of onshore cable parameters for EW 1 and EW 2

	EW 1	EW 2	
Description	Interconnection	Export	Interconnection
Source capacity	410 Megawatts	630 Megawatts	620 Megawatts
Voltage	345 kV	345 kV	345 kV
Average Loading per Cable*	618 A	703 A	703 A
Peak Loading per Cable*	727 A	1,153 A	1153 A
Number of circuits per duct Installation Configuration	2	2	2
Number of cables per phase	1	1	1
Typical Separation between Duct Banks (and range)	Typical: 0-10 ft (0-3 m)†	N/A	N/A
Phase Cable Type, Outer Diameter (OD)	Single-core XLPE, 5.2-inch Outer Diameter (133 millimeter)	Single-core XLPE, 5.26-inch Outer Diameter (133.7 millimeter [mm])	
Phase Conductor Diameter	2.25-inches (57.1 mm)		
GCC cable type, Outer Diameter	N/A		
Minimum Burial Depth‡	3 ft (0.9m)		
Evaluation Height	At 3.3 ft (1 m) above ground		

* All loading levels are given on a per-cable basis.
† Center-to-center spacing between trefoil bundles.
‡ To the top of the duct bank or conduit.

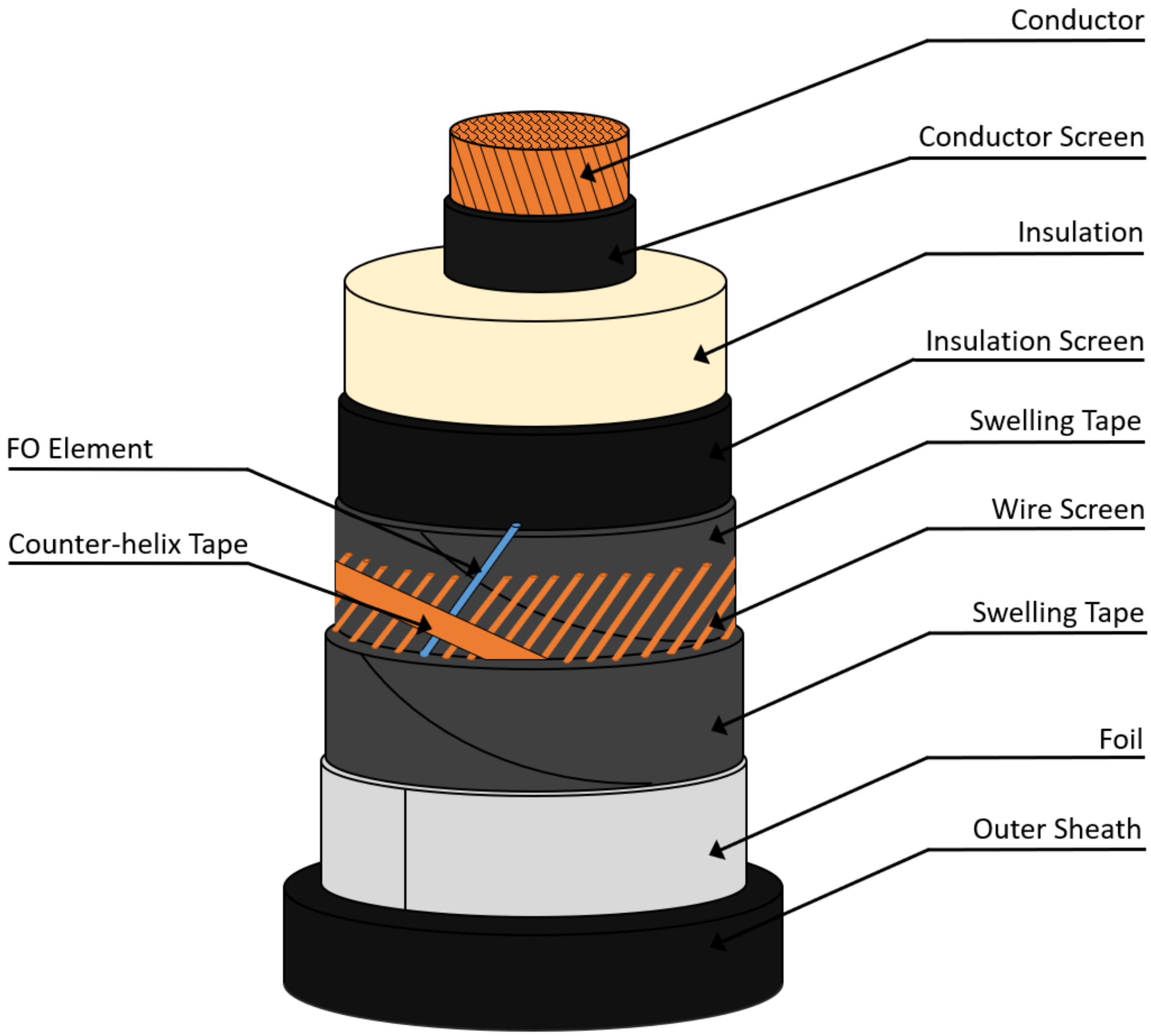

Figure A-1. Representative cross-section of a single conductor of an onshore cable.

EW 1: Duct Bank Configurations

Figure A-2 below shows a cross-section of the underground duct banks with cables in the Typical trefoil configuration. Short cable segments under a road may be in the Road Crossing configuration; in the Road Crossing configuration, the cables will be installed in a trefoil configuration inside of larger direct buried conduits or pipes, rather than in duct banks (Figure A-3). The minimum target burial depth to the top of the trefoil-containing pipes is 3 ft (0.9 m), and the range of possible separation distances between circuit centers at some locations beyond that of the Typical configuration is 10 to 20 ft (3 to 6 m). Alternatively, the cables may be installed in duct banks with a Flat configuration (Figure A-4) for short distances when the Typical configuration is not possible. The minimum separation distance between onshore cable circuits in the Flat configuration is 0 to 10 ft (0 to 3 m).

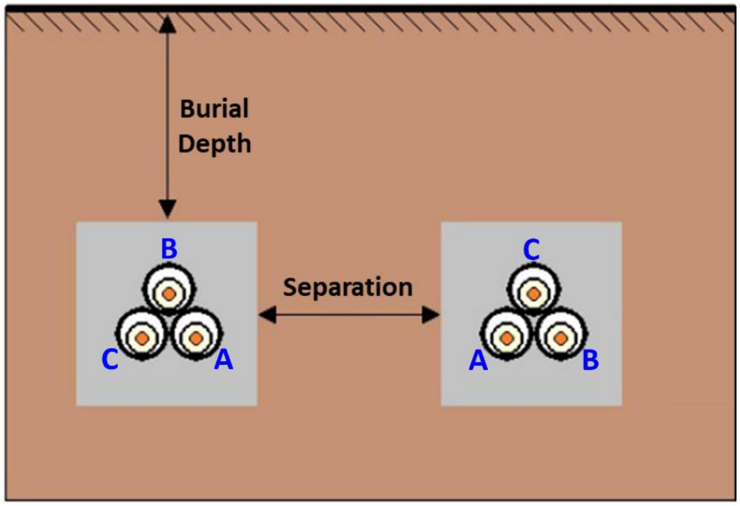

Figure A-2. Representative cross-section of the Typical configuration of onshore cables in duct banks. Optimized arrangement of phase conductors indicated by letters A, B, and C.

The configuration with Separation = 0.0 ft (0.0 m) represents the preferred and most likely configuration for both the onshore export cables and interconnection cables comprising the majority of the route for EW 1.

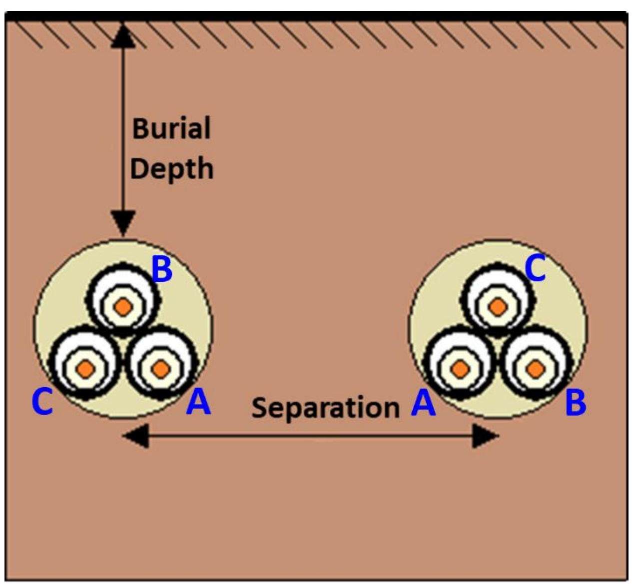

Figure A-3. Representative cross-section of the road crossing configuration of onshore cables. Optimized arrangement of phase conductors indicated by letters A, B, and C.

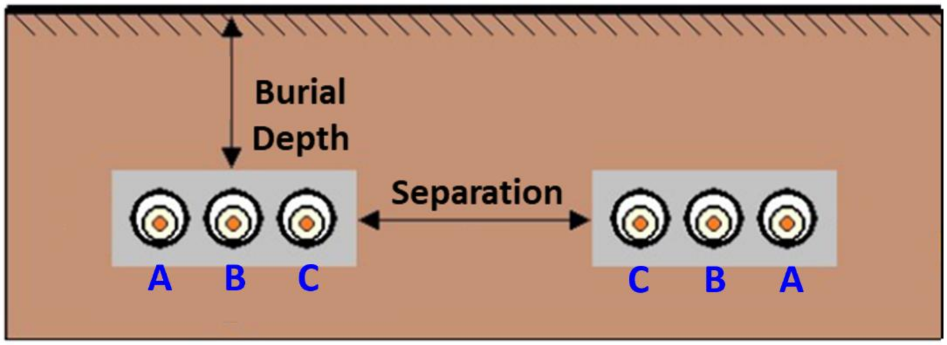

Figure A-4. Representative cross-section of the flat configuration of onshore cables. Optimized arrangement of phase conductors indicated by letters A, B, and C.

EW 2: Duct Bank and Road Crossing Configurations

Figure A-5 shows a cross-section of the underground double-circuit duct bank for both the onshore export cables and onshore interconnection cables. Figure A-6 shows a cross-section of the underground double-circuit Road Crossing configuration, which may be used for short cable segments, for example, where the cables may pass under a road. The minimum target burial depth to the top of the trefoil-containing duct bank or conduit pipes is 3 ft (0.9 m).

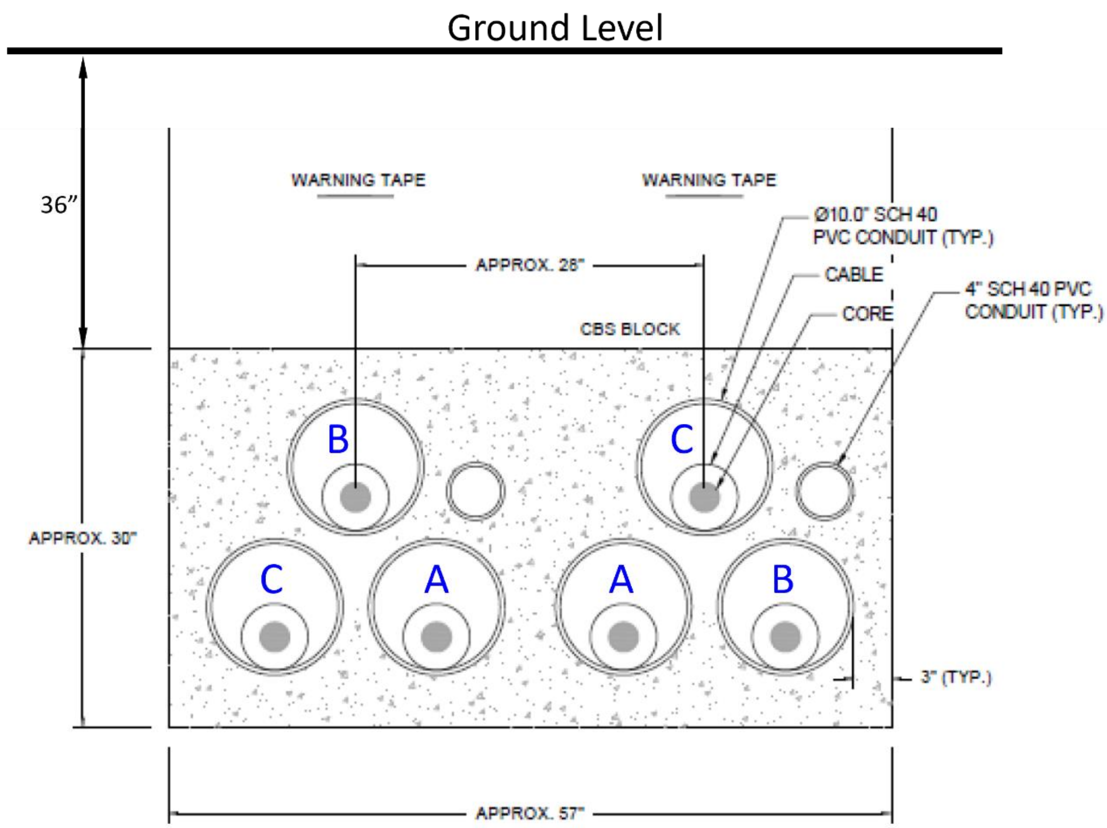

Figure A-5. Schematic of the double-circuit underground duct bank configuration for the 345 kV onshore export cables and 345 kV interconnection cables. Optimized arrangement of phase conductors indicated by letters A, B, and C.

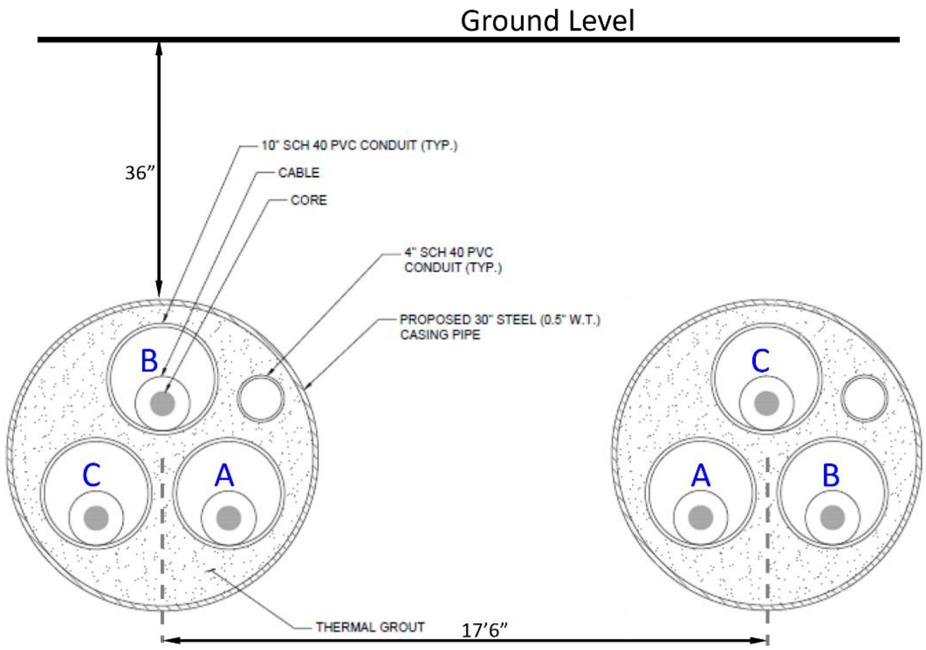

Figure A-6. Schematic of the double-circuit underground Road Crossing configuration for the 345 kV onshore export cables and 345 kV interconnection cables. Optimized arrangement of phase conductors indicated by letters A, B, and C.

Attachment B

Calculated Magnetic Field Levels

EW 1 Magnetic Fields

Table B-1. Calculated magnetic-field levels (mG) at 3.3 ft (1.0 m) above ground for the EW 1 345-kV interconnection cables in Typical and alternative configurations at preferred circuit spacing and at **average** loading

Configuration	Spacing	Distance from Center of Configuration								
		-75 ft	-50 ft	-25 ft	-10 ft	Max	10 ft	25 ft	50 ft	75 ft
Typical	0 ft*	0.9	1.9	7.0	26	37	26	7.0	1.9	0.9
Road Crossing	10 ft**	0.9	2.0	8.3	44	75	44	8.3	2.0	0.9
Flat	0 ft*	0.1	0.4	2.9	28	124	28	2.9	0.4	0.1

* Spacing represents the edge-to-edge distance between adjacent duct banks.
** Spacing represents the center-to-center distance between circuits.

Table B-2. Calculated magnetic-field levels (mG) at 3.3 ft (1.0 m) above ground for the EW 1 345-kV interconnection cables in Typical and alternative configurations at preferred circuit spacing and at **peak** loading

Configuration	Spacing	Distance from Center of Configuration								
		-75 ft	-50 ft	-25 ft	-10 ft	Max	10 ft	25 ft	50 ft	75 ft
Typical	0 ft*	1.0	2.3	8.2	30	44	30	8.2	2.3	1.0
Road Crossing	10 ft**	1.0	2.4	9.8	52	88	52	9.8	2.4	1.0
Flat	0 ft*	0.1	0.5	3.4	33	145	33	3.4	0.5	0.1

* Spacing represents the edge-to-edge distance between adjacent duct banks.
** Spacing represents the center-to-center distance between circuits.

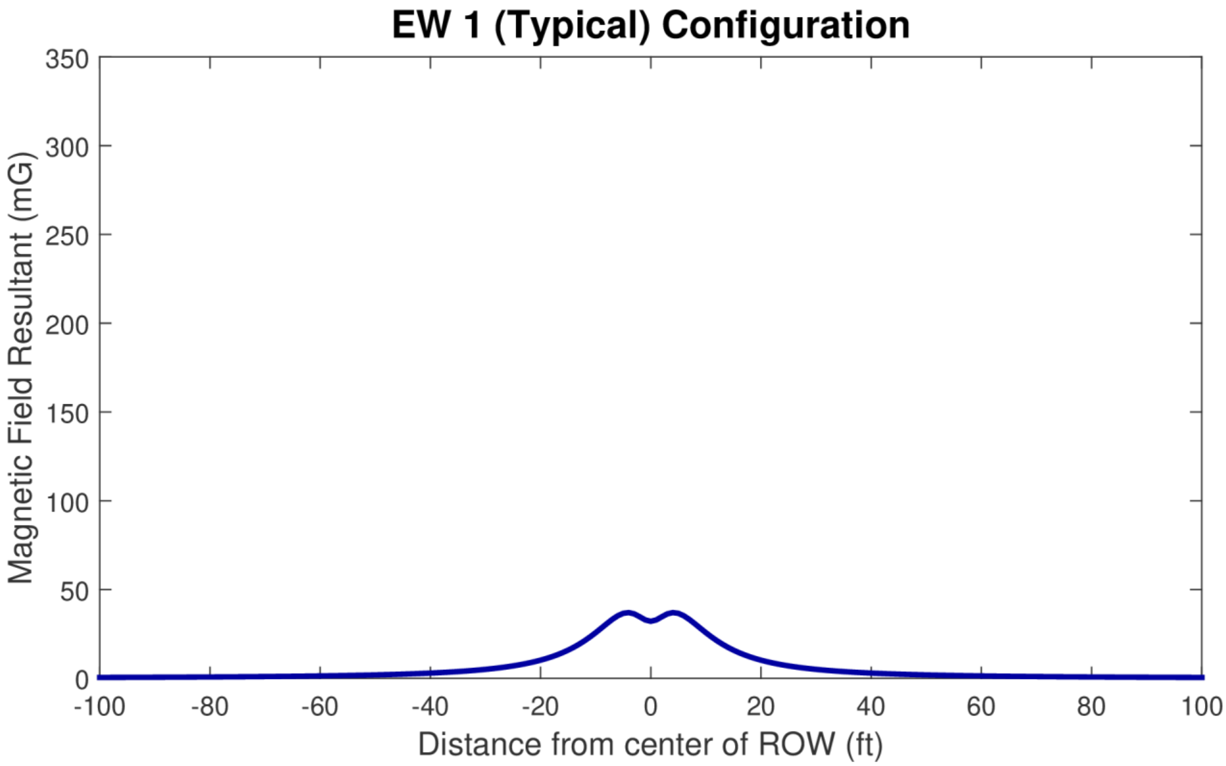

Figure B-1. Calculated magnetic-field levels at 3.3 ft (1.0 m) above ground for the EW 1 345-kV interconnection cable in the Typical configuration at average loading.

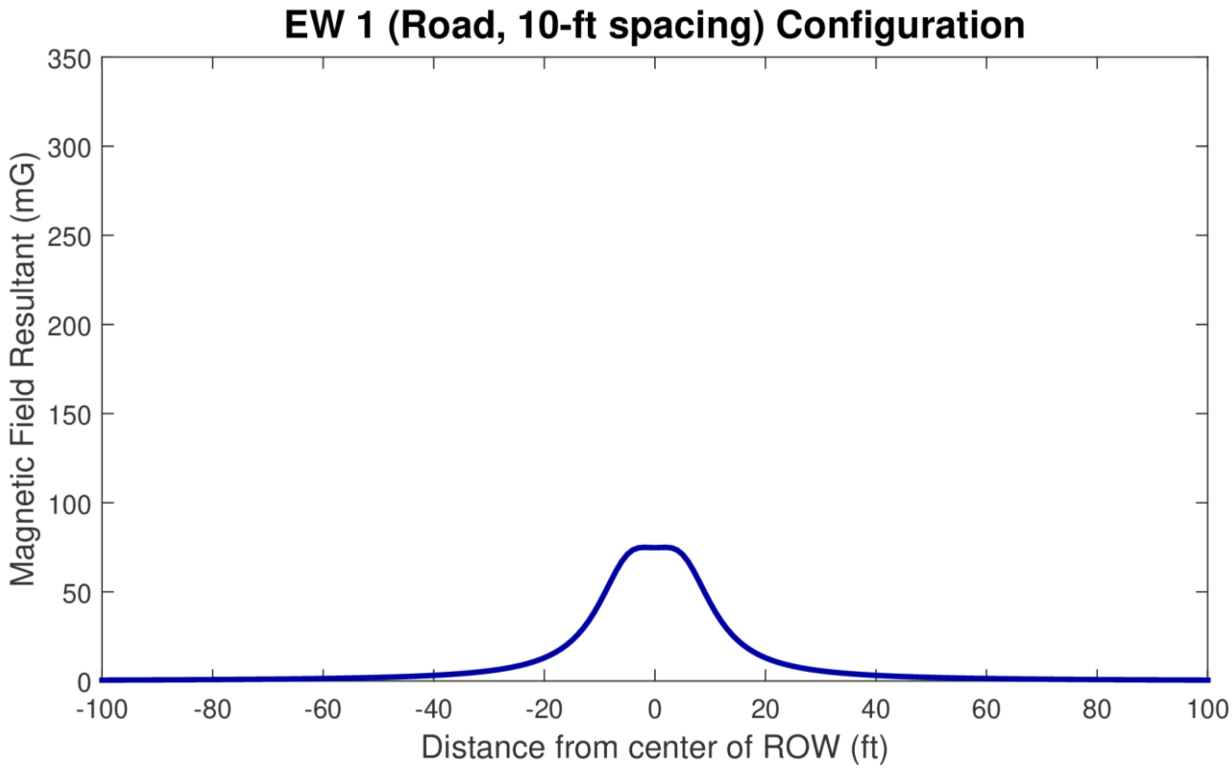

Figure B-2. Calculated magnetic-field levels at 3.3 ft (1 m) above ground for the EW 1 345-kV interconnection cable for the Road Crossing configuration at the preferred circuit spacing (10 ft [3 m]) at average loading.

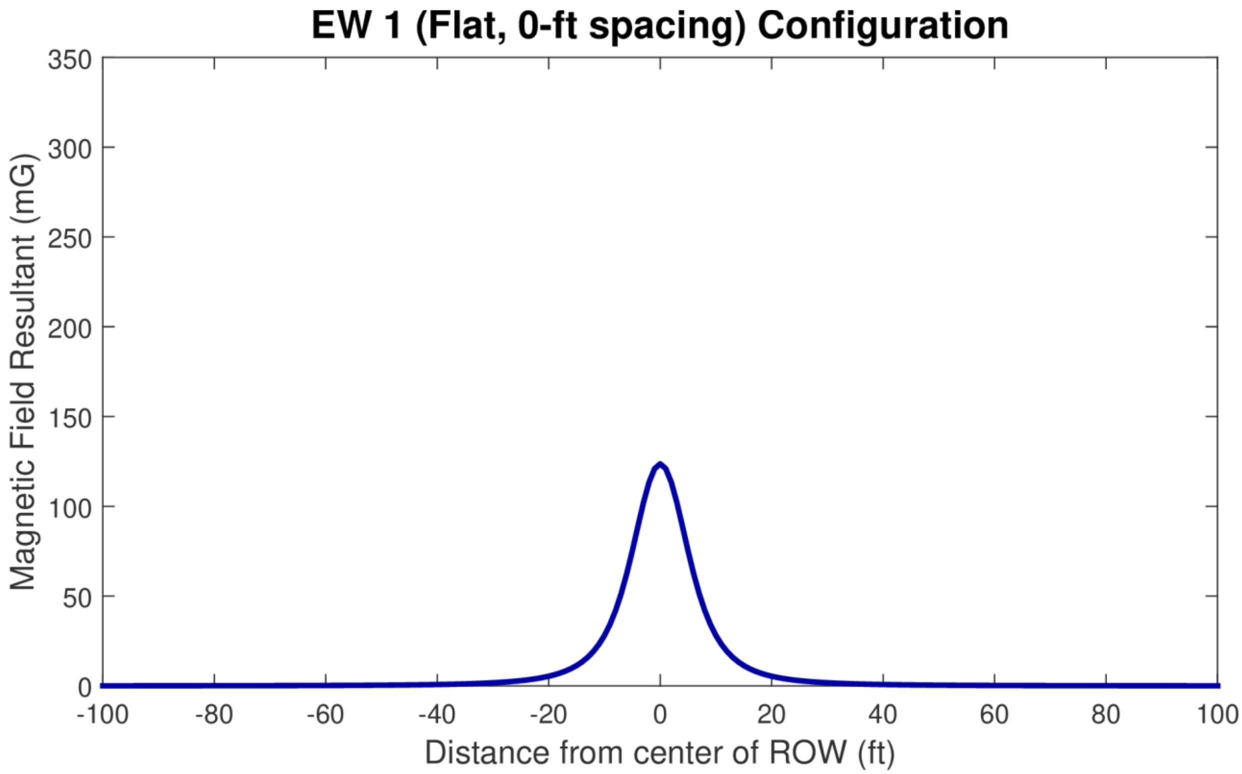

Figure B-3. Calculated magnetic-field levels at 3.3 ft (1.0 m) above ground for the EW 1 345-kV interconnection cable for the Flat configuration at average loading.

EW 2 Magnetic Fields

Table B-3. Calculated magnetic-field levels (mG) at 3.3 ft (1.0 m) above ground for the EW 2 345 kV onshore export cable and 345-kV onshore interconnection cable at average loading in each of the two configurations considered.

Export Cable and Interconnection Cable Configuration	Distance from Center of Configuration*								
	-75 ft	-50 ft	-25 ft	-10 ft	Max	10 ft	25 ft	50 ft	75 ft
Duct Bank	0.7	1.6	5.8	23	37	23	5.8	1.6	0.7
Road Crossing	0.8	1.9	9.8	56	60	56	9.8	1.9	0.8

*Horizontal distance is measured from the midpoint of the two trefoil circuits

Table B-4. Calculated magnetic-field levels (mG) at 3.3 ft (1.0 m) above ground for the EW 2 345 kV onshore export cable and 345-kV onshore interconnection cable at peak loading in each of the two configurations considered.

Export Cable and Interconnection Cable Configuration	Distance from Center of Configuration*								
	-75 ft	-50 ft	-25 ft	-10 ft	Max	10 ft	25 ft	50 ft	75 ft
Duct Bank	1.2	2.6	9.5	37	61	37	9.5	2.6	1.2
Road Crossing	1.3	3.0	16	91	98	91	16	3.0	1.3

*Horizontal distance is measured from the midpoint of the two trefoil circuits

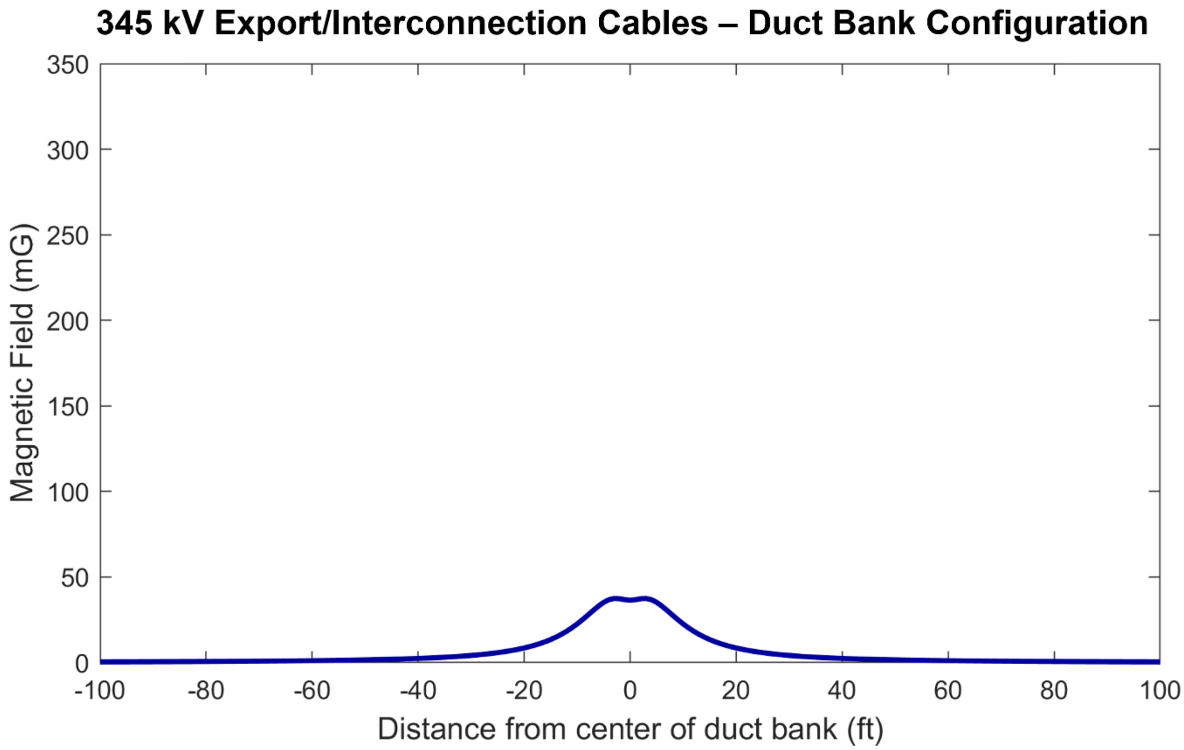

Figure B-4. Calculated magnetic-field levels at 3.3 ft (1 m) above ground for the EW 2 345-kV export cable and 345-kV interconnection cable for the duct bank configuration at average loading.

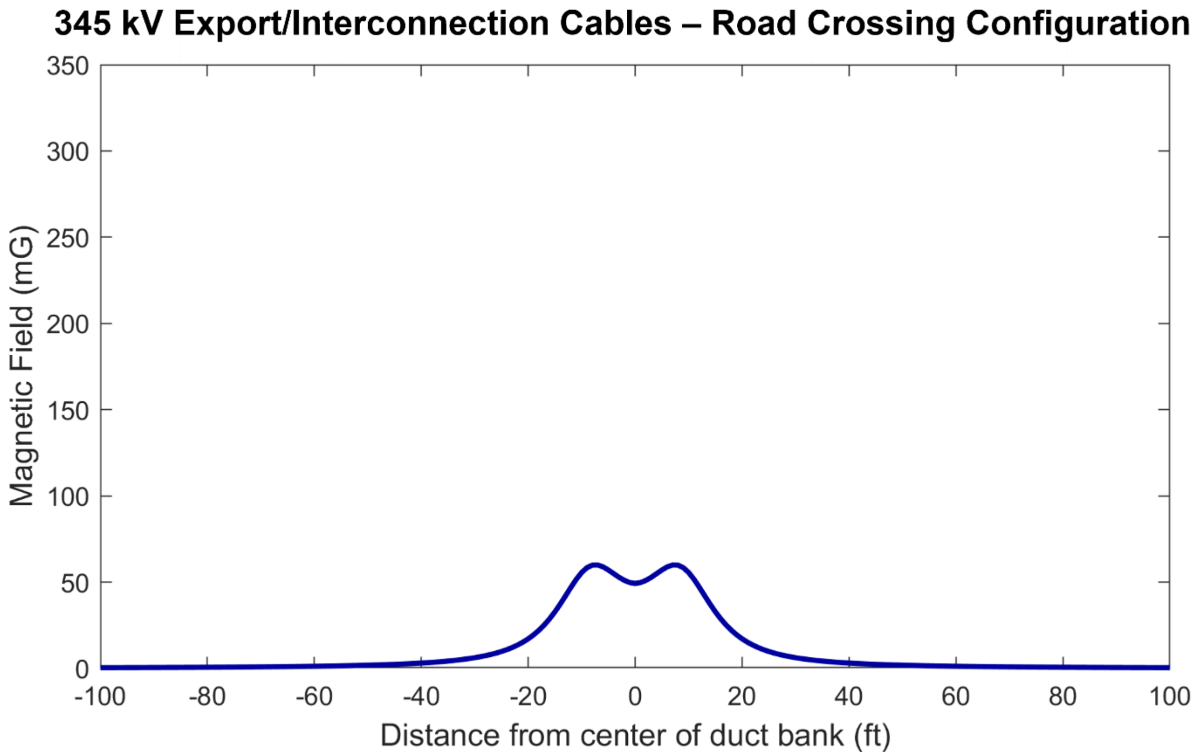

Figure B-5. Calculated magnetic-field levels at 3.3 ft (1 m) above ground for the EW 2 345-kV export cable and 345-kV interconnection cable for the Road Crossing configuration at average loading