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APPENDIX DD

Onshore Electric and Magnetic Field Assessment

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Prepared for

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Onshore Electric and Magnetic Field Assessment

Beacon Wind Project

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ACRONYMS AND ABBREVIATIONS

AC	alternating current
ACGIH	American Conference of Governmental Industrial Hygienists
AGRE	Astoria Gateway for Renewable Energy
Beacon Wind	Beacon Wind LLC
BOEM	Bureau of Ocean Energy Management
BW1	Beacon Wind 1
BW2	Beacon Wind 2
COP	Construction and Operations Plan
DC	direct current
EMF	electric and magnetic field
GPS	global positioning system
HDD	horizontal directional drilling
HVAC	high-voltage alternating current
HVDC	high-voltage direct current
Hz	Hertz
ICES	International Committee on Electromagnetic Safety
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IEEE	Institute of Electrical and Electronics Engineers
Integral	Integral Consulting Inc.
Lease Area	Renewable Energy Lease Area OCS-A 0520
mG	milliGauss
MW	megawatt
NYPA	New York Power Authority
NYPSC	New York Public Service Commission
NYSERDA	New York State Energy Research and Development Authority
PDE	project design envelope
POI	Point of Interconnection
ROW	right-of-way
TLV	Threshold Limit Value

TWA	time-weighted average
WHO	World Health Organization
WNC	winter normal conductor
XLPE	cross-linked polyethylene

LIMITATIONS

At the request of Beacon Wind LLC (Beacon Wind), Integral Consulting Inc. (Integral) assessed the electric and magnetic field (EMF) levels associated with the offshore submarine export cables and onshore cables that will transfer electricity generated by Beacon Wind 1 (BW1) and Beacon Wind 2 (BW2) (collectively referred to hereafter as the Project). This report is focused on the onshore portion of the BW1 and BW2 Project. The cables assessed include the onshore export cables and the onshore interconnection cables located in Queens, New York, and Waterford, Connecticut, where the renewable electricity generated will be interconnected to the electric grid.

In performing the EMF assessment, Integral relied on data provided by Beacon Wind including information on the design, specifications, and usage of the offshore and onshore cables associated with BW1 and BW2. All details on the rating, location of routing, and burial depth of the cables were provided by Beacon Wind. Integral cannot verify the correctness of the data provided by Beacon Wind.

A range of project designs are being considered to allow for assessments of proposed activities and the flexibility to make development decisions prior to construction. The project design envelope (PDE) involves several scenarios with potential EMF effects that are associated with project infrastructure. This EMF assessment considers the information available at this time; the precise locations and schedule of the construction and operation scenarios may be subject to change as the engineering design progresses.

Although Integral 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 Beacon Wind. Beacon Wind has confirmed to Integral that the data contained herein are not subject to Critical Energy Infrastructure Information restrictions.

Integral 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 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

Beacon Wind LLC (Beacon Wind) proposes to construct and operate the Beacon Wind 1 (BW1) and Beacon Wind 2 (BW2) (collectively referred to hereafter as the Project) as two separate developments within the Bureau of Ocean Energy Management (BOEM) designated Renewable Energy Lease Area OCS-A 0520 (Lease Area).

The purpose of the Project is to generate renewable electricity from an offshore wind farm(s) located in the Lease Area. The Project addresses the need identified by northeastern states to achieve offshore renewable energy targets: New York (9,000 megawatts [MW]), Connecticut (2,000 MW), Rhode Island (up to 1,000 MW), and Massachusetts (5,600 MW). Beacon Wind has entered into a purchase and sales agreement for an offshore wind renewable energy certificate for at least 1,230 MW for BW1 as a result of New York State's solicitation for offshore renewable energy certificates, with BW2 is being developed to addresses the need for renewable energy identified by states across the region, including New York, Massachusetts, Rhode Island, and Connecticut.

The assessment of electric and magnetic fields (EMFs) presented in this report was performed by Integral Consulting Inc. (Integral) in support of the Construction and Operations Plan (COP). The assessment was performed to evaluate EMFs associated with representative configurations of the proposed BW1 and BW2 onshore electrical transmission systems. The onshore systems consist of high-voltage direct current (HVDC) onshore export cables that will be buried underground, and high-voltage alternating current (HVAC) onshore interconnection cables that will be either buried underground or present as overhead transmission lines.

The approach for assessing project-related EMF impacts to human health and the environment was guided by the internationally-accepted environmental risk assessment approach as well as other standard methods for EMF assessment accepted within the scientific, engineering, and health communities. The focus of this assessment is the onshore transmission systems at their landfall locations for BW1 (Astoria Power Complex, New York) and BW2 (Millstone Power Complex, Connecticut or Astoria Power Complex, New York). Both locations constitute industrial land use settings, with limited ecological habitat present. Accordingly, the assessment is performed with focus on human health considerations. A separate, comprehensive risk assessment has been additionally performed to address potential project-related EMF impacts to marine life in the offshore EMF assessment (Integral 2022) prepared in support of the COP.

The onshore EMF assessment included quantitative modeling of EMF for the BW1 and BW2 onshore components of the transmission systems, specifically the HVDC onshore export cables and the HVAC onshore interconnection cables. The direct current (DC) and alternating current (AC) magnetic fields associated with the operation of equipment within the BW1 and BW2 onshore substation facilities were not modeled, as fields from these sources can be expected to be at minimal levels outside the facility perimeters. The EMF modeling was based on the maximum capacity limits of the cables corresponding to the winter normal conductor rating. The modeled results were compared to EMF exposure limits developed by New York Public Service Commission (NYPSC) for the state of New York and by the International Commission on Non-Ionizing Radiation Protection (ICNIRP), an internationally-recognized organization committed to EMF health and safety.

- The maximum magnetic field strengths modeled for the BW1 and BW2 HVDC onshore export cables are between 6 to 2,300 times below the ICNIRP DC magnetic field exposure limits protective of human health.
- The maximum magnetic fields modeling for the BW1 and BW2 HVAC onshore interconnection cables are between 1.5 to 10.5 times lower than the ICNIRP AC magnetic field exposure limit of 2000 mG, protective of human health. Importantly, the magnetic fields modeled for the HVAC onshore interconnection cables meet the NYPSC interim guideline of 200 mG for AC magnetic fields with an assumed ROW width of 110 ft (33.5 m), or 55 ft (17 m) from the centerline of the ROW.
- The maximum electric field strength for the BW1 and BW2 HVAC onshore interconnect cables proposed as overhead cables are between 1.2 to 4.2 times lower than the ICNIRP 60-Hz AC electric field exposure limit protective of human health of 4.2 kV/m. For the HVDC onshore export cables and for onshore interconnection cables run underground (BW1, between AGRE West and the Astoria West POI), electric fields will be isolated from the outside environment using metal sheathing and by being buried, respectively.
- Electric fields modeled for the BW2 HVAC onshore interconnection cables meet the NYPSC guideline for electrical fields (1.6 kV/m) with an assumed ROW width of 110 ft (33.5 m), or 55 ft (16.8 m) from the center line of the ROW.

Collectively, the EMF assessment indicates that potential human health risks associated with exposure to project-related EMF from the BW1 and BW2 onshore electric transmission systems proposed for Queens, New York and Waterford, Connecticut are *de minimis*.[1]

[1] In risk assessment, the term "*de minimis*" refers to risk levels that are too small to be meaningful or taken into consideration.

1 INTRODUCTION

1.1 PROJECT DESCRIPTION

Beacon Wind LLC (Beacon Wind) proposes to construct and operate Beacon Wind 1 (BW1) and Beacon Wind 2 (BW2) (collectively referred to hereafter as the Project), as two separate developments within the Bureau of Ocean Energy Management (BOEM) designated Renewable Energy Lease Area OCS-A 0520 (Lease Area). The Lease Area covers approximately 128,811 ac (521 km^2) and is located approximately 20 mi (32 km) south of Nantucket, Massachusetts, and 60 mi (97 km) east of Montauk, New York (**Figure 1**). The Lease Area was awarded through the BOEM competitive renewable energy lease auction of the Wind Energy Area offshore of Massachusetts.

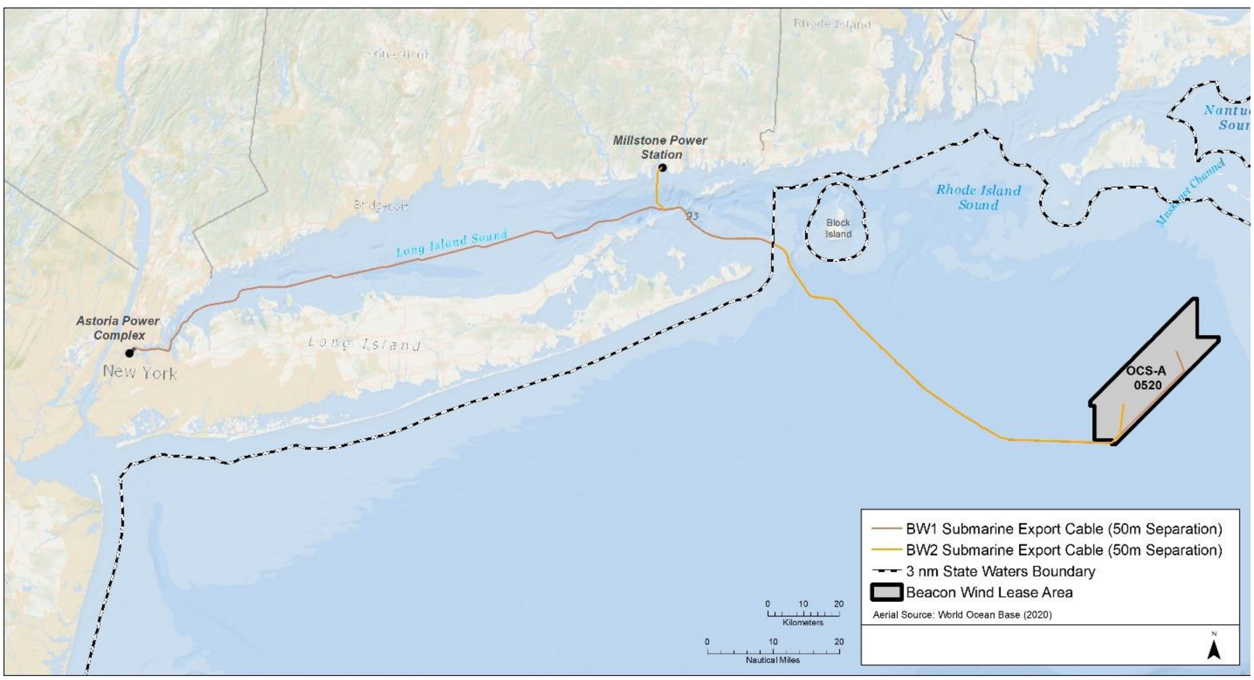

Figure 1. Beacon Wind Project Overview Showing Lease Area and the Location of the Onshore Substation Facilities for BW1 and BW2.

The purpose of the Project is to generate renewable electricity from an offshore wind farm(s) located in the Lease Area. The Project addresses the need identified by northeastern states to achieve offshore renewable energy targets: New York (9,000 megawatts [MW]), Connecticut (2,000 MW), Rhode Island (up to 1,000 MW), and Massachusetts (5,600 MW).

The BW1 wind farm has a 25-year offtake agreement with the New York State Energy Research and Development Authority (NYSERDA) to deliver the power to its identified POI in Queens, New York.

BW1, located in the northern 56,535 ac (229 km^2) of the Lease Area will be developed first with a landfall at the Astoria Power Complex in Queens, New York; and then BW2 will be developed, located in the southern 51,611 ac (209 km^2) of the Lease Area with a landfall either at the Millstone Power Complex in Waterford, Connecticut or at the Astoria Power Complex. An overlap in the Lease Area, comprising of 20,665 ac (84 km^2) could be used for BW1 or BW2. BW1 and BW2 will be constructed independently and will operate as electrically isolated transmission systems that will connect the individual offshore substations to their respective onshore Points of Interconnection (POIs) by way of submarine export cable routes.

BW1 will connect to the New York Independent System Operator via an existing substation owned by the Consolidated Edison Company of New York, Inc. The interconnectedness of the New England transmission system, managed by the New England Independent System Operator, allows a single point of interconnection in the region to deliver offshore wind energy to all of the New England states (Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire, and Maine). The magnitude of regional targets for offshore wind and the limited amount of developable area, given current and reasonably foreseeable BOEM leasing activity, demonstrates a need for full-build out of the Lease Area.

The components of BW1 that are discussed in this onshore EMF assessment report include:

1. Landfall at the Astoria Power Complex, Queens, New York
2. HVDC Onshore Export Cable—One 320 kV high-voltage direct current (HVDC) onshore export cable circuit (two cables) installed underground from the landfall to the onshore substation facility within the Astoria Power Complex (approximately 600 ft [183 m])
3. Onshore Substation Facility—One onshore substation facility (inclusive of an onshore converter station and onshore substation) that will transform the direct current (DC) voltage to 138 kV alternating current (AC) at the Astoria Power Complex with two sites under consideration consisting of the New York Power Authority [NYPA] site location and the Astoria Gateway for Renewable Energy [AGRE] West site)
4. HVAC Onshore Interconnection Cables—Three 138 kV cable circuits, each with nine high-voltage alternating current (HVAC) onshore interconnection cables
    a. From the NYPA onshore substation facility, circuits are buried underground to the Astoria West POI with each circuit ranging in length from approximately 544 to 1,230 ft (166 to 375 m).
    b. From the AGRE West substation facility, circuits are carried on overhead transmission structures in 1 to 3 circuit configurations to the Astoria West POI.

The components of the BW2 transmission system discussed in this onshore EMF assessment report include:

1. Potential Landfall at the Millstone Power Complex, Waterford, Connecticut and its accompanying infrastructure: or the Astoria Power Complex, Queens, New York
   a. HVDC Onshore Export Cable—One 320 kV HVDC onshore export cable circuit (two cables) installed underground from the landfall to the onshore substation facility within the Millstone Power Complex (approximately 330 ft [100 m]).
   b. Onshore Substation Facility—One onshore substation facility (inclusive of an onshore converter station and onshore substation) that will transform the DC voltage to 345 kV AC at the Millstone Power Complex.
   c. HVAC Onshore Interconnection Cables—One 345 kV overhead transmission line circuit, extending 200 ft (61 m) from the Millstone Power Complex onshore substation facility to the POI.
2. Potential Landfall at the Astoria Power Complex, Queens, New York and its accompanying infrastructure:
   a. HVDC Onshore Export Cable—One 320 kV high-voltage direct current (HVDC) onshore export cable circuit (two cables) installed underground from the landfall to the onshore substation facility within the Astoria Power Complex (approximately 600 ft [183 m]).
   b. Onshore Substation Facility— One onshore substation facility (AGRE East) (inclusive of an onshore converter station and onshore substation) that will transform the DC voltage to 138 kV AC.
   c. HVAC Onshore Interconnection Cables—Three 138kV circuits carried on overhead transmission structures extending from the AGRE East substation to the Astoria POI East.

1.2 ELECTRIC AND MAGNETIC FIELDS

EMFs are generated as a result of electrical currents flowing through a conductor. The onshore portions of the BW1 and BW2 transmission systems will include DC conductors (i.e., the HVDC onshore export cables) and AC conductors (i.e., the HVAC onshore interconnection cables), generating both DC and AC EMFs, respectively. Electric, magnetic, and induced electric fields generally may occur with electrical current flowing through conductors.

1.2.1 Magnetic Fields

Earth has a geomagnetic field, which creates a background DC magnetic field that is present everywhere on earth. Earth's geomagnetic field is a result of the magnetism of the minerals in the earth's crust and core. A DC current flowing through a cable will produce a DC magnetic field whose strength will vary based on the proximity of the cable conductors, the direction of the cable path relative to earth's geomagnetic field, the loading, and the cable burial depth. This cable-induced DC magnetic field can combine with earth's background magnetic field resulting in increasing or decreasing of total magnetic field strength. Similar to how a DC electric field is generated from earth's geomagnetic field, ions moving through the magnetic field generated by a DC cable will also generate a motion-induced DC electric field.

The current flowing through an AC cable will produce an AC magnetic field. The strength of this magnetic field will vary based on the configuration of the 3-phase AC cable, the loading, and the cable burial depth. No background AC magnetic fields naturally exist. An induced electric field will also occur as a result of AC cables and their associated magnetic fields. The induced AC electric field will have a frequency related to the frequency of the AC cable, resulting from either the rotation of the AC magnetic field or ions passing through the AC magnetic field.

1.2.2 Electric Fields

BW1 project cables will not be a direct source of electric fields above ground due to shielding of the electric field by the cable's metallic sheaths and because the cables will be buried underground. The shielding prevents electric fields from passing outside of the HVDC onshore export cables and HVAC onshore interconnection cables. Electric fields are also blocked by burial underground. Similarly, for BW2, the HVDC onshore export cables will also not be a direct source of electric fields above ground due to shielding of the electric field by the cable's metallic sheaths. Because overhead transmission lines are not constructed with metal sheathing, the BW2 HVAC onshore interconnection cables present as overhead transmission lines will be a direct source of electric fields in the immediate surrounding environment.

While an induced electric field may occur related to the AC magnetic field described above in **Section 1.2.1**, it will be several orders of magnitude below and *de minimis*[2] relative to the direct electric field considered for the BW2 HVAC onshore interconnection cables present as overhead transmission lines.

[2] In risk assessment, the term "*de minimis*" refers to risk levels that are too small to be meaningful or taken into consideration.

1.3 ENVIRONMENTAL RISK ASSESSMENT PROCESS

Risk assessment is used worldwide by health, environment and other regulatory agencies, and in the U.S. examples are:

- U.S. Department of Commerce (e.g., National Oceanic and Atmospheric Administration)
- U.S. Environmental Protection Agency
- U.S. Department of the Interior (e.g., U.S. Fish & Wildlife Service)
- U.S. Department of Health and Human Services
- U.S. Department of Labor
- U.S. Department of Agriculture
- U.S. Food and Drug Administration
- U.S. Department of Defense

The approach used in this assessment of onshore, project-related EMF impacts to human health and the environment was based on the internationally accepted process of environmental risk assessment. Risk assessment has been in use for nearly five decades and is considered the standard for how to evaluate risks that may be posed to the environment. The National Research Council describes the risk assessment process as a systematic and scientific framework for assessing, communicating, and managing risk (NRC 1983).

The risk assessment process involves consideration of the physical setting where exposure to an environmental stressor[3] could occur and the types of individuals (e.g., industrial worker, general public) that might be exposed. This information is combined with information about the types of effects that could occur and the levels of exposure that individuals should be limited to (i.e., "exposure limits"). The direct comparison of exposure to exposure limits is used to describe the level of potential risk and its likelihood of occurrence.

Both the Astoria Power Complex and Millstone Power Complex sites are located in highly developed, industrial settings (zoned as commercial/industrial). Both locations are anticipated to have workers regularly present in indoor and outdoor settings. The sites will predominantly consist of electrical transmission system infrastructure (e.g., buried HVDC onshore export cables, electrical substations, HVAC onshore interconnection cables [buried and overhead]), associated support buildings and storage areas, and paved/graveled surfaces. Access to the sites will be restricted to the general public.

Because the Astoria Power Complex and Millstone Power Complex sites are industrial in nature and will be areas of active operation, there will be limited available onshore habitat and other conditions suitable for regular use by wildlife. In the case of offshore areas, a comprehensive risk assessment has been additionally conducted for BW1 and BW2 to address potential project-related EMF impacts to marine life in the offshore EMF assessment (Integral 2022) prepared in support of the COP.

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[3] A variety of stressors that can be evaluated in risk assessment include chemical stressors (e.g., toxic pollutants), physical stressors (e.g., climate change, flooding, EMF), or biological stressors (e.g., disease, invasive species, parasites) in the environment (USEPA 1992, 1998).

Accordingly, the focus of this assessment is on potential exposures to workers at the Astoria Power Complex and Millstone Power Complex sites, as well as the general public in areas immediately beyond the sites.

The remainder of this report consists of the following:

- **Section 2—EMF Exposure Limits for Human Health.** EMF exposure limits developed by the State of New York and international health and safety organizations are presented and discussed. Connecticut has not established state-specific exposure limits for EMF.
- **Section 3—Assessment Methods.** The methods for assessment and modeling of project-related onshore EMF for BW1 and BW2 are presented and described.
- **Section 4—Calculated Magnetic and Electric Fields.** Using the assessment and modeling methods described in **Section 3**, calculated magnetic and electric field levels are combined alongside information on human health exposure limits described in **Section 2** to characterize potential risks to human health.
- **Section 5—Summary and Conclusions.** A summary of the findings and the conclusions of the risk assessment for project-related onshore EMF for BW1 and BW2 presented.

2 EMF EXPOSURE LIMITS FOR HUMAN HEALTH

The assessment of project-related EMF for BW1 and BW2 consists of evaluating potential human health exposures to DC magnetic fields for the HVDC onshore export cables and evaluating both AC magnetic and electric fields for the HVAC onshore interconnection cables. Both the Astoria Power Complex and Millstone Power Complex are located in industrial settings with limited access to the general public. While onsite access will be restricted, the exact routing of the HVAC export cables beyond the site boundaries to the POIs remains uncertain at this time. Accordingly, EMF limits for transmission infrastructure for both occupational and general public exposures considered for this assessment are described below. Consideration is given both to New York and Connecticut limits where available. No such limits have been developed at the federal level in the U.S., though limits established by internationally-recognized environment, health and safety organizations are also presented. The limits relevant to exposure conditions present at the Astoria Power Complex and Millstone Power Complex are identified for use in comparison to the project-related onshore EMF assessed and summarized in **Sections 3** and **4**.

2.1 MAGNETIC FIELD EXPOSURE LIMITS

The New York Public Service Commission (NYPSC) established guidelines for new transmission lines in its interim policy statement on magnetic fields (NYPSC 1990). This interim policy statement limits the magnitude of AC magnetic fields generated by new transmission lines to 200 milliGauss (mG) or less at a frequency of 60 Hertz (Hz) at the edge of the right-of-way (ROW). The value of 200 mG is referenced by NYPSC (1990) as an interim standard. The value is not directly based on human health, but rather is based on the average of calculated magnetic fields for "typical" overhead 345 kV transmission circuits in New York State. The interim standard was established so that EMF from new transmission lines would not exceed typical levels from existing transmission lines throughout New York.

NYPSC's interim policy statement requires that the AC magnetic field level be assessed at 3.3 ft (1 m) above the ground, with the transmission line operating at a current flow equal to the winter normal conductor (WNC) rating. Consistent with the interim policy statement, the modeled maximum flux density is used in this assessment to compare to the 200 mG interim standard (NYPSC 1990).[4] Because a ROW is not currently specified for some portions of the HVAC onshore interconnection cable routes, the distances where computed magnetic fields met the NYPSC interim standard of 200 mG were noted.

[4] Although the NYPSC (1990) interim policy statement was developed specifically for AC EMF, Integral assessed project-related magnetic fields from the onshore DC portions (i.e., HVDC onshore export cables) in general accordance with the direction provided by NYPSC (1990). See **Section 3** for additional discussion.

Connecticut has not established state-specific exposure limits for EMF.

A variety of internationally recognized health and safety organizations have developed EMF exposure limits. Unlike the NYPSC interim standard that is based on level derived from typical transmission lines in the state, the below describe limits that are intended to ensure safety of human health with an adequate margin of safety to allow for uncertainties in the science.

- For AC magnetic fields of 60-Hz, the International Commission on Non-Ionizing Radiation Protection (ICNIRP) has set a guideline of 2,000 mG for the general public based on continuous exposure (ICNIRP 2010). The International Committee on Electromagnetic Safety (ICES) has developed an exposure reference level of 9,040 mG for the general population (ICES 2019). The American Conference of Governmental Industrial Hygienists (ACGIH) has developed a Threshold Limit Value (TLV) of 10,000 mG.
- For DC static magnetic fields, the ICNIRP has also set guidelines for limits of exposure of 4,000,000 mG for the general public (whole-body exposure), occupational limits of 20,000,000 mG for chest and head exposure, and 80,000,000 mG for limb exposure (ICNIRP 2009). Persons sensitive to magnetic fields, such as those with pacemakers, should not be affected at magnetic field strengths of 10,000 mG or less (ICNIRP 2009). ACGIH (2015) has developed time-weighted average (TWA) limit of 600,000 mG for workers assuming an 8-hour workday, as well as TLV ceiling limit of 5,000 mG for medical electronic device wearers.
- As part of its International EMF Project, the World Health Organization (WHO) has conducted comprehensive reviews of EMF health effects research and existing standards and guidelines, with the WHO website for the International EMF Project (WHO 2022) noting that, "The main conclusion from the WHO reviews is that EMF exposures below the limits recommended in the ICNIRP international guidelines do not appear to have any known consequence on health." This reference is inclusive of the ICNIRP AC magnetic field value of 2,000 mG and DC magnetic field values of 4,000,000 mG for the general public and 10,000 mG for individuals with pacemakers described above (as well as the ICNIRP electric field guidelines discussed below).

2.2 ELECTRIC FIELD EXPOSURE LIMITS

As described above, BW1 and BW2 HVDC onshore export cables and BW1 HVAC onshore interconnection cables will not be a direct source of electric fields above ground due to shielding from cable construction and because the cables will be buried underground. The BW2 HVAC onshore interconnection cables will occur as an overhead transmission line, and therefore will be a direct source of electric fields in the immediate surrounding environment.

The NYPSC established guidelines in 1978 for 60-Hz AC electric fields generated by new overhead transmission lines in Opinion No. 78-13 (NYPSC 1978). The electric field limit is 1.6 kV/m at the ROW edge since the voltage applied to overhead conductors is a direct source of electric fields in the surrounding environment.

ICNIRP has set an exposure limit for 60-Hz AC electric fields of 4.2 kV/m for the general public based on continuous exposure (ICNIRP 2010) and limit of 8.3 kV/m for occupational exposures. ACGIH has established guidelines for 60-Hz AC electric fields of 25 kV/m for a general worker and 1 kV/m for a workers with pacemakers (ACGIH 2015).

2.3 SELECTED VALUES FOR COMPARISON TO PROJECT-RELATED EMF

Table 1 presents the limits selected for comparison to the modeled project-related EMF presented and described in **Sections 3** and **4**. The NYPSC AC 60-Hz magnetic field value of 200 mG and the AC 60-Hz electric field value of 1.6 kV/m were selected for use in comparison to modeled EMF as one of the landfall locations (i.e., the Astoria Power Complex) is located in Queens, New York. The ICNIRP values were additionally selected because they are referenced by WHO as exposure limits regarded as protective of human health (WHO 2022).

Table 1. Selected EMF Exposure Limits

EMF	"Typical" Transmission Systems		Human Health Limits	
	Value	Source	Value	Source
Magnetic Fields				
AC 60-Hz	200 mG	NYPSC 1990	2,000 mG[a]	ICNIRP 2010
DC	N/A	N/A	4,000,000 mG[a] 10,000 mG[b]	ICNIRP 2009 ICNIRP 2009
Electric Fields				
AC 60-Hz	1.6 kV/m	NYPSC 1978	4.2 kV/m	ICNIRP 2010

Notes:
a. Exposure limit for the general public
b. Exposure limit for individuals with pacemakers

3 ASSESSMENT METHODS

The methods for assessing and modeling the potential project-related EMF levels for the BW1 and BW2 onshore electric transmission systems are presented below. Modeling is performed specifically for the HVDC onshore export cables and the HVAC onshore interconnection cables associated with each of the systems.

Integral relied upon data provided by Beacon Wind (e.g., details on the configuration, construction, phasing, rating, location of routing, and burial depth of cables) to calculate electric and magnetic field levels. The calculations assumed that all conductors are parallel to one another and infinite in length, the load on the phase conductors is balanced, there is no attenuation of magnetic fields from any surrounding material, and there are no unbalanced currents flowing along the outer sheaths of the cables.

3.1 HVDC ONSHORE EXPORT CABLES

The DC current flowing through the HVDC onshore export cables will produce a DC magnetic field. The strength of this static magnetic field will vary based on the proximity of the two cable conductors, or poles, the direction of the cable path relative to earth's geomagnetic field, the loading, and the cable burial depth. Along the proposed route of the HVDC onshore export cables and within the Astoria Power Complex, the earth's DC magnetic field has a strength of 512 mG (Chulliat et al. 2020). Earth's DC magnetic field also has a value of 512 mG along the BW2 HVDC onshore export cable within the Millstone Power Complex. This ever-present DC magnetic field can influence the DC magnetic field generated by the DC cables. The strength of the DC magnetic field along the onshore export cable was calculated using the Biot-Savart Law. Earth's geomagnetic field was added to the magnetic field from the DC cables, using vector addition, to calculate the total DC magnetic field.

In addition, Integral evaluated the extent to which the HVDC onshore export cables magnetic fields may influence magnetic compass direction, referred to as compass deflection. A compass needle typically points along the direction of the earth's geomagnetic field (here set equal to 512 mG for both BW1 and BW2), but a new DC magnetic field source may cause a deviation in the apparent direction of magnetic north immediately near the cable. This deviation was calculated as the compass deflection, which is the difference in angular direction in degrees between the horizontal component of the ambient geomagnetic field and the horizontal component direction of the combined geomagnetic field from the earth and the DC field from the cables. Magnetic field values are reported as magnetic flux density (in mG) and were calculated as the strength of the magnetic field along the major axis of the ellipse.

Compass deflection is used in this assessment as simply a point of comparison. While it is possible magnetic fields from cables could influence compass direction, it would be limited to immediately above the cable. In addition, vehicles on land generally rely on global positioning system (GPS) equipment for navigation and will not be impacted by the altered magnetic field above the DC cables or any other project cables. Also, when a compass is used for navigation by a moving vessel or vehicle, changes in compass readings occur naturally by virtue of the direction of travel and the sensitivity of a compass alone. For this assessment, compass deflection is used as a relative point of comparison only, and not to imply the actual degree to which compass equipment may or may not be impacted while in use.

3.1.1 BW1—HVDC Onshore Export Cable

The BW1 HVDC onshore export cable route will consist of one 320 kV HVDC cable circuit installed underground from the landfall to the NYPA onshore substation facility within the Astoria Power Complex. The length of the cable circuit may be up to approximately 600 ft (183 m) in length underground, depending on the final routing.

The orientation of the HVDC onshore export cables was set at 222°, corresponding to the cable route as it enters the horizontal directional drilling (HDD) conduit to the onshore converter station (**Figure 2**). This cable orientation is applicable to the cable terminating at the NYPA or the AGRE onshore converter facility location. The proposed separation of the two cable conductors is 6.6 ft (2 m). The proposed target burial depth will be 4.4 ft (1.33 m) with a proposed maximum burial depth of 13 ft (4 m). The magnetic field and compass deflection as a result of the HVDC onshore export cables were computed for the single amperage, a single pole separation, and two burial depths as shown in **Table 2**. Model results were evaluated at 3.3 ft (1 m) above ground using the assumed WNC rating of the cable.

Table 2. BW1 Onshore Export Cables Parameters Used for the EMF Assessment

Cable Parameter	Values
Voltage	±320 kV
Cable Ampacity Rating	2459.5 A
Pole Separation	6.6 ft (2 m) separation
Proposed Burial Depths	4.4, 13 ft (1.33, 4 m)

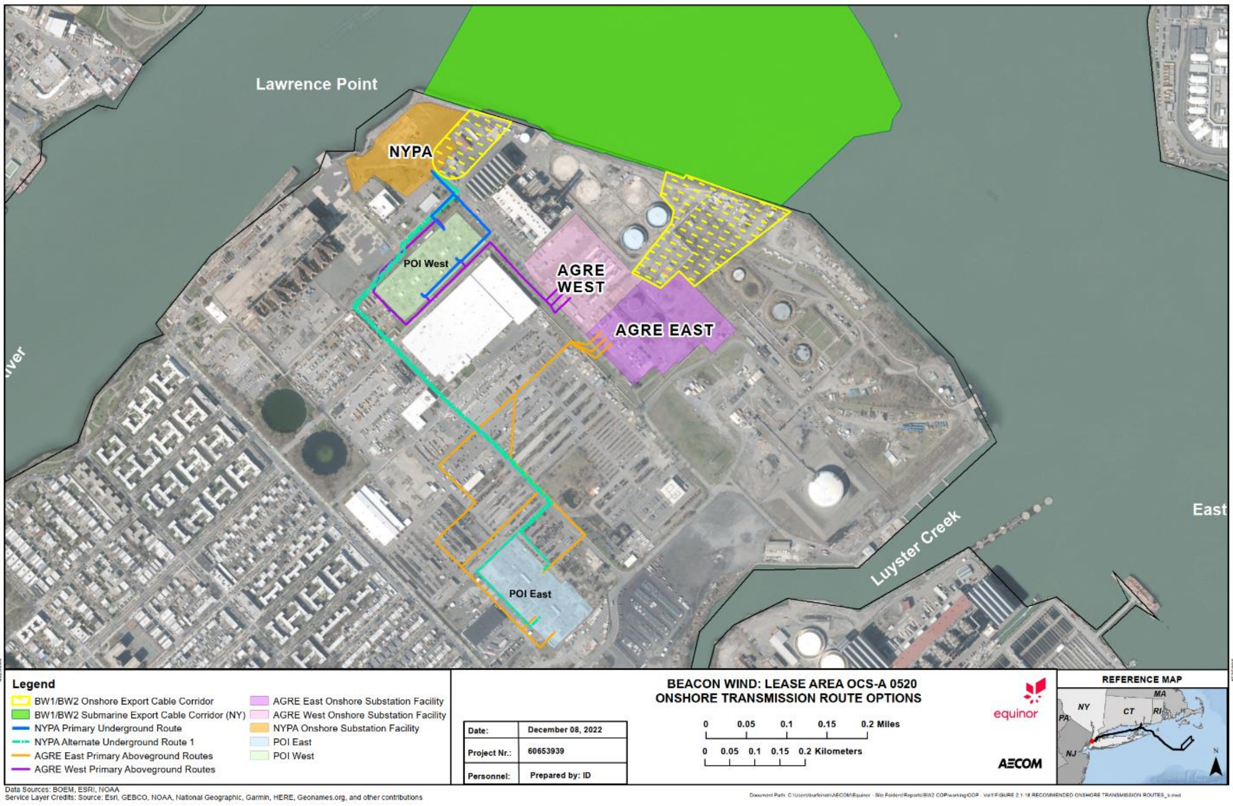

Figure 2. Depiction of the Astoria Power Complex for the BW1 Onshore Electric Transmission System with the Proposed Converter Station Facility Locations, the Location of the HVDC Onshore Export Cables, and the HVAC Onshore Interconnection Cables.

3.1.2 BW2—HVDC Onshore Export Cables

3.1.2.1 Millstone Power Complex

The BW2 HVDC onshore export cable route at the Millstone Power Complex will consist of one 320 kV HVDC cable circuit installed underground from the landfall to the onshore substation facility within the Millstone Power Complex. The length of the cable circuit may be up to approximately 330 ft (100 m).

The orientation of the BW2 HVDC onshore export cables was set at 82°, corresponding to the cable route as it enters the HDD conduit to the Millstone Power Complex (**Figure 3**). The proposed separation of the two cable conductors is 6.6 ft (2 m). The proposed target burial depth will be 4.4 ft (1.33 m) with a proposed maximum burial depth of 13 ft (4 m). The magnetic field and compass deflection as a result of the HVDC onshore export cables were computed for the single amperage, a single pole separation, and two burial depths as shown in

Table 3. Model results were evaluated at 3.3 ft (1 m) above ground using the assumed WNC rating of the cable.

Table 3. BW2 Onshore Export Cables Parameters Used for the EMF Assessment

Cable Parameter	Values
Voltage	$\pm$320 kV
Cable Ampacity Rating	2459.5 A
Pole Separation	6.6 ft (2 m) separation
Proposed Burial Depths	4.4, 13 ft (1.33, 4 m)

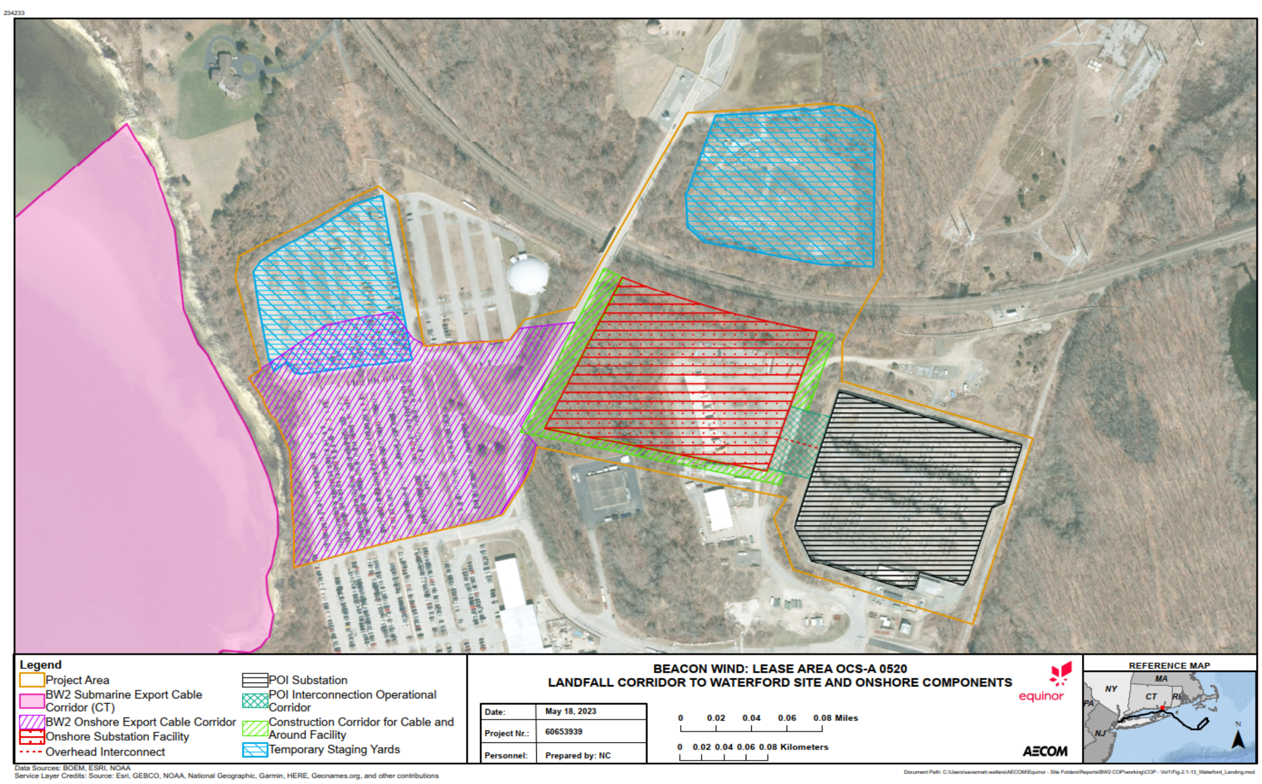

Figure 3. Depiction of the Millstone Power Complex for BW2 Onshore Infrastructure Showing the Proposed Facility Locations, the Location of the HVDC Onshore Export Cables, and the HVAC Overhead Interconnection Cables.

3.1.2.2 Astoria Power Complex

The BW2 HVDC onshore export cable route at the Astoria Power Complex consists of one 320 kV HVDC cable circuit installed underground from the landfall to the AGRE West onshore substation. The length of the cable circuit may be up to approximately 600 ft (183 m) in length underground, depending on the final routing.

The location of the landfall and export cable route for BW2 at the Astoria Power Complex is similar to that for BW1. In addition, the configuration and orientation (Table 2), are assumed to be representative for the Astoria Power Complex landfall for BW2. Thus, the magnetic field strength and compass deflection calculated for the BW1 Astoria Power Complex Onshore Exposure cable are assumed to be representative of the Astoria Power Complex landfall for BW2.

3.2 HVAC ONSHORE INTERCONNECTION CABLES

Current flowing through AC cables will produce an AC magnetic field. The strength of this magnetic field will vary based on the configuration of the 3-phase AC cable, the loading, and the burial depth.

A two-dimensional model of the planned configuration of the HVAC onshore interconnection cables line, including the phase conductors and any assumed ground continuity conductors, was applied to predict the AC magnetic field. Calculations were performed using a Python implementation of the FIELDS model, developed by Southern California Edison. The model predicts electric and magnetic fields near parallel sets of power lines by assuming the conductors are infinitely long and computing the fields along a transect perpendicular to the power lines. The FIELDS model operates using Maxwell's equations, which accurately apply the laws of physics as related to electricity and magnetism (EPRI 1982, 1993). Results of the model have been checked extensively against each other and against other software (e.g., CORONA, from the Bonneville Power Administration, U.S. Department of Energy) to ensure that the implementations are consistent. In these validation tests, program results for EMFs were found to be in very good agreement with each other (Mamishev and Russell 1995).

AC magnetic field calculations were performed along a transect perpendicular to the transmission line centerlines and reported at a height of 3.3 ft (1 m) above ground. This is consistent with Institute of Electrical and Electronics Engineers (IEEE) Standards—C95.3.1-2010 and 0644-2019 (IEEE 2010, 2019). Induced currents on ground continuity conductors can be a dominant effect in accurate predictions of magnetic field levels above underground duct banks, and were therefore included for modeling.[5] For underground cables, specific to BW1, the conductor locations were determined with the assumption that each cable rests at the bottom of its containing conduit. For the overhead cables, specific to BW2, the conductors were assumed to be unsheathed wire supported a specified distance above the ground by towers. Magnetic field values are reported as rms flux density in mG and were calculated as the strength of the magnetic field along the major axis of the ellipse.

[5] The effects of current imbalance, sheath currents, and cable materials surrounding the copper conductor, including ferromagnetic shielding effects and eddy currents, were not modeled. It was further assumed there would be no attenuation of magnetic fields by any surrounding materials (e.g., the duct bank, the earth, etc.).

3.2.1 BW1—HVAC Onshore Interconnection Cables

At the Astoria Power Complex, there are two sites under consideration for the BW1 onshore substation facility, including the NYPA site location or the AGRE West site.

The NYPA site will transform DC from the HVDC onshore export cables to 138 kV AC (60-Hz) for transmission via the underground HVAC onshore interconnection cables. The HVAC onshore interconnection cables from the NYPA site will consist of three 138 kV cable circuits (duct banks) buried underground from the onshore substation facility to the Astoria West POI. The three duct banks used for the HVAC onshore interconnection cables will be separated by an edge-to-edge distance of 15 ft (4.6 m) (**Figure 4**). The duct banks will range in length from approximately 544 to 1,230 ft (166 to 375 m). Each duct bank will consist of nine single-core cross-linked polyethylene (XLPE) copper conductors of 4.5 in (11.4 cm) total diameter with a conductor diameter of 2.5 in (6.4 cm), individually installed in separate 8 in. (20 cm) diameter polyvinyl chloride conduits. Two proposed burial depths of the duct banks were evaluated: a minimum burial depth of 3 ft (0.9 m) and a planned burial depth of 8 ft (2.4 m). Model results were evaluated at 3.3 ft (1 m) above ground using the assumed WNC rating of the cable.

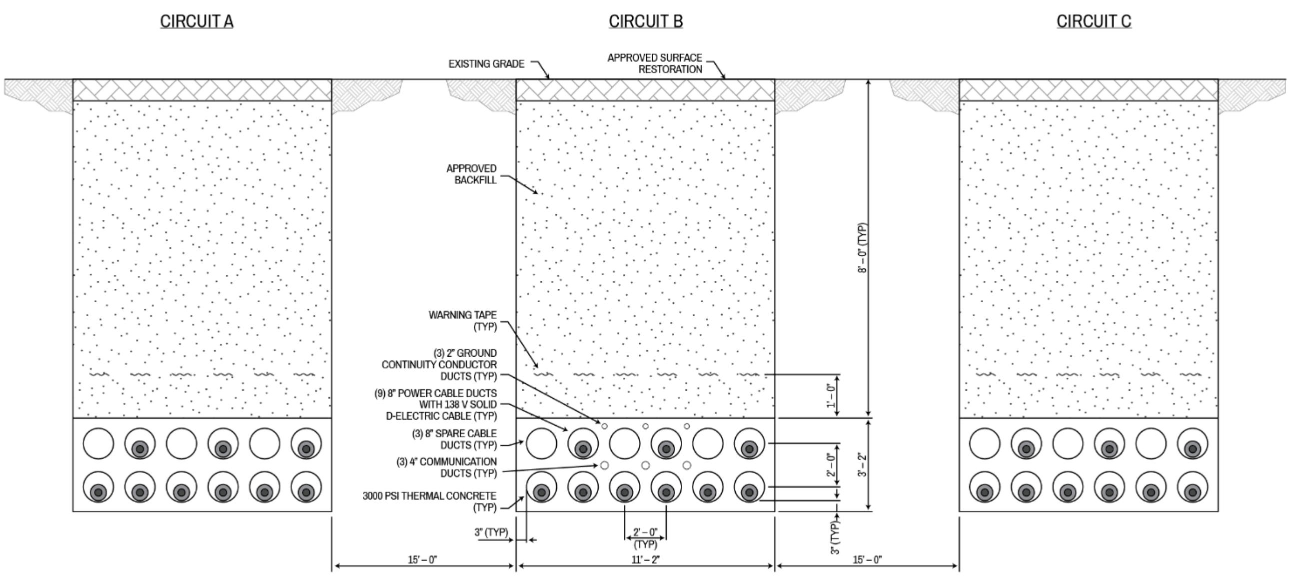

Figure 4. Proposed Three Duct Bank Configuration of BW1 Onshore Interconnection Cables.

AC magnetic fields were modeled for the HVAC onshore interconnection cables using the parameters presented above and summarized in **Table 4**.

Table 4. BW1 NYPA to the Astoria West POI Onshore Interconnection Cables Parameters Used for the EMF Assessment

Cable Parameter	Values
Voltage	138 kV
Amperage	2379 A
Number of Duct Banks	3
Number of Cables per Duct Bank	9
Cable Diameter	4.5 in. (11.4 cm) total diameter; 2.5 in. (6.4 cm) conductor diameter
Proposed Burial Depths	3 ft (0.9 m) and 8 ft (2.4 m)
Separation between Duct Banks	15 ft (4.6 m)

At the AGRE West site, the substation facility will transform the DC current from the HVDC onshore export cables to 138 kV AC (60-Hz) for transmission via overhead HVAC onshore interconnection cables. The HVAC onshore interconnection cables will consist of 138 kV overhead lines extending from the AGRE West substation facility to the Astoria West POI. Leaving the substation facility, the HVAC Onshore Interconnection cable will consist of an overhead line configuration with three circuits. However, at various points the cable will split into double and single circuit overhead line configurations.

Based on documentation made available to Integral, overhead line structures will conduct multiple circuits, with a total of six, 3-phase AC conductors per circuit. Specific overhead line structure designs were uncertain at the time of this writing, so Integral's calculations for the triple circuit configuration are derived from the Triple Circuit Tangent structure description made available. Double and single circuit configurations are also derived from this description by making appropriate changes (i.e., reducing the design from 3 to 2 or 1 circuits). For all structures, conductors are assumed to be arranged in 2-cable, horizontal bundles at each height, with lines in a bundle separated by 0.5 ft (0.15 m). Cable bundles are assumed to be suspended from the end of an insulated support projecting 7.5 ft (2.3 m) latterly from central pole structures. We assume that conductor bundles will be separated vertically by 9 ft (2.7 m), with the lowest bundle located at 23 ft (7.0 m) above the ground. We assume that individual conductors will consist of aluminum wires around steel cores, and will conduct an assumed amperage of 1502 A per conductor. Model results were evaluated at 3.3 ft (1 m) above ground using the assumed WNC rating of the cable.

AC magnetic fields were modeled for the HVAC onshore interconnection cables using the parameters presented above and summarized in **Table 5**.

Table 5. BW1 AGRE West to POI West Onshore Interconnection Cables Parameters Used for the EMF Assessment

Cable Parameter	Values
Voltage	138 kV
Amperage	1502 A
Number of conductors per circuit	6
Single Circuit	6
Double Circuit	12
Triple Circuit	18
Cable Diameter	1.47 in (3.74 cm, 2156 kcmil)
Separation between Conductors	9 ft (2.7 m)
Height of Conductors above Ground	23 ft (7.0 m)

3.2.2 BW2—HVAC Onshore Interconnection Cables

3.2.2.1 Millstone Power Complex

At the Millstone Power Complex, the BW2 onshore substation facility will transform the DC current from the HVDC onshore export cables to 345 kV AC (60-Hz) for transmission via the overhead HVAC onshore interconnection cables. The HVAC onshore interconnection cables will consist of a 345 kV overhead line extending from the onshore substation facility to the Millstone POI.

The overhead line(s) used for the HVAC onshore interconnection cables will be separated by 5 ft (1.52 m) and located 22 ft (6.7 m) above the ground. The cables will consist of aluminum wires around steel cores, and the WNC rating for the cables is 2,631 A. Model results were evaluated at 3.3 ft (1 m) above ground using the assumed WNC rating of the cable.

AC magnetic fields were modeled for the HVAC onshore interconnection cables using the parameters presented above and summarized in Table 6.

Table 6. BW2 Millstone Power Complex HVAC Onshore Interconnection Cables Parameters Used for the EMF Assessment

Cable Parameter	Values
Voltage	345 kV
Amperage	2631 A
Number of Cables Overhead Transmission	3
Cable Diameter	1.544 in. (3.9 cm) total diameter; 1.544 in. (3.9 cm) conductor diameter
Separation between Conductors	5 ft (1.52 m)
Height of Conductors above Ground	22 ft (6.7 m)

3.2.2.2 Astoria Power Complex

At the Astoria Power Complex, the BW2 onshore substation facility will transform the DC current from the HVDC onshore export cables to 138 kV AC (60-Hz) for transmission via overhead HVAC onshore interconnection cables. The HVAC onshore interconnection cables will consist of 138 kV overhead lines extending from the AGRE East substation facility to the East POI. Leaving the substation facility, the HVAC Onshore Interconnection cable will consist of an overhead line configuration with three circuits. However, at various points the cable will split into double and single circuit overhead line configurations.

Based on documentation made available to Integral, overhead line structures will conduct multiple circuits, with a total of six, 3-phase AC conductors per circuit. Specific overhead line structure designs were uncertain at the time of this writing, so Integral's calculations for the triple circuit configuration are derived from the Triple Circuit Tangent structure description made available. Double and single circuit configurations are also derived from this description by making appropriate changes (i.e., reducing the design from 3 to 2 or 1 circuits). For all structures, conductors are assumed to be arranged in 2-cable, horizontal bundles at each height, with lines in a bundle separated by 0.5 ft (0.15 m). Cable bundles are assumed to be suspended from the end of an insulated support projecting 7.5 ft (2.3 m) latterly from central pole structures. We assume that conductor bundles will be separated vertically by 9 ft (2.7 m), with the lowest bundle located at 23 ft (7.0 m) above the ground. We assume that individual conductors will consist of aluminum wires around steel cores, and will conduct an assumed amperage of 1502 A per conductor. Model results were evaluated at 3.3 ft (1 m) above ground using the assumed WNC rating of the cable.

AC magnetic fields were modeled for the HVAC onshore interconnection cables using the parameters presented above and summarized in **Table 7**.

Table 7. BW2 Astoria Power Complex HVAC Onshore Interconnection Cables Parameters Used for the EMF Assessment

Cable Parameter	Values
Voltage	138 kV
Amperage	1502 A
Number of conductors per circuit	6
Single Circuit	6
Double Circuit	12
Triple Circuit	18
Cable Diameter	1.47 in (3.74 cm, 2156 kcmil)
Separation between Conductors	9 ft (2.7 m)
Height of Conductors above Ground	23 ft (7.0 m)

3.3 BW1 AND BW2—ONSHORE SUBSTATIONS

The EMF assessment of the onshore substations did not require quantitative modeling. This is because the highest magnetic field and electric field levels around the perimeter of substations will likely be due to the HVDC onshore export cables and HVAC onshore interconnection cables entering and exiting the stations. This is consistent with IEEE Standard 1127 (IEEE 2013).

4 CALCULATED MAGNETIC AND ELECTRIC FIELDS

EMF levels for the BW1 and BW2 onshore electric transmission systems are presented below. Model results are presented specifically for the HVDC onshore export cables and the HVAC onshore interconnection cables associated with each of the systems. The modeled EMF levels are presented alongside the EMF exposure limits for human health presented in **Section 2**. Discussion is additionally provided to describe potential compass deflection in the immediate vicinity of project-related magnetic fields.

4.1 MAGNETIC FIELDS—HVDC ONSHORE EXPORT CABLES

Model results for DC magnetic fields and compass deflection for the BW1 and BW2 HVDC onshore export cables are presented below.

4.1.1 BW1—HVDC Onshore Export Cables

The strength of the magnetic field from the BW1 HVDC onshore export cables with the poles separated by 6.6 ft (2 m) was evaluated at the planned target and maximum burial depths. The maximum predicted value for the magnetic field strength is 1,702 mG, at 3.3 ft (1 m) above the ground, directly above one pole of the cable at its proposed target burial depth of 4.4 ft (1.3 m) (**Figure 5**). Field strength rapidly decreases with distance from the cables, reaching background levels within 12 ft (3.7 m) from the cable poles (15 ft [4.6 m] from the centerline). At the proposed maximum burial depth of 13 ft (4 m), the maximum magnetic field is 799 mG and rapidly decreases to background levels within 21 ft (6.4 m) from the cable poles (24 ft [7.3 m] from the centerline).

4.1.1.1 Comparison to Magnetic Field Exposure Limits

The maximum magnetic field level for the BW1 HVDC onshore export cables is approximately ~2,350 times lower than the ICNIRP magnetic field exposure limit of 4,000,000 mG for the general public and 6 times lower than the exposure limit of 10,000 mG for individuals with pacemakers. Based on the comparison, potential human health risks associated with exposure to project-related magnetic fields from the BW1 HVDC onshore export cables are considered *de minimis*.

Figure 5 shows a visual comparison of the modeled magnetic field strength and the two ICNIRP exposure limits using a logarithmic scale on the vertical axis (i.e., y-axis). Each major increment on the y-axis represents a power of 10, with the lowest increment as 100 mG, and the highest as 10,000,000 mG. Logarithmic scales are used so that data with large differences, such as the differences that exist between the lower magnetic fields that were modeled and the higher ICNIRP exposure limits, can be displayed and compared on a single graph.

Additional modeled values for the BW1 HVDC onshore export cables are provided in **Appendix A, Table A-1**.

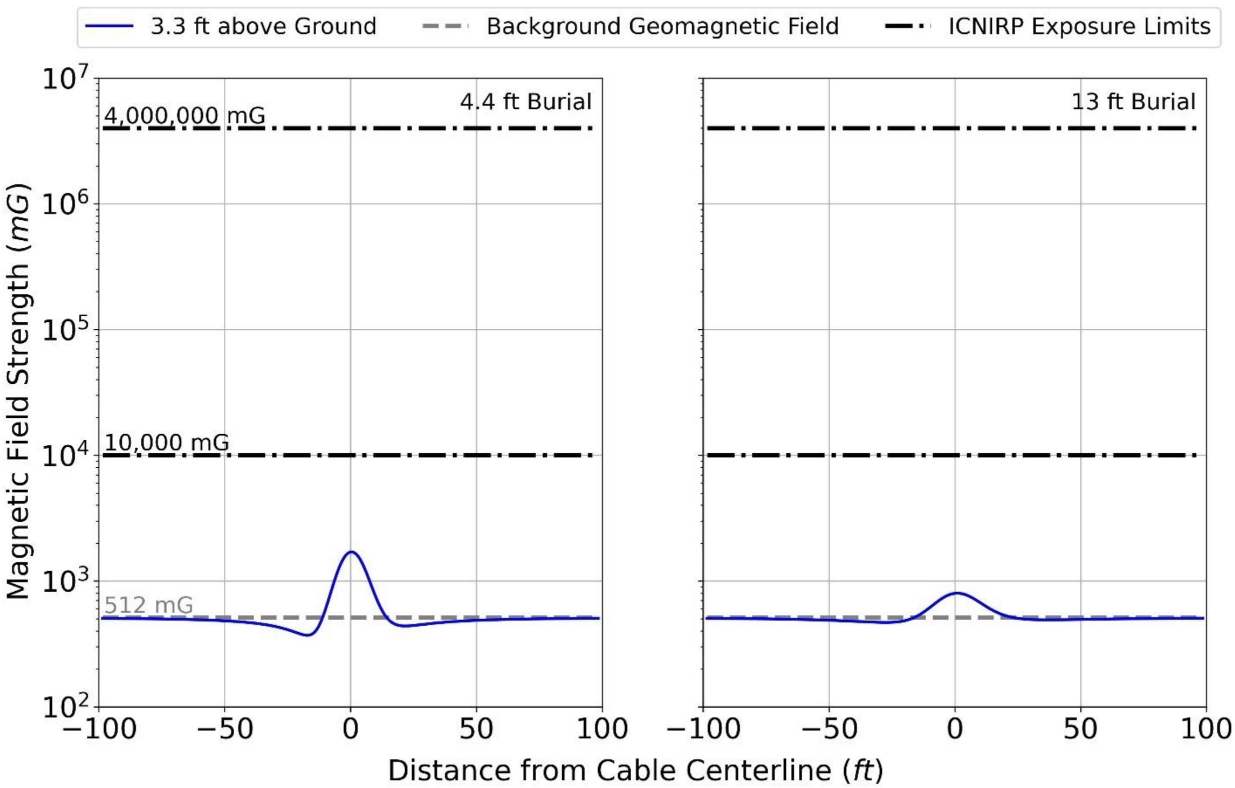

Figure 5. Magnetic Field Strength from the BW1 Onshore Export Cables for Multiple Burial Depths, Shown on a Log Y-Axis. Earth's Geomagnetic Field Is Also Shown as a Grey Dashed Line. Two ICNIRP Exposure Limits Are Shown as a Black Dashed Line.

4.1.1.2 Compass Deflection

The maximum compass deflection directly above the cable poles for the 4.4 ft (1.3 m) burial scenario, at 3.3 ft (1 m) above the ground, is 111°. The maximum deflection decreases to 59° for the 13 ft (4 m) burial depth scenarios. The amount of compass deflection rapidly decreases when moving away from the cable poles, similar to the trend seen in the magnetic field graphics.

Additional values for the compass deflection from the BW1 HVDC onshore export cables are provided in **Appendix A, Table A-2**.

4.2 BW2—HVDC ONSHORE EXPORT CABLES

4.2.1 Millstone Power Complex

The strength of the magnetic field from the BW2 HVDC onshore export cables to the Millstone Power Complex with the poles separated by 6.6 ft (2 m) was evaluated at the planned target and maximum burial depths. The largest predicted value for the magnetic field strength is 1,710 mG, at 3.3 ft (1 m) above the ground, directly above one pole of the cable at its proposed target burial depth of 4.4 ft (1.3 m) (**Figure 6**). Field strength rapidly decreases with distance away from the cables, reaching background levels within 14 ft (4.3 m) from the cables poles (17 ft [5.2 m] from the centerline). At the proposed maximum burial depth of 13 ft (4 m), the maximum magnetic field is 805 mG and rapidly decreases to background levels within 25 ft (7.6 m) from the cable poles (28 ft [8.5 m] from the centerline).

4.2.1.1 Comparison to Magnetic Field Exposure Limits

The maximum magnetic field level for the BW2 HVDC onshore export cables is approximately ~2,339 times lower than the ICNIRP magnetic field exposure limit of 4,000,000 mG for the general public and 6 times lower than the exposure limit of 10,000 mG for individuals with pacemakers (**Figure 6**). Based on this comparison, potential human health risks associated with exposure to project-related magnetic fields from the BW2 HVDC onshore export cables to the Millstone Power Complex are considered *de minimis*.

Additional modeled values for the BW2 HVDC onshore export cables to the Millstone Power Complex are provided in **Appendix A, Table A3**.

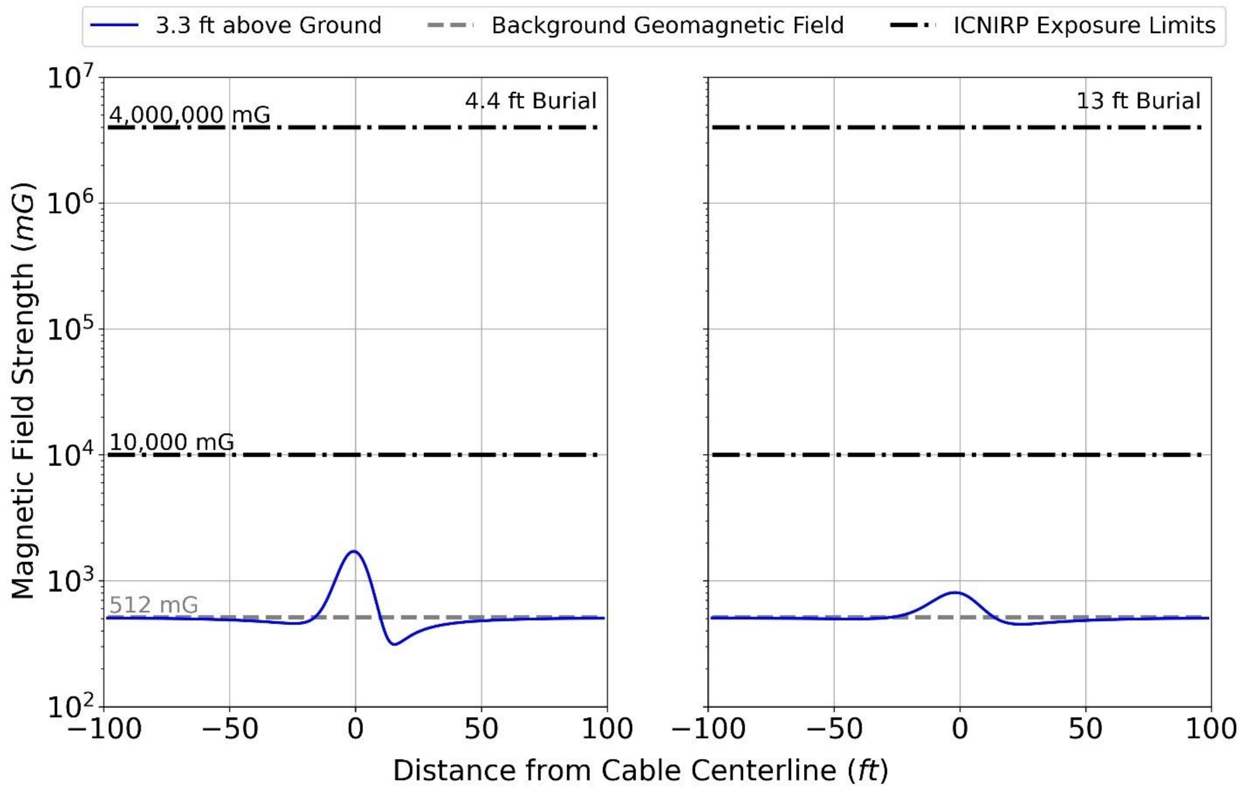

Figure 6. Magnetic Field Strength from the BW2 Onshore Export Cables for Multiple Burial Depths, Shown on a Log Y-Axis. Earth's Geomagnetic Field Is Also Shown as a Grey Dashed Line. Two ICNIRP Exposure Limits Are Shown as a Black Dashed Line.

4.2.1.2 Compass Deflection

The maximum compass deflection directly above the cable poles for the 4.4 ft (1.3 m) burial scenario, at 3.3 ft (1 m) above the ground, is 346°. The maximum deflection decreases to 71° for the 13 ft (4 m) burial depth scenarios. The amount of compass deflection rapidly decreases when moving away from the cable poles, similar to the trend seen in the magnetic field graphics.

Additional values for the compass deflection from the BW2 HVDC onshore export cables are provided in **Appendix A, Table A-4**.

4.2.2 Astoria Power Complex

The magnetic field for the BW2 HVDC onshore export cables to the Astoria Power Complex AGRE East site is assumed to be identical to that of the onshore export cables to the BW1

Astoria Power Complex NYPA site. For convenience and completeness, that analysis is reapplied here.

The strength of the magnetic field from the BW2 HVDC onshore export cables with the poles separated by 6.6 ft (2 m) was evaluated at the planned target and maximum burial depths. The maximum predicted value for the magnetic field strength is 1,702 mG, at 3.3 ft (1 m) above the ground, directly above one pole of the cable at its proposed target burial depth of 4.4 ft (1.3 m) (**Figure 7**). Field strength rapidly decreases with distance from the cables, reaching background levels within 12 ft (3.7 m) from the cable poles (15 ft [4.6 m] from the centerline). At the proposed maximum burial depth of 13 ft (4 m), the maximum magnetic field is 799 mG and rapidly decreases to background levels within 21 ft (6.4 m) from the cable poles (24 ft [7.3 m] from the centerline).

4.2.2.1 Comparison to Magnetic Field Exposure Limits

The maximum magnetic field level for the BW2 HVDC onshore export cables to the AGRE West site is approximately ~2,350 times lower than the ICNIRP magnetic field exposure limit of 4,000,000 mG for the general public and 6 times lower than the exposure limit of 10,000 mG for individuals with pacemakers. Based on the comparison, potential human health risks associated with exposure to project-related magnetic fields from the BW2 HVDC onshore export cables to the AGRE West site are considered *de minimis*.

Figure 5Figure 7 shows a visual comparison of the modeled magnetic field strength and the two ICNIRP exposure limits using a logarithmic scale on the vertical axis (i.e., y-axis). Each major increment on the y-axis represents a power of 10, with the lowest increment as 100 mG, and the highest as 10,000,000 mG. Logarithmic scales are used so that data with large differences, such as the differences that exist between the lower magnetic fields that were modeled and the higher ICNIRP exposure limits, can be displayed and compared on a single graph.

Additional modeled values for the BW2 HVDC onshore export cables to the AGRE West site are provided in **Appendix A, Table A1**.

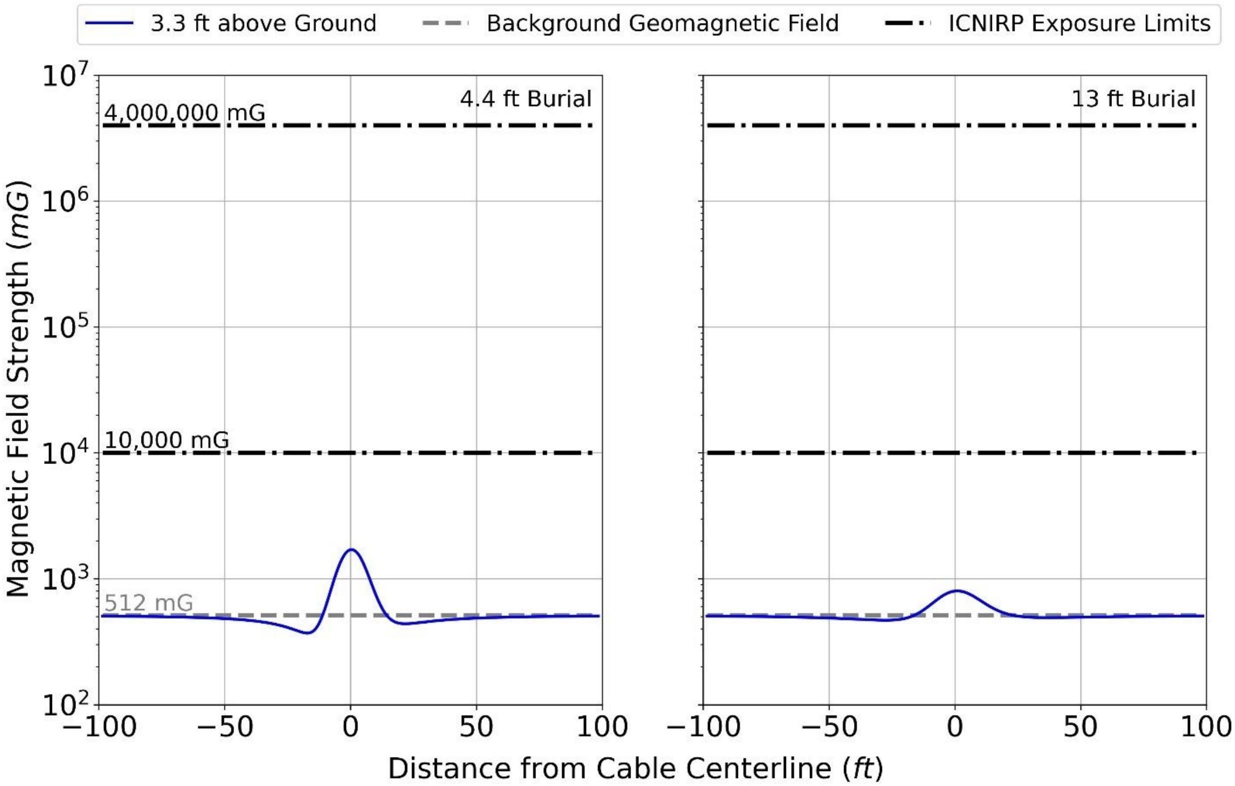

Figure 7. Magnetic Field Strength from the BW2 Onshore Export Cables to the AGRE West site for Multiple Burial Depths, Shown on a Log Y-Axis. Earth's Geomagnetic Field Is Also Shown as a Grey Dashed Line. Two ICNIRP Exposure Limits Are Shown as a Black Dashed Line.

4.2.2.2 Compass Deflection

The maximum compass deflection directly above the cable poles for the 4.4 ft (1.3 m) burial scenario, at 3.3 ft (1 m) above the ground, is 111°. The maximum deflection decreases to 59° for the 13 ft (4 m) burial depth scenarios. The amount of compass deflection rapidly decreases when moving away from the cable poles, similar to the trend seen in the magnetic field graphics.

Additional values for the compass deflection from the BW2 HVDC onshore export cables to the AGRE West site are provided in **Appendix A, Table A-2**.

4.3 AC MAGNETIC FIELDS

Model results for AC magnetic fields and electric fields for the BW1 and BW2 HVAC onshore interconnection cables are presented below.

4.3.1 BW1—HVAC Onshore Interconnection Cables

4.3.1.1 NYPA Converter Station to Astoria West POI

Figure 8 shows the rms magnetic field strength at 3.3 ft (1 m) above the ground, directly above the outer duct bank, for a duct bank at the target depth of 8 ft (2.4 m). The largest predicted value for the maximum magnetic field strength is 550 mG. A ROW width of 110 ft (33.5 m) (55 ft [16.8 m]) from the center line) is assumed, at which point the magnetic field drops to below the NYPSC interim standard of 200 mG (NYPSC 1990). If the burial depth of the HVAC onshore interconnection cable is below the proposed target depth of 8 ft (2.4 m), the strength of the magnetic field at 3.3 ft (1 m) above the ground will be further reduced. In addition, the maximum magnetic field strength of 550 mG is approximately 3.6 times lower than the ICNIRP 60-Hz AC magnetic field exposure limit of 2,000 mG. A more detailed table of model input values used for the BW1 HVAC onshore interconnection cables, with a burial depth of 8 ft (2.4 m), are provided in **Appendix B, Table B-1**.

Figure 9 shows the rms magnetic field strength at 3.3 ft (1 m) above the ground, directly above the outer duct bank, for a duct bank at the proposed minimum burial depth of 3 ft (0.9 m). The largest predicted value for the maximum magnetic field strength is 1,300 mG. A ROW width of 110 ft (33.5 m) (55 ft [16.8 m] from the center line) is assumed, at which point the magnetic field drops to below 200 mG. In addition, the maximum magnetic field strength of 1,300 mG is approximately 1.5 times lower than the ICNIRP 60-Hz AC magnetic field exposure limit of 2,000 mG. A more detailed table of model input values used for the BW1 HVAC onshore interconnection cables, with a burial depth of 3 ft (0.9 m), are provided in **Appendix B, Table B-2**.

These comparisons indicate that potential human health risks associated with exposure to project-related magnetic fields from the BW1 HVAC onshore interconnection cables from the NYPA Converter Station to the Astoria West POI are *de minimis*.

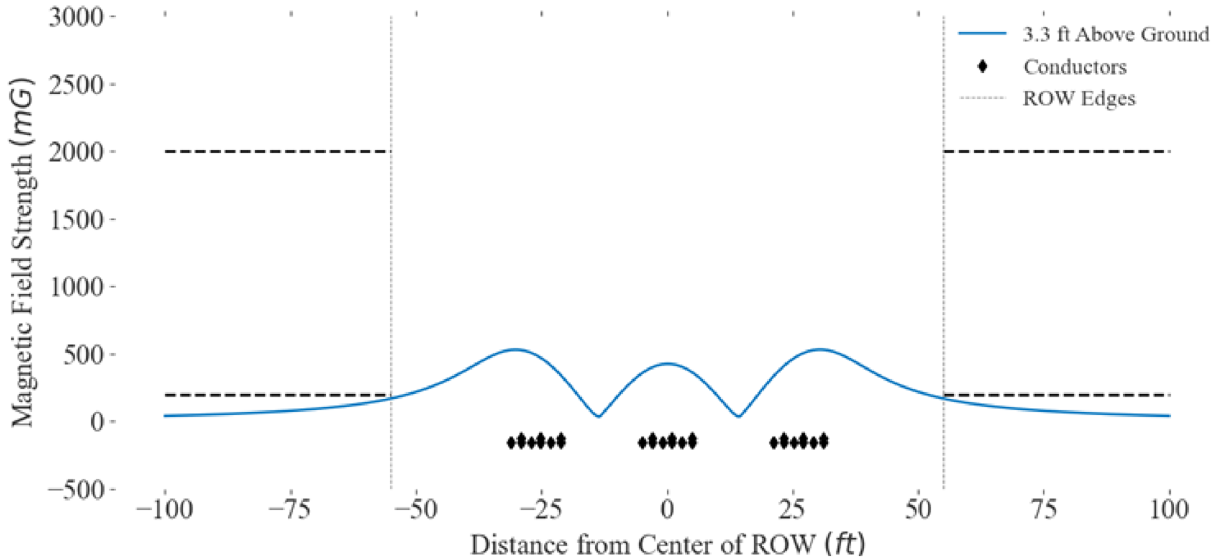

Figure 8. Magnetic Field Strength from the BW1 Onshore Interconnection Cables from the NYPA Converter Substation to the Astoria West POI, for a Burial Depth of 8 ft (2.4 m). The Conductor Layout is Shown as Black Dots. The ROW Width is Shown as Vertical Dashed Lines. Two Exposure Limits are Shown as Black Dashed Lines.

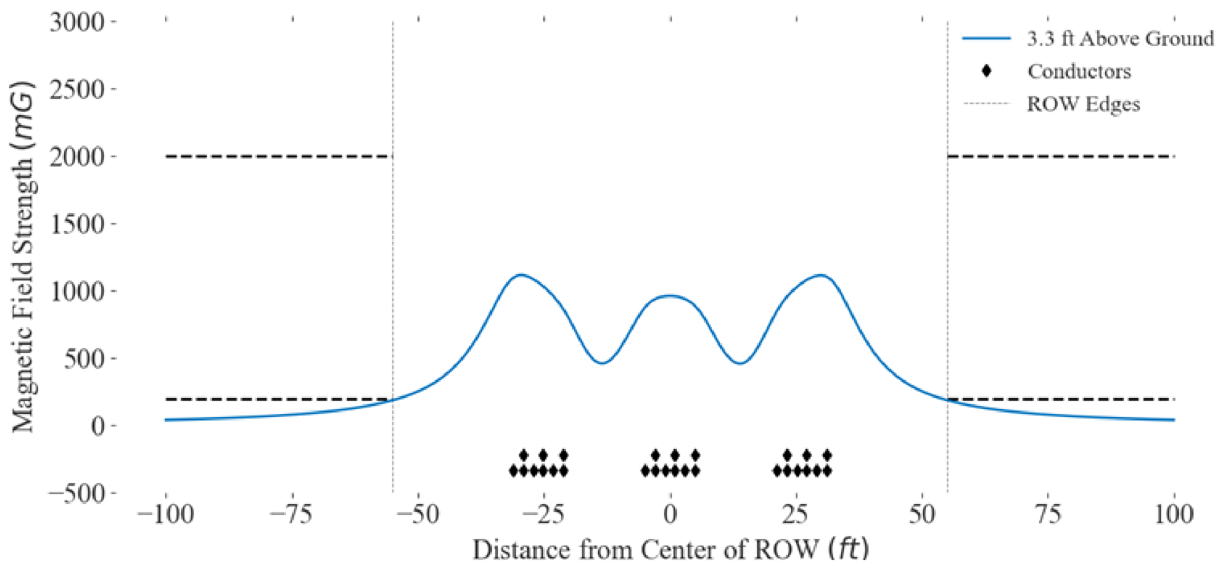

Figure 9. Magnetic Field Strength from the BW1 Onshore Interconnection Cables from the NYPA Converter Substation to the Astoria West POI, for a Burial Depth of 3 ft (0.9 m). The Conductor Layout is Shown as Black Dots. The ROW Width is Shown as Vertical Dashed Lines. Two Exposure Limits are Shown as Black Dashed Lines.

Collectively, these comparisons indicate that potential human health risks associated with exposure to project-related magnetic fields from the BW1 HVAC onshore interconnection cables running from the NYPA Converter Substation to the Astoria West POI are *de minimis*.

4.3.1.2 AGRE West to Astoria West POI

Figure 10 shows the rms magnetic field strength at 3.3 ft (1 m) above the ground for the triple circuit configuration. The largest predicted value for the maximum magnetic field strength is 236 mG. A ROW width of 110 ft (33.5 m) (55 ft [16.8 m]) from the center line) is assumed, at which point the magnetic field is below the NYPSC interim standard of 200 mG (NYPSC 1990). The maximum magnetic field strength of 236 mG is approximately 8.5 times lower than the ICNIRP 60-Hz AC magnetic field exposure limit of 2,000 mG. A more detailed table of model input values used for the BW1 HVAC onshore interconnection cable configuration from the AGRE West Converter Station to the Astoria West POI is provided in **Appendix B, Table B-3**.

Figure 11 shows the rms magnetic field strength at 3.3 ft (1 m) above the ground for the double circuit configuration. The largest predicted value for the maximum magnetic field strength is 191 mG. A ROW width of 110 ft (33.5 m) (55 ft [16.8 m]) from the center line) is assumed, at which point the magnetic field is below the NYPSC interim standard of 200 mG (NYPSC 1990). The maximum magnetic field strength of 191 mG is approximately 10.5 times lower than the ICNIRP 60-Hz AC magnetic field exposure limit of 2,000 mG. A more detailed table of model input values used for the BW1 HVAC onshore interconnection cable configuration from the AGRE West Converter Station to the Astoria West POI is provided in **Appendix B, Table B-4.**

Figure 12 shows the rms magnetic field strength at 3.3 ft (1 m) above the ground for the single circuit configuration. The largest predicted value for the maximum magnetic field strength is 205 mG. A ROW width of 110 ft (33.5 m) (55 ft [16.8 m]) from the center line) is assumed, at which point the magnetic field is below the NYPSC interim standard of 200 mG (NYPSC 1990). The maximum magnetic field strength of 205 mG is approximately 9.8 times lower than the ICNIRP 60-Hz AC magnetic field exposure limit of 2,000 mG. A more detailed table of model input values used for the BW1 HVAC onshore interconnection cable configuration from the AGRE West Converter Station to the Astoria West POI is provided in **Appendix B, Table B-5.**

These comparisons indicate that potential human health risks associated with exposure to project-related magnetic fields from the BW1 HVAC onshore interconnection cables from the AGRE West Converter Station to the Astoria West POI are *de minimis*.

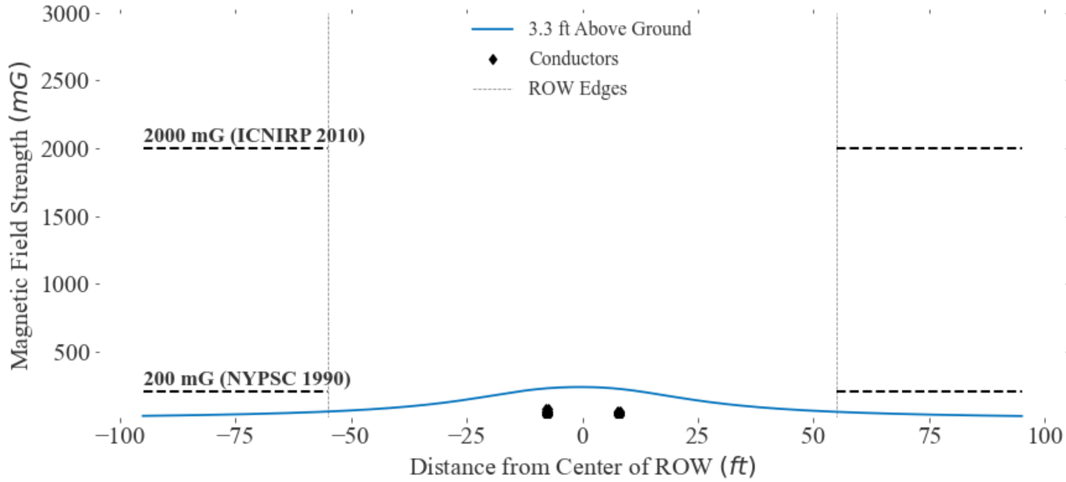

Figure 10. Magnetic Field Strength for a BW1 Onshore Interconnection Cable from the AGRE West Converter Station to the Astoria West POI for a Triple Circuit Overhead Configuration. The Height of the Lowest Cable is 23 ft (7 m). The Conductor Layout are Shown as Black Dots. The ROW Width is Shown as Vertical Dashed Lines. Two Exposure Limits are Shown as Black Dashed Lines.

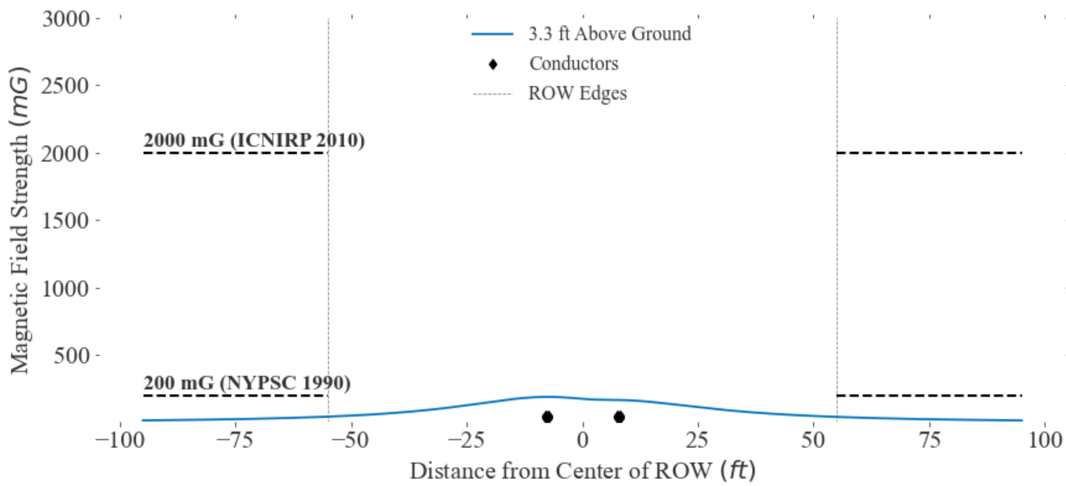

Figure 11. Magnetic Field Strength for a BW1 Onshore Interconnection Cable from the AGRE West Converter Station to the Astoria West POI for a Double Circuit Overhead Configuration. The Height of the Lowest Cable is 23 ft (7 m). The Conductor Layout is Shown as Black Dots. The ROW Width is Shown as Vertical Dashed Lines. Two Exposure Limits are Shown as Black Dashed Lines.

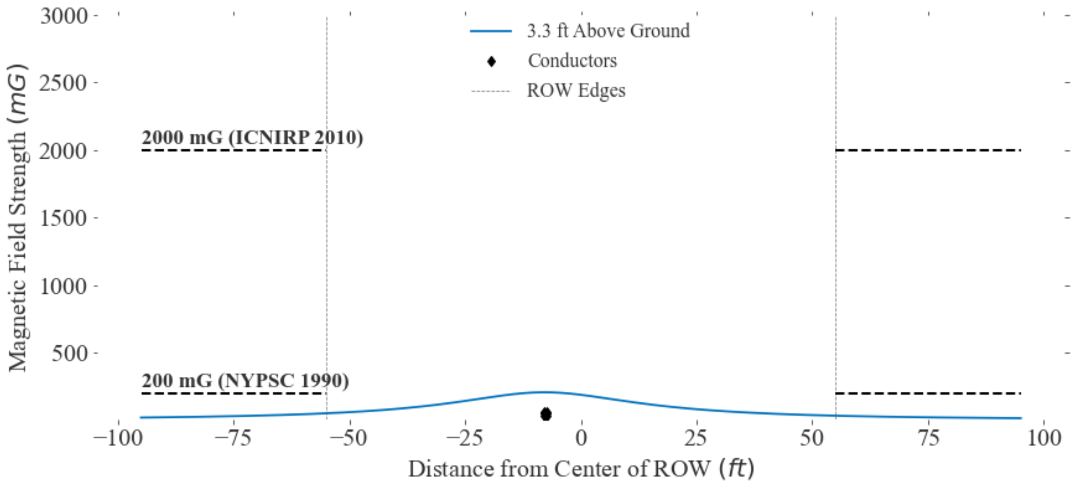

Figure 12. Magnetic Field Strength for a BW1 Onshore Interconnection Cable from the AGRE West Converter Station to the Astoria West POI for a Single Circuit Overhead Configuration. The Height of the Lowest Cable is 23 ft (7 m). The Conductor Layout is Shown as Black Dots. The ROW Width is Shown as Vertical Dashed Lines. Two Exposure Limits are Shown as Black Dashed Lines.

4.3.2 BW2—HVAC Onshore Interconnection Cables

4.3.2.1 Millstone Power Complex

Figure 13shows the rms magnetic field 3.3 ft (1 m) above the ground, directly below the overhead line, for an overhead line situated 19 ft (5.8 m) above the ground. The largest predicted value for the maximum magnetic field strength is 400 mG. A ROW width of 100 ft (30.5 m) (50 ft [15 m] from the center line) is assumed, at which point the magnetic field drops well below the NYPSC interim standard of 200 mG (NYPSC 1990). In addition, the maximum magnetic field strength of 400 mG is approximately 5 times lower than the ICNIRP 60-Hz AC magnetic field exposure limit of 2,000 mG. A more detailed table of model input values used for the BW2 HVAC onshore interconnection cables are provided in **Appendix B, Table B-6**.

These comparisons indicate that potential human health risks associated with exposure to project-related magnetic fields from the BW2 HVAC onshore interconnection cables from the Millstone Power Complex are *de minimis*.

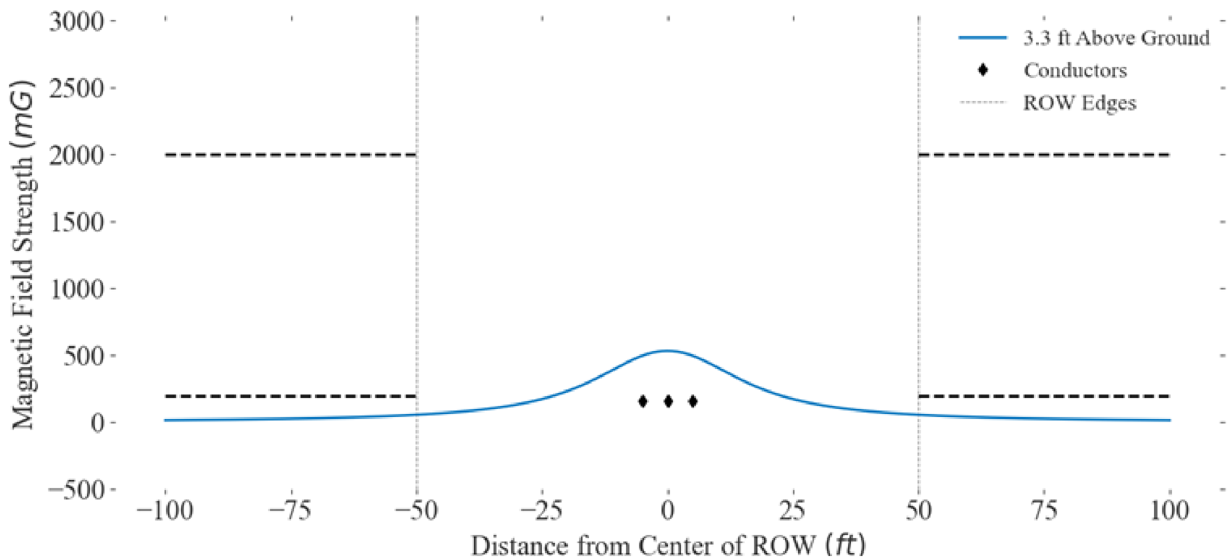

Figure 13. Magnetic Field Strength from the BW2 Onshore Interconnection Cables from the Millstone Power Complex for an Overhead Transmission Cable Located 19 ft (5.8 m) Above the Ground. The Conductor Layout is Shown as Black Dots. The ROW Width is Shown as Vertical Dashed Lines. Two Exposure Limits are Shown as Black Dashed Lines.

4.3.2.2 Astoria Power Complex: AGRE East to Astoria East POI

Figure 14 shows the rms magnetic field strength at 3.3 ft (1 m) above the ground for the triple circuit configuration. The minimum line height is assumed to be 23 ft (7 m). The largest predicted value for the maximum magnetic field strength is 236 mG. A ROW width of 110 ft (33.5 m) (55 ft [16.8 m]) from the center line) is assumed, at which point the magnetic field is below the NYPSC interim standard of 200 mG (NYPSC 1990). The maximum magnetic field strength of 236 mG is approximately 8.5 times lower than the ICNIRP 60-Hz AC magnetic field exposure limit of 2,000 mG. A more detailed table of model input values used for the BW1 HVAC onshore interconnection cable configuration from the AGRE East Converter Station to the Astoria East POI is provided in **Appendix B, Table B-7**.

Figure 15 shows the rms magnetic field strength at 3.3 ft (1 m) above the ground for the double circuit configuration. The minimum line height is assumed to be 23 ft (7 m). The largest predicted value for the maximum magnetic field strength is 191 mG. A ROW width of 110 ft (33.5 m) (55 ft [16.8 m]) from the center line) is assumed, at which point the magnetic field is below the NYPSC interim standard of 200 mG (NYPSC 1990). The maximum magnetic field strength of 191 mG is approximately 10.5 times lower than the ICNIRP 60-Hz AC magnetic field exposure limit of 2,000 mG. A more detailed table of model input values used for the BW1 HVAC onshore interconnection cable configuration from the AGRE East Converter Station to the Astoria East POI is provided in **Appendix B, Table B-8**.

Figure 16 shows the rms magnetic field strength at 3.3 ft (1 m) above the ground for the single circuit configuration. The minimum line height is assumed to be 23 ft (7 m). The largest predicted value for the maximum magnetic field strength is 205 mG. A ROW width of 110 ft (33.5 m) (55 ft [16.8 m]) from the center line) is assumed, at which point the magnetic field is below the NYPSC interim standard of 200 mG (NYPSC 1990). The maximum magnetic field strength of 205 mG is approximately 9.8 times lower than the ICNIRP 60-Hz AC magnetic field exposure limit of 2,000 mG. A more detailed table of model input values used for the BW1 HVAC onshore interconnection cable configuration from the AGRE East Converter Station to the Astoria East POI is provided in **Appendix B, Table B-9**.

These comparisons indicate that potential human health risks associated with exposure to project-related magnetic fields from the BW2 HVAC onshore interconnection cables from the AGRE East Converter Station to the Astoria East POI are *de minimis*.

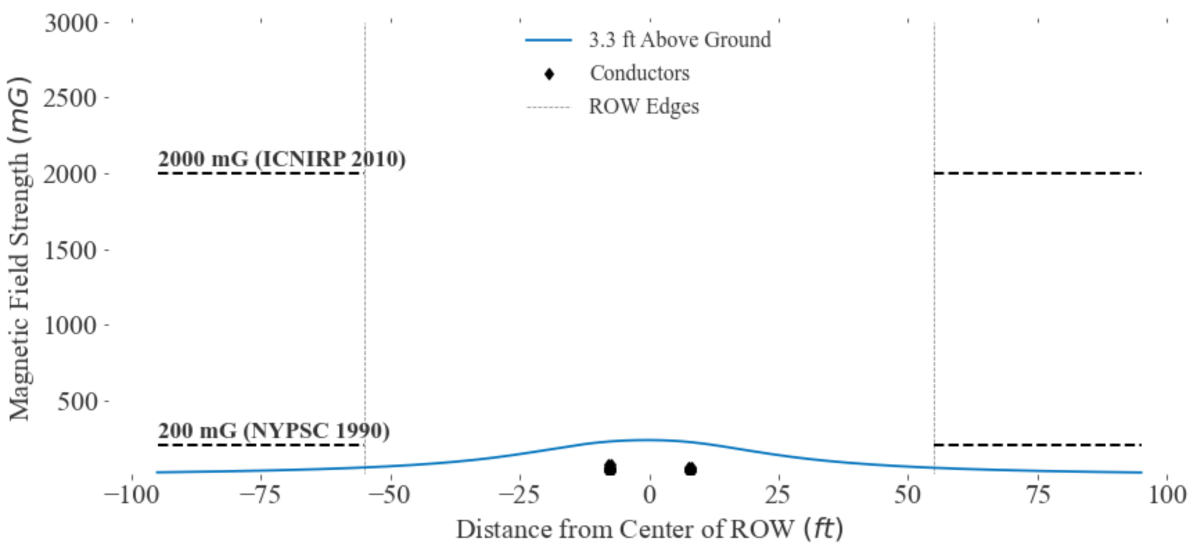

Figure 14. Magnetic Field Strength for a BW2 Onshore Interconnection Cable from the AGRE East Converter Station to the Astoria East POI for a Triple Circuit Overhead Configuration. The Height of the Lowest Cable is 23 ft (7 m). The Conductor Layout is Shown as Black Dots. The ROW Width is Shown as Vertical Dashed Lines. Two Exposure Limits are Shown as Black Dashed Lines.

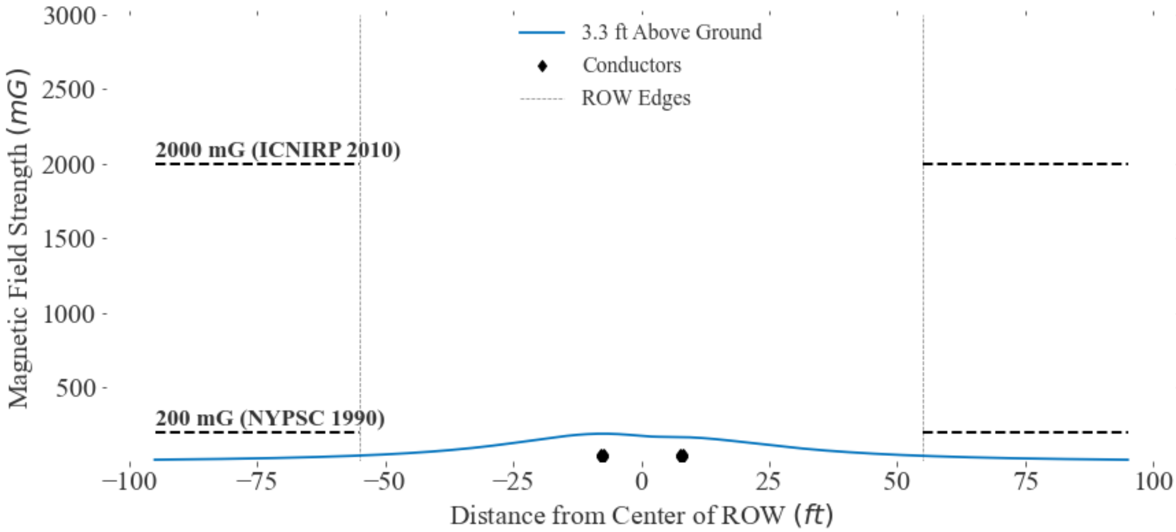

Figure 15. Magnetic Field Strength for a BW2 Onshore Interconnection Cable from the AGRE East Converter Station to the Astoria East POI for a Double Circuit Overhead Configuration. The Height of the Lowest Cable is 23 ft (7 m). The Conductor Layout is Shown as Black Dots. The ROW Width is Shown as Vertical Dashed Lines. Two Exposure Limits are Shown as Black Dashed Lines.

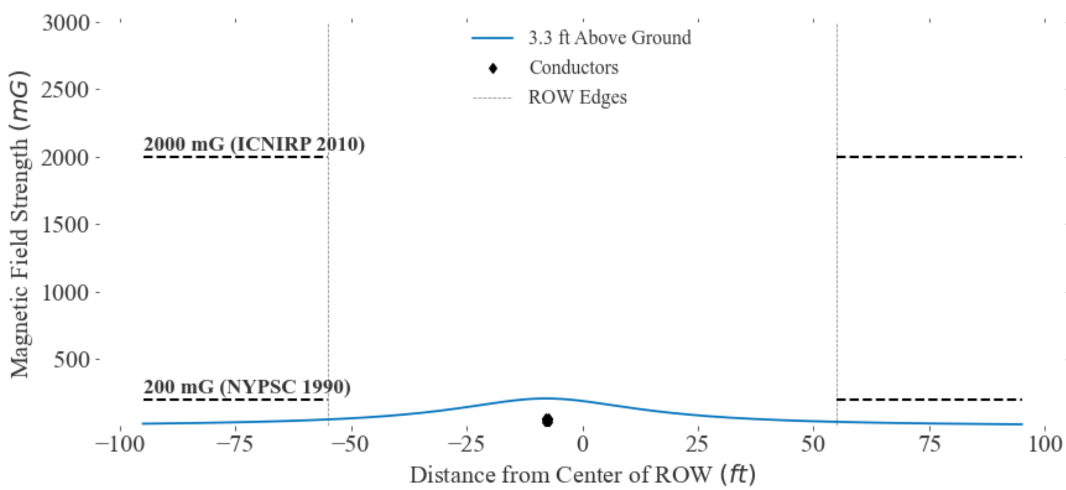

Figure 16. Magnetic Field Strength for a BW2 Onshore Interconnection Cable from the AGRE East Converter Station to the Astoria East POI for a Single Circuit Overhead Configuration. The Height of the Lowest Cable is 23 ft (7 m). The Conductor Layout is Shown as Black Dots. The ROW Width is Shown as Vertical Dashed Lines. Two Exposure Limits are Shown as Black Dashed Lines.

4.4 AC ELECTRIC FIELDS

4.4.1 BW1—HVAC Onshore Interconnection Cables

4.4.1.1 Astoria Power Complex: AGRE West to the Astoria West POI

Figure 17 shows the electric field at 3.3 ft (1 m) above the ground, directly below the overhead line, for the triple circuit configuration. The minimum line height is assumed to be 23 ft (7 m). The maximum predicted value for the maximum electric field strength is 1.1 kV/m. A ROW width of 110 ft (33.5 m) (55 ft [16.8 m]) from the center line) is assumed, at which point the electric field is well below the NYPSC interim standard of 1.6 kV/m (NYPSC 1990). In addition, the maximum electric field strength of 1.1 kV/m is approximately 3.8 times lower than the ICNIRP 60-Hz AC electric field exposure limit of 4.2 kV/m. A more detailed table of model input values used for the BW1 HVAC onshore interconnection cables are provided in **Appendix B, Table B-3**.

Figure 18 shows the electric field at 3.3 ft (1 m) above the ground, directly below the overhead line for the double circuit configuration. The minimum line height is assumed to be 23 ft (7 m). The maximum predicted value for the maximum electric field strength is 0.99 kV/m. A ROW width of 110 ft (33.5 m) (55 ft [16.8 m]) from the center line) is assumed, at which point the electric field is well below the NYPSC interim standard of 1.6 kV/m (NYPSC 1990). In addition, the maximum electric field strength of 0.99 kV/m is approximately 4.2 times lower than the ICNIRP 60-Hz AC electric field exposure limit of 4.2 kV/m. A more detailed table of model input values used for the BW1 HVAC onshore interconnection cables are provided in **Appendix B, Table B-4**.

Figure 19 shows the electric field at 3.3 ft (1 m) above the ground, directly below the overhead for the single circuit configuration. The minimum line height is assumed to be 23 ft (7 m). The maximum predicted value for the maximum electric field strength is 1.2 kV/m. A ROW width of 110 ft (33.5 m) (55 ft [16.8 m]) from the center line) is assumed, at which point the electric field is well below the NYPSC interim standard of 1.6 kV/m (NYPSC 1990). In addition, the maximum electric field strength of 1.2 kV/m is approximately 3.5 times lower than the ICNIRP 60-Hz AC electric field exposure limit of 4.2 kV/m. A more detailed table of model input values used for the BW1 HVAC onshore interconnection cables are provided in **Appendix B, Table B-5**.

These comparisons indicate that potential human health risks associated with exposure to project-related electric fields from the BW1 HVAC onshore interconnection cables from the AGRE West Converter Station to the Astoria West POI are *de minimis*.

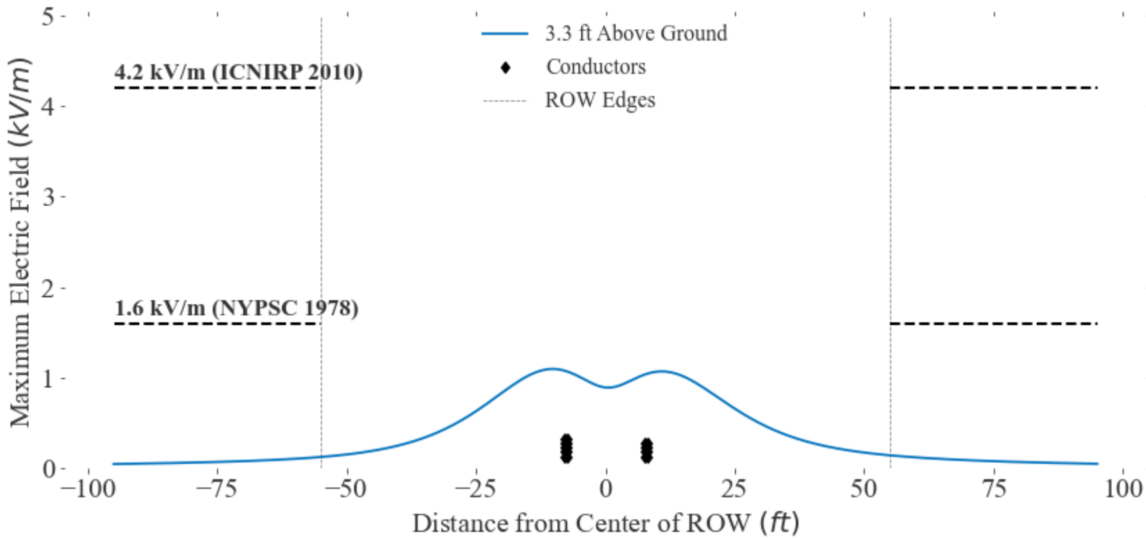

Figure 17. Electric Field Strength for a BW1 Onshore Interconnection Cable from the AGRE West Converter Station to the Astoria West POI for a Triple Circuit Overhead Configuration. The Height of the Lowest Cable is 23 ft (7 m). The Conductor Layout is Shown as Black Dots. The ROW Width is Shown as Vertical Dashed Lines. Two Exposure Limits are Shown as Black Dashed Lines.

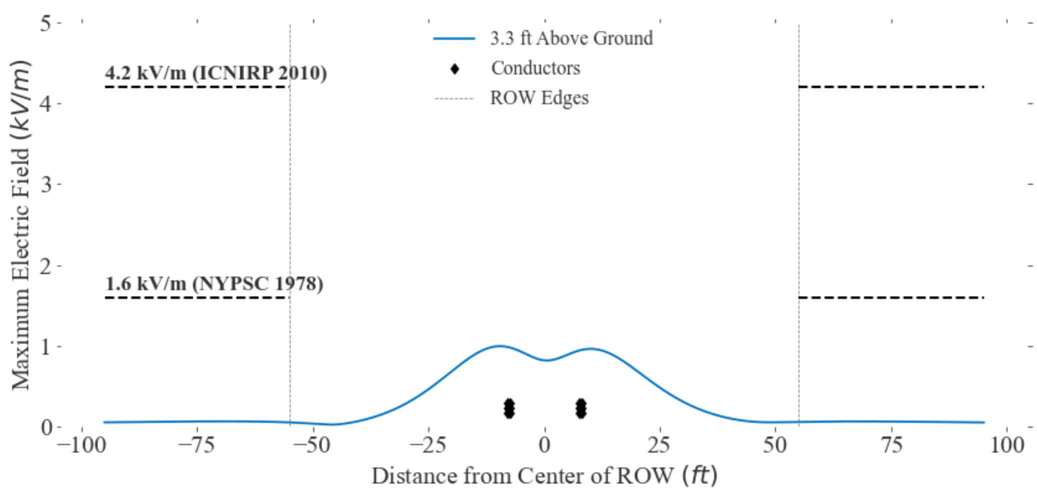

Figure 18. Electric Field Strength for a BW2 Onshore Interconnection Cable from the AGRE West Converter Station to the Astoria West POI for a Double Circuit Overhead Configuration. The Height of the Lowest Cable is 23 ft (7 m). The Conductor Layout is Shown as Black Dots. The ROW Width is Shown as Vertical Dashed Lines. Two Exposure Limits are Shown as Black Dashed Lines.

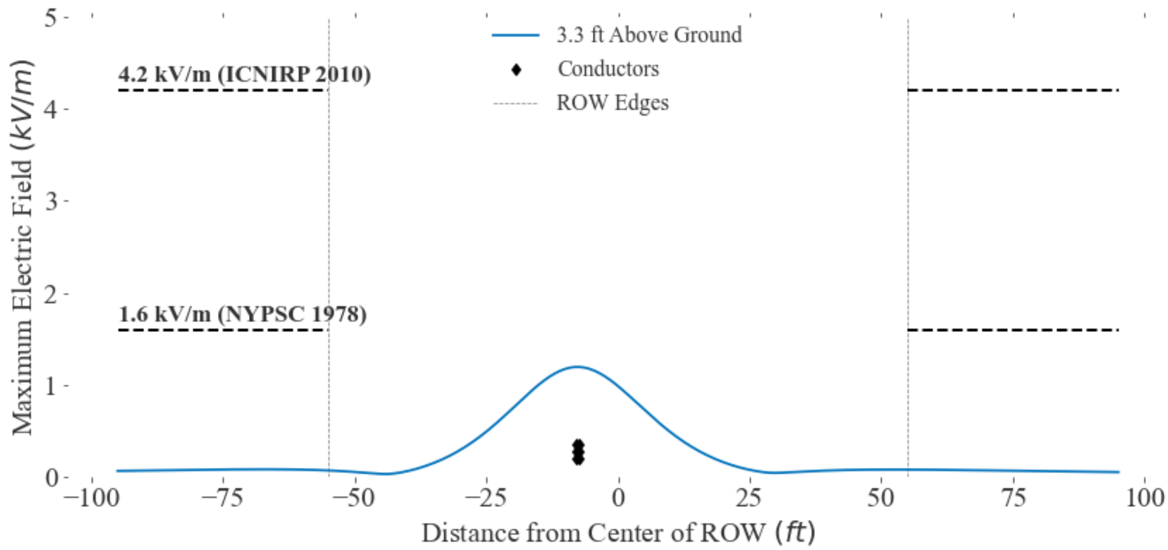

Figure 19. Electric Field Strength for a BW1 Onshore Interconnection Cable from the AGRE West Converter Station to the Astoria West POI for a Single Circuit Overhead Configuration. The Height of the Lowest Cable is 23 ft (7 m). The Conductor Layout is Shown as Black Dots. The ROW Width is Shown as Vertical Dashed Lines. Two Exposure Limits are Shown as Black Dashed Lines.

4.4.2 BW2—HVAC Onshore Interconnection Cables

4.4.2.1 Millstone Power Complex

Figure 20 shows the electric field at 3.3 ft (1 m) above the ground, directly below the overhead line, for an overhead line situated 22 ft (6.7 m) above the ground in the Millstone Power Complex. The maximum predicted value for the maximum magnetic field strength is 3.4 kV/m. A ROW width of 100 ft (30.5 m) (50 ft [15 m] from the center line) is assumed, at which point the electric field drops well below the NYPSC interim standard of 1.6 kV/m (NYPSC 1990). In addition, the maximum electric field strength of 3.4 kV/m is approximately 1.2 times lower than the ICNIRP 60-Hz AC electric field exposure limit of 4.2 kV/m. A more detailed table of model input values used for the BW2 HVAC onshore interconnection cables are provided in **Appendix B, Table B-6**.

These comparisons indicate that potential human health risks associated with exposure to project-related electric fields from the BW2 HVAC onshore interconnection cables of the Millstone Power Complex are *de minimis*.

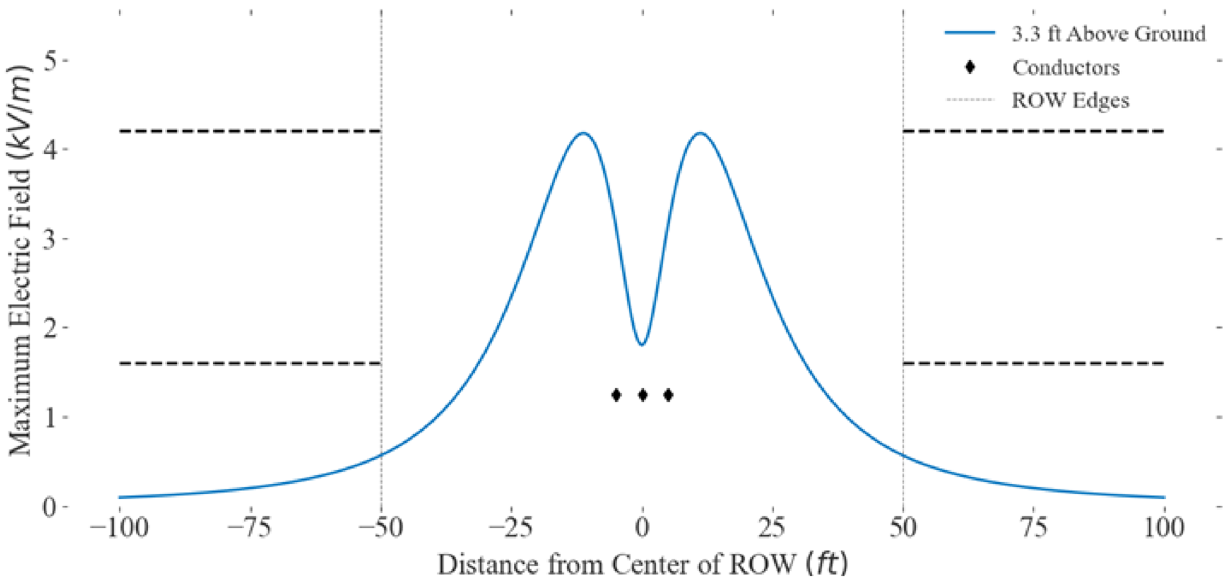

Figure 20. Electric Field Strength from the BW2 Onshore Interconnection Cables from the Millstone Power Complex for an Overhead Transmission Cable Located 19 ft (5.8 m) Above the Ground. The Conductor Layout is Shown as Black Dots. The ROW Width is Shown as Vertical Dashed Lines. Two Exposure Limits are Shown as Black Dashed Lines.

4.4.2.2 Astoria Power Complex: AGRE East to Astoria East POI

Figure 21 shows the electric field at 3.3 ft (1 m) above the ground, directly below the overhead line, for the triple circuit configuration. The minimum line height is assumed to be 23 ft (7 m). The maximum predicted value for the maximum electric field strength is 1.1 kV/m. A ROW width of 110 ft (33.5 m) (55 ft [16.8 m]) from the center line) is assumed, at which point the electric field is well below the NYPSC interim standard of 1.6 kV/m (NYPSC 1990). In addition, the maximum electric field strength of 1.1 kV/m is approximately 3.8 times lower than the ICNIRP 60-Hz AC electric field exposure limit of 4.2 kV/m. A more detailed table of model input values used for the BW2 HVAC onshore interconnection cables are provided in **Appendix B, Table B-7**.

Figure 22 shows the electric field at 3.3 ft (1 m) above the ground, directly below the overhead line for the double circuit configuration. The minimum line height is assumed to be 23 ft (7 m). The maximum predicted value for the maximum electric field strength is 0.99 kV/m. A ROW width of 110 ft (33.5 m) (55 ft [16.8 m]) from the center line) is assumed, at which point the electric field is well below the NYPSC interim standard of 1.6 kV/m (NYPSC 1990). In addition, the maximum electric field strength of 0.99 kV/m is approximately 4.2 times lower than the ICNIRP 60-Hz AC electric field exposure limit of 4.2 kV/m. A more detailed table of model input values used for the BW2 HVAC onshore interconnection cables are provided in **Appendix B, Table B-8**.

Figure 23 shows the electric field at 3.3 ft (1 m) above the ground, directly below the overhead for the single circuit configuration. The minimum line height is assumed to be 23 ft (7 m). The maximum predicted value for the maximum electric field strength is 1.2 kV/m. A ROW width of 110 ft (33.5 m) (55 ft [16.8 m]) from the center line) is assumed, at which point the electric field is well below the NYPSC interim standard of 1.6 kV/m (NYPSC 1990). In addition, the maximum electric field strength of 1.2 kV/m is approximately 3.5 times lower than the ICNIRP 60-Hz AC electric field exposure limit of 4.2 kV/m. A more detailed table of model input values used for the BW1 HVAC onshore interconnection cables are provided in **Appendix B, Table B-9**.

These comparisons indicate that potential human health risks associated with exposure to project-related electric fields from the BW2 HVAC onshore interconnection cables from the AGRE East Converter Station to the Astoria East POI are *de minimis*.

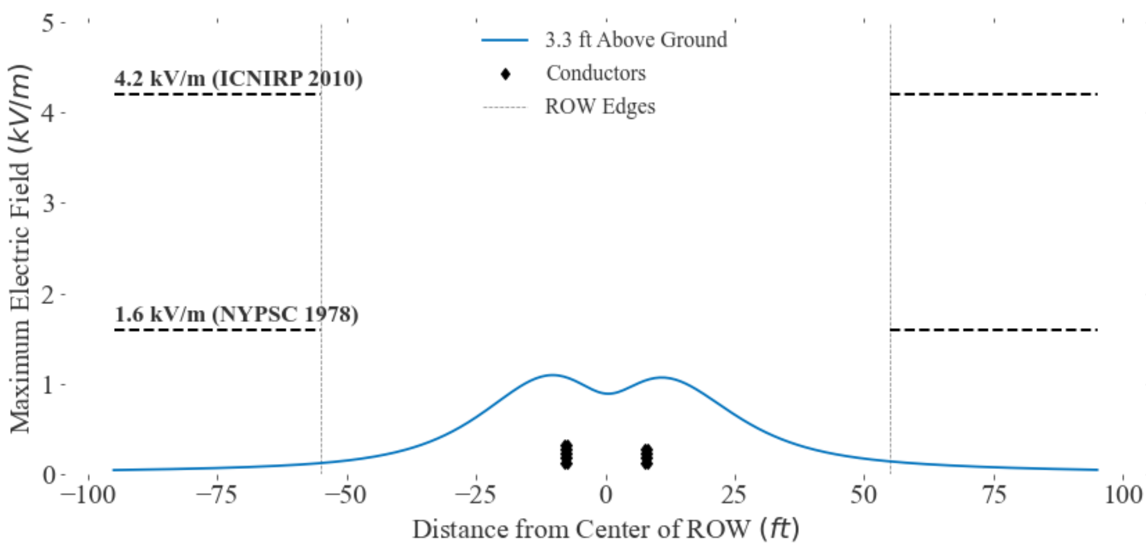

Figure 21. Electric Field Strength for a BW2 Onshore Interconnection Cable from the AGRE East Converter Station to the Astoria East POI for a Triple Circuit Overhead Configuration. The Height of the Lowest Cable is 23 ft (7 m). The Conductor Layout is Shown as Black Dots. The ROW Width is Shown as Vertical Dashed Lines. Two Exposure Limits are Shown as Black Dashed Lines.

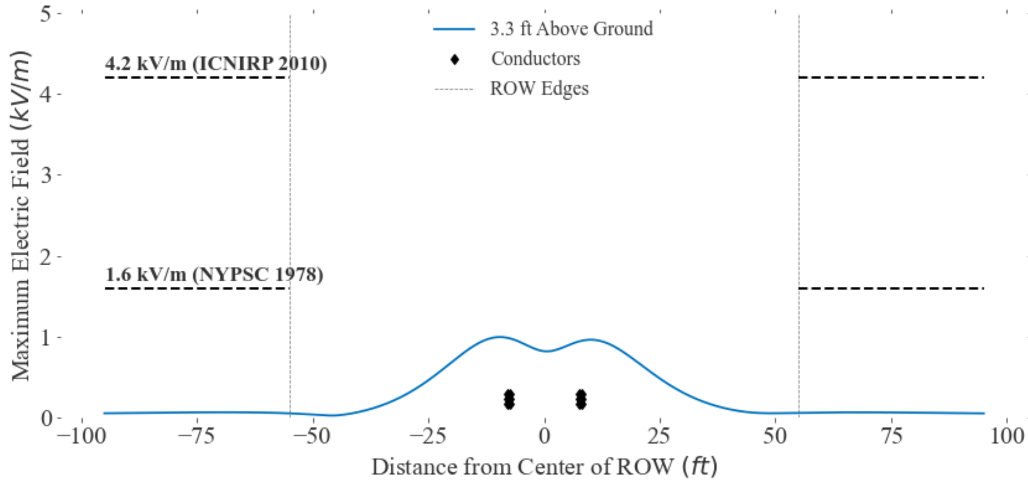

Figure 22. Electric Field Strength for a BW2 Onshore Interconnection Cable from the AGRE East Converter Station to the Astoria East POI for a Double Circuit Overhead Configuration. The Height of the Lowest Cable is 23 ft (7 m). The Conductor Layout is Shown as Black Dots. The ROW Width is Shown as Vertical Dashed Lines. Two Exposure Limits are Shown as Black Dashed Lines.

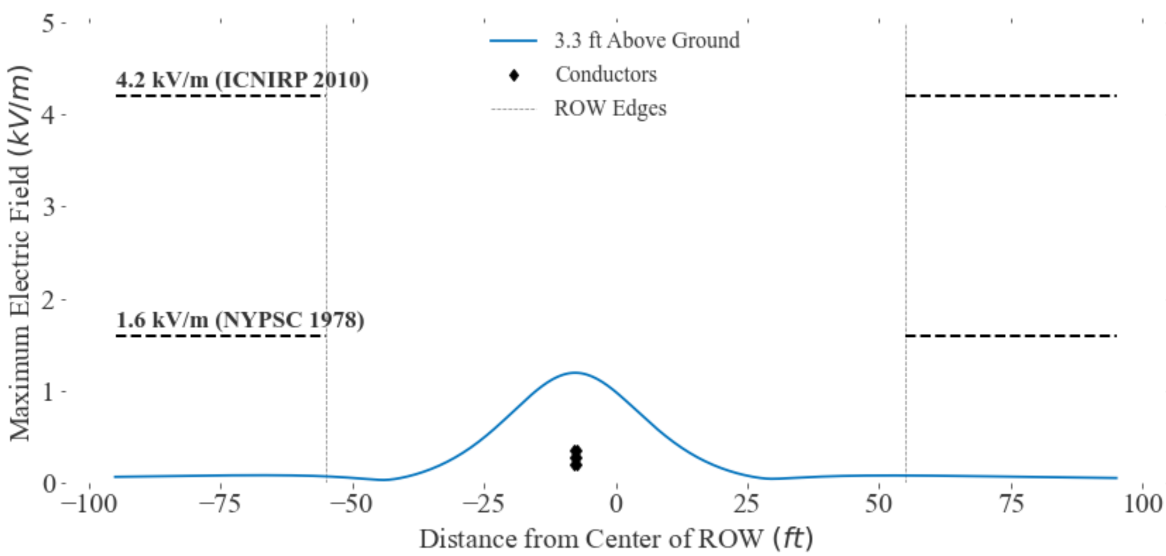

Figure 23. Electric Field Strength for a BW2 Onshore Interconnection Cable from the AGRE East Converter Station to the Astoria East POI for a Single Circuit Overhead Configuration. The Height of the Lowest Cable is 23 ft (7 m). The Conductor Layout is Shown as Black Dots. The ROW Width is Shown as Vertical Dashed Lines. Two Exposure Limits are Shown as Black Dashed Lines.

5 SUMMARY AND CONCLUSIONS

Integral performed the assessment for project-related onshore EMF for BW1 and BW2 presented in support of the COP. The approach for assessing project-related EMF impacts to human health and the environment was guided by the internationally-accepted environmental risk assessment approach as well as other standard methods for EMF assessment accepted within the scientific, engineering, and health communities.

The BW1 proposed transmission system will connect the offshore wind farm to the POI at the Astoria Power Complex in Queens, New York. The BW1 transmission system components evaluated in this report include one 320 kV HVDC onshore export cable circuit and three 138 kV HVAC onshore interconnection cable circuits. Interconnection cable circuits will be conducted either in underground duct banks or on overhead transmission structures.

The BW2 proposed transmission system will connect the offshore wind farm to POIs at either the Millstone Power Complex in Waterford, Connecticut, or the Astoria Power Complex in Queens, New York. The BW2 transmission system components of the Millstone Power Complex evaluated in this report include one 320 kV HVDC onshore export cable circuit and one 345 kV HVAC overhead onshore interconnection cable circuit. The BW2 transmission system components of the Astoria Power Complex evaluated in this report include one 320 kV HVDC onshore export cable circuit and three 138 kV HVAC overhead onshore interconnection cable circuits.

The EMF assessment included quantitative modeling of EMF for the BW1 and BW2 onshore components related to the HVDC onshore export cables and the HVAC onshore interconnection cables. The DC and AC magnetic fields associated with the operation of equipment within the BW1 and BW2 onshore substation facilities were not modeled, as fields from these sources can be expected to be at minimal levels outside the facility perimeters. The EMF modeling was based on the maximum capacity limits of the cables corresponding to the WNC rating.

The modeled results were compared to EMF exposure limits developed by the NYPSC and by ICNIRP, an internationally-recognized organization committed to EMF health and safety. The predicted DC and AC EMF values are summarized below.

- The maximum magnetic field strengths modeled for the BW1 and BW2 HVDC onshore export cables are between 6 to 2,300 times below the ICNIRP DC magnetic field exposure limits protective of human health.
- The maximum magnetic fields modeling for the BW1 and BW2 HVAC onshore interconnection cables are between 1.5 to 10.5 times lower than the ICNIRP AC magnetic field exposure limit of 2000 mG, protective of human health. Importantly, the magnetic fields modeled for the HVAC onshore interconnection cables meet the NYPSC interim

guideline of 200 mG for AC magnetic fields with an assumed ROW width of 110 ft (33.5 m), or 55 ft (17 m) from the centerline of the ROW.

- The maximum electric field strength for the BW1 and BW2 HVAC onshore interconnect cables proposed as overhead cables are between 1.2 to 4.2 times lower than the ICNIRP 60-Hz AC electric field exposure limit protective of human health of 4.2 kV/m. For the HVDC onshore export cables and for onshore interconnection cables run underground (BW1, between AGRE West and the Astoria West POI), electric fields will be prevented from passing to the outside environment metal sheathing and being buried, respectively.

- Electric fields modeled for the BW2 HVAC onshore interconnection cables meet the NYPSC guideline for electrical fields (1.6 kV/m) with an assumed ROW width of 110 ft (33.5 m), or 55 ft (16.8 m) from the center line of the ROW.

Collectively, the EMF assessment indicates that potential human health risks associated with exposure to project-related EMF from the BW1 and BW2 onshore electric transmission systems proposed for Queens, New York and Waterford, Connecticut are *de minimis*.

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APPENDIX A—DC MAGNETIC FIELD AND COMPASS DEFLECTION LOOKUP TABLES

Table A-1. Magnetic Field Strength in mG for BW1 HVDC Onshore Export Cables with 6.6 ft (2 m) Separated Configuration Evaluated at 3.3 ft (1 m) above the Ground

	Cable Burial Depth (ft)	
Distance from Cable Centerline (ft)	4.4	13
-100	504.0	504.1
-99	503.8	504.0
-98	503.7	503.8
-97	503.5	503.7
-96	503.3	503.5
-95	503.1	503.3
-94	502.9	503.2
-93	502.8	503.0
-92	502.6	502.8
-91	502.3	502.6
-90	502.1	502.4
-89	501.9	502.2
-88	501.7	502.0
-87	501.5	501.8
-86	501.2	501.6
-85	501.0	501.3
-84	500.7	501.1
-83	500.4	500.9
-82	500.2	500.6
-81	499.9	500.4
-80	499.6	500.1
-79	499.3	499.8
-78	498.9	499.5
-77	498.6	499.2
-76	498.2	498.9
-75	497.9	498.6
-74	497.5	498.3
-73	497.1	497.9
-72	496.7	497.6
-71	496.3	497.2

Table A-1. Magnetic Field Strength in mG for BW1 HVDC Onshore Export Cables with 6.6 ft (2 m) Separated Configuration Evaluated at 3.3 ft (1 m) above the Ground

	Cable Burial Depth (ft)	
Distance from Cable Centerline (ft)	4.4	13
-70	495.8	496.8
-69	495.4	496.5
-68	494.9	496.0
-67	494.4	495.6
-66	493.9	495.2
-65	493.3	494.7
-64	492.7	494.3
-63	492.1	493.8
-62	491.5	493.3
-61	490.8	492.8
-60	490.1	492.2
-59	489.4	491.6
-58	488.7	491.1
-57	487.8	490.4
-56	487.0	489.8
-55	486.1	489.1
-54	485.2	488.5
-53	484.2	487.8
-52	483.1	487.0
-51	482.0	486.3
-50	480.9	485.5
-49	479.6	484.6
-48	478.3	483.8
-47	477.0	482.9
-46	475.5	482.0
-45	473.9	481.0
-44	472.3	480.1
-43	470.5	479.1
-42	468.6	478.0
-41	466.6	477.0
-40	464.5	475.9
-39	462.2	474.8
-38	459.7	473.7
-37	457.1	472.5
-36	454.3	471.4

Table A-1. Magnetic Field Strength in mG for BW1 HVDC Onshore Export Cables with 6.6 ft (2 m) Separated Configuration Evaluated at 3.3 ft (1 m) above the Ground

	Cable Burial Depth (ft)	
Distance from Cable Centerline (ft)	4.4	13
-35	451.3	470.3
-34	448.1	469.2
-33	444.6	468.2
-32	440.8	467.2
-31	436.8	466.2
-30	432.5	465.4
-29	427.9	464.8
-28	422.9	464.3
-27	417.5	464.1
-26	411.8	464.2
-25	405.8	464.7
-24	399.4	465.7
-23	392.7	467.3
-22	385.8	469.5
-21	378.9	472.6
-20	372.2	476.7
-19	366.3	482.0
-18	361.7	488.6
-17	359.4	496.7
-16	360.8	506.5
-15	367.8	518.2
-14	382.7	531.8
-13	408.1	547.4
-12	446.8	565.1
-11	501.3	584.6
-10	573.5	605.9
-9	664.6	628.6
-8	774.8	652.2
-7	902.7	676.2
-6	1044.3	699.9
-5	1193.1	722.6
-4	1339.7	743.5
-3	1473.0	762.0
-2	1582.3	777.3
-1	1659.1	788.8

Table A-1. Magnetic Field Strength in mG for BW1 HVDC Onshore Export Cables with 6.6 ft (2 m) Separated Configuration Evaluated at 3.3 ft (1 m) above the Ground

	Cable Burial Depth (ft)	
Distance from Cable Centerline (ft)	4.4	13
0	1697.9	796.2
1	1696.3	799.3
2	1654.9	798.0
3	1577.7	792.4
4	1471.7	783.0
5	1347.1	770.3
6	1214.5	754.8
7	1083.8	737.3
8	962.2	718.3
9	854.1	698.6
10	761.3	678.7
11	684.0	659.1
12	621.3	640.2
13	571.7	622.3
14	533.2	605.7
15	504.2	590.4
16	482.9	576.5
17	467.6	564.1
18	457.0	553.1
19	450.0	543.4
20	445.7	534.9
21	443.4	527.5
22	442.6	521.2
23	442.8	515.7
24	443.7	511.1
25	445.1	507.2
26	446.9	504.0
27	448.9	501.2
28	451.0	499.0
29	453.2	497.1
30	455.4	495.6
31	457.5	494.4
32	459.7	493.5
33	461.7	492.8
34	463.7	492.2

Table A-1. Magnetic Field Strength in mG for BW1 HVDC Onshore Export Cables with 6.6 ft (2 m) Separated Configuration Evaluated at 3.3 ft (1 m) above the Ground

	Cable Burial Depth (ft)	
Distance from Cable Centerline (ft)	4.4	13
35	465.6	491.8
36	467.5	491.6
37	469.2	491.4
38	470.9	491.4
39	472.5	491.4
40	474.0	491.5
41	475.5	491.7
42	476.9	491.8
43	478.2	492.1
44	479.4	492.3
45	480.6	492.6
46	481.7	492.9
47	482.8	493.2
48	483.8	493.6
49	484.8	493.9
50	485.7	494.2
51	486.6	494.6
52	487.5	494.9
53	488.3	495.2
54	489.0	495.6
55	489.8	495.9
56	490.4	496.3
57	491.1	496.6
58	491.7	496.9
59	492.4	497.2
60	492.9	497.5
61	493.5	497.8
62	494.0	498.1
63	494.5	498.4
64	495.0	498.7
65	495.5	499.0
66	496.0	499.3
67	496.4	499.5
68	496.8	499.8
69	497.2	500.0

Table A-1. Magnetic Field Strength in mG for BW1 HVDC Onshore Export Cables with 6.6 ft (2 m) Separated Configuration Evaluated at 3.3 ft (1 m) above the Ground

	Cable Burial Depth (ft)	
Distance from Cable Centerline (ft)	4.4	13
70	497.6	500.3
71	498.0	500.5
72	498.3	500.8
73	498.7	501.0
74	499.0	501.2
75	499.3	501.4
76	499.6	501.6
77	499.9	501.9
78	500.2	502.1
79	500.5	502.3
80	500.7	502.4
81	501.0	502.6
82	501.2	502.8
83	501.5	503.0
84	501.7	503.2
85	501.9	503.3
86	502.2	503.5
87	502.4	503.6
88	502.6	503.8
89	502.8	503.9
90	503.0	504.1
91	503.1	504.2
92	503.3	504.4
93	503.5	504.5
94	503.7	504.6
95a	503.8	504.8
96	504.0	504.9
97	504.1	505.0
98	504.3	505.1
99	504.4	505.2
100	504.6	505.4

Table A-2. Compass Deflection in Degrees for BW1 HVDC Onshore Export Cables with 6.6 ft (2 m) Separated Configuration Evaluated at 3.3 ft (1 m) above the Ground

	Cable Burial Depth (ft)	
Distance from Cable Centerline (ft)	4.4	13
-100	-0.3	-0.6
-99	-0.3	-0.6
-98	-0.3	-0.6
-97	-0.3	-0.7
-96	-0.3	-0.7
-95	-0.3	-0.7
-94	-0.3	-0.7
-93	-0.4	-0.7
-92	-0.4	-0.8
-91	-0.4	-0.8
-90	-0.4	-0.8
-89	-0.4	-0.8
-88	-0.4	-0.9
-87	-0.4	-0.9
-86	-0.5	-0.9
-85	-0.5	-1.0
-84	-0.5	-1.0
-83	-0.5	-1.0
-82	-0.5	-1.1
-81	-0.5	-1.1
-80	-0.6	-1.1
-79	-0.6	-1.2
-78	-0.6	-1.2
-77	-0.6	-1.3
-76	-0.7	-1.3
-75	-0.7	-1.4
-74	-0.7	-1.4
-73	-0.7	-1.5
-72	-0.8	-1.5
-71	-0.8	-1.6
-70	-0.8	-1.7
-69	-0.9	-1.7
-68	-0.9	-1.8
-67	-1.0	-1.9
-66	-1.0	-2.0

Table A-2. Compass Deflection in Degrees for BW1 HVDC Onshore Export Cables with 6.6 ft (2 m) Separated Configuration Evaluated at 3.3 ft (1 m) above the Ground

	Cable Burial Depth (ft)	
Distance from Cable Centerline (ft)	4.4	13
-65	-1.0	-2.1
-64	-1.1	-2.2
-63	-1.2	-2.3
-62	-1.2	-2.4
-61	-1.3	-2.5
-60	-1.3	-2.6
-59	-1.4	-2.7
-58	-1.5	-2.9
-57	-1.6	-3.0
-56	-1.6	-3.1
-55	-1.7	-3.3
-54	-1.8	-3.5
-53	-1.9	-3.7
-52	-2.0	-3.9
-51	-2.2	-4.1
-50	-2.3	-4.3
-49	-2.4	-4.5
-48	-2.6	-4.8
-47	-2.8	-5.1
-46	-3.0	-5.4
-45	-3.2	-5.7
-44	-3.4	-6.1
-43	-3.6	-6.5
-42	-3.9	-6.9
-41	-4.2	-7.4
-40	-4.5	-7.8
-39	-4.9	-8.4
-38	-5.3	-9.0
-37	-5.7	-9.6
-36	-6.2	-10.3
-35	-6.8	-11.1
-34	-7.4	-11.9
-33	-8.1	-12.8
-32	-8.9	-13.8
-31	-9.8	-14.9

Table A-2. Compass Deflection in Degrees for BW1 HVDC Onshore Export Cables with 6.6 ft (2 m) Separated Configuration Evaluated at 3.3 ft (1 m) above the Ground

	Cable Burial Depth (ft)	
Distance from Cable Centerline (ft)	4.4	13
-30	-10.8	-16.2
-29	-12.0	-17.5
-28	-13.4	-19.0
-27	-15.0	-20.6
-26	-16.9	-22.3
-25	-19.1	-24.3
-24	-21.6	-26.4
-23	-24.6	-28.6
-22	-28.2	-31.1
-21	-32.4	-33.7
-20	-37.4	-36.5
-19	-43.1	-39.3
-18	-49.6	-42.3
-17	-56.8	-45.2
-16	-64.4	-48.1
-15	-72.2	-50.9
-14	-79.6	-53.5
-13	-86.5	-55.7
-12	-92.5	-57.4
-11	-97.6	-58.6
-10	-101.8	-59.2
-9	-105.1	-58.8
-8	-107.6	-57.5
-7	-109.5	-54.9
-6	-110.5	-50.8
-5	-110.8	-45.1
-4	-110.0	-37.5
-3	-107.3	-28.4
-2	-100.0	-18.4
-1	-74.6	-8.7
0	0.0	0.0
1	31.2	7.2
2	39.9	12.9
3	43.3	17.2
4	44.7	20.5

Table A-2. Compass Deflection in Degrees for BW1 HVDC Onshore Export Cables with 6.6 ft (2 m) Separated Configuration Evaluated at 3.3 ft (1 m) above the Ground

	Cable Burial Depth (ft)	
Distance from Cable Centerline (ft)	4.4	13
5	45.2	22.9
6	45.0	24.6
7	44.4	25.7
8	43.5	26.4
9	42.2	26.8
10	40.6	26.9
11	38.9	26.8
12	36.9	26.4
13	34.9	25.9
14	32.7	25.3
15	30.5	24.6
16	28.4	23.8
17	26.2	22.9
18	24.2	22.0
19	22.3	21.1
20	20.4	20.1
21	18.7	19.2
22	17.2	18.3
23	15.7	17.3
24	14.4	16.4
25	13.2	15.6
26	12.1	14.7
27	11.1	13.9
28	10.2	13.1
29	9.4	12.4
30	8.6	11.7
31	7.9	11.1
32	7.3	10.4
33	6.8	9.8
34	6.3	9.3
35	5.8	8.8
36	5.4	8.3
37	5.0	7.8
38	4.7	7.4
39	4.4	7.0

Table A-2. Compass Deflection in Degrees for BW1 HVDC Onshore Export Cables with 6.6 ft (2 m) Separated Configuration Evaluated at 3.3 ft (1 m) above the Ground

	Cable Burial Depth (ft)	
Distance from Cable Centerline (ft)	4.4	13
40	4.1	6.6
41	3.8	6.3
42	3.6	5.9
43	3.3	5.6
44	3.1	5.3
45	2.9	5.0
46	2.8	4.8
47	2.6	4.5
48	2.5	4.3
49	2.3	4.1
50	2.2	3.9
51	2.1	3.7
52	2.0	3.5
53	1.8	3.4
54	1.8	3.2
55	1.7	3.1
56	1.6	2.9
57	1.5	2.8
58	1.4	2.7
59	1.4	2.6
60	1.3	2.4
61	1.2	2.3
62	1.2	2.2
63	1.1	2.1
64	1.1	2.1
65	1.0	2.0
66	1.0	1.9
67	0.9	1.8
68	0.9	1.7
69	0.9	1.7
70	0.8	1.6
71	0.8	1.5
72	0.8	1.5
73	0.7	1.4
74	0.7	1.4

Table A-2. Compass Deflection in Degrees for BW1 HVDC Onshore Export Cables with 6.6 ft (2 m) Separated Configuration Evaluated at 3.3 ft (1 m) above the Ground

	Cable Burial Depth (ft)	
Distance from Cable Centerline (ft)	4.4	13
75	0.7	1.3
76	0.6	1.3
77	0.6	1.2
78	0.6	1.2
79	0.6	1.2
80	0.6	1.1
81	0.5	1.1
82	0.5	1.0
83	0.5	1.0
84	0.5	1.0
85	0.5	0.9
86	0.4	0.9
87	0.4	0.9
88	0.4	0.8
89	0.4	0.8
90	0.4	0.8
91	0.4	0.8
92	0.4	0.7
93	0.4	0.7
94	0.3	0.7
95a	0.3	0.7
96	0.3	0.7
97	0.3	0.6
98	0.3	0.6
99	0.3	0.6
100	0.3	0.6

Table A-3. Magnetic Field Strength in mG for BW2 HVDC Onshore Export Cables with 6.6 ft (2 m) Separated Configuration Evaluated at 3.3 ft (1 m) above the Ground

	Cable Burial Depth (ft)	
Distance from Cable Centerline (ft)	4.4	13
-100	505.4	506.4
-99	505.2	506.3
-98	505.1	506.2
-97	505.0	506.0
-96	504.8	505.9
-95	504.7	505.8
-94	504.5	505.7
-93	504.3	505.6
-92	504.2	505.5
-91	504.0	505.3
-90	503.8	505.2
-89	503.6	505.1
-88	503.5	505.0
-87	503.3	504.8
-86	503.1	504.7
-85	502.9	504.5
-84	502.6	504.4
-83	502.4	504.3
-82	502.2	504.1
-81	502.0	503.9
-80	501.7	503.8
-79	501.5	503.6
-78	501.2	503.5
-77	500.9	503.3
-76	500.6	503.1
-75	500.4	502.9
-74	500.1	502.8
-73	499.7	502.6
-72	499.4	502.4
-71	499.1	502.2
-70	498.7	502.0
-69	498.4	501.8
-68	498.0	501.6
-67	497.6	501.4
-66	497.2	501.1

Table A-3. Magnetic Field Strength in mG for BW2 HVDC Onshore Export Cables with 6.6 ft (2 m) Separated Configuration Evaluated at 3.3 ft (1 m) above the Ground

	Cable Burial Depth (ft)	
Distance from Cable Centerline (ft)	4.4	13
-65	496.8	500.9
-64	496.4	500.7
-63	495.9	500.5
-62	495.4	500.3
-61	494.9	500.0
-60	494.4	499.8
-59	493.9	499.6
-58	493.3	499.3
-57	492.7	499.1
-56	492.1	498.9
-55	491.5	498.6
-54	490.8	498.4
-53	490.1	498.2
-52	489.4	498.0
-51	488.6	497.8
-50	487.8	497.6
-49	487.0	497.4
-48	486.1	497.2
-47	485.2	497.0
-46	484.3	496.9
-45	483.3	496.8
-44	482.2	496.7
-43	481.2	496.7
-42	480.0	496.7
-41	478.8	496.8
-40	477.6	496.9
-39	476.3	497.1
-38	475.0	497.4
-37	473.6	497.8
-36	472.1	498.4
-35	470.6	499.0
-34	469.1	499.8
-33	467.6	500.9
-32	466.0	502.1
-31	464.5	503.6

Table A-3. Magnetic Field Strength in mG for BW2 HVDC Onshore Export Cables with 6.6 ft (2 m) Separated Configuration Evaluated at 3.3 ft (1 m) above the Ground

	Cable Burial Depth (ft)	
Distance from Cable Centerline (ft)	4.4	13
-30	462.9	505.4
-29	461.5	507.5
-28	460.1	510.0
-27	458.9	513.0
-26	458.0	516.5
-25	457.4	520.5
-24	457.3	525.3
-23	458.0	530.7
-22	459.6	537.1
-21	462.4	544.3
-20	467.0	552.6
-19	473.9	562.0
-18	483.7	572.6
-17	497.3	584.4
-16	515.9	597.6
-15	540.7	612.1
-14	573.1	627.9
-13	614.8	644.9
-12	667.5	662.9
-11	732.8	681.6
-10	812.2	700.8
-9	906.3	720.1
-8	1014.9	738.7
-7	1135.8	756.3
-6	1264.3	772.2
-5	1393.0	785.6
-4	1512.0	795.9
-3	1610.3	802.6
-2	1678.2	805.2
-1	1708.9	803.4
0	1698.8	797.0
1	1648.0	786.3
2	1559.4	771.4
3	1439.0	752.9
4	1295.7	731.3

Table A-3. Magnetic Field Strength in mG for BW2 HVDC Onshore Export Cables with 6.6 ft (2 m) Separated Configuration Evaluated at 3.3 ft (1 m) above the Ground

	Cable Burial Depth (ft)	
Distance from Cable Centerline (ft)	4.4	13
5	1140.6	707.5
6	984.7	682.3
7	837.5	656.3
8	705.4	630.5
9	592.3	605.4
10	499.6	581.6
11	427.5	559.6
12	375.0	539.7
13	340.4	522.1
14	320.7	506.8
15	312.6	493.7
16	312.6	482.8
17	317.8	474.0
18	326.0	466.9
19	335.8	461.4
20	346.1	457.3
21	356.4	454.4
22	366.4	452.5
23	375.8	451.4
24	384.7	450.9
25	392.9	451.0
26	400.6	451.5
27	407.6	452.3
28	414.1	453.4
29	420.0	454.6
30	425.5	456.0
31	430.6	457.5
32	435.2	459.1
33	439.5	460.7
34	443.5	462.3
35	447.2	463.8
36	450.6	465.4
37	453.8	467.0
38	456.7	468.5
39	459.4	470.0

Table A-3. Magnetic Field Strength in mG for BW2 HVDC Onshore Export Cables with 6.6 ft (2 m) Separated Configuration Evaluated at 3.3 ft (1 m) above the Ground

	Cable Burial Depth (ft)	
Distance from Cable Centerline (ft)	4.4	13
40	462.0	471.4
41	464.3	472.8
42	466.5	474.1
43	468.6	475.4
44	470.5	476.7
45	472.4	477.9
46	474.1	479.1
47	475.7	480.2
48	477.2	481.2
49	478.6	482.3
50	479.9	483.2
51	481.2	484.2
52	482.3	485.1
53	483.5	485.9
54	484.5	486.8
55	485.5	487.6
56	486.5	488.3
57	487.4	489.1
58	488.3	489.8
59	489.1	490.5
60	489.8	491.1
61	490.6	491.7
62	491.3	492.3
63	492.0	492.9
64	492.6	493.4
65	493.2	494.0
66	493.8	494.5
67	494.3	495.0
68	494.9	495.5
69	495.4	495.9
70	495.9	496.3
71	496.3	496.8
72	496.8	497.2
73	497.2	497.6
74	497.6	497.9

Table A-3. Magnetic Field Strength in mG for BW2 HVDC Onshore Export Cables with 6.6 ft (2 m) Separated Configuration Evaluated at 3.3 ft (1 m) above the Ground

	Cable Burial Depth (ft)	
Distance from Cable Centerline (ft)	4.4	13
75	498.0	498.3
76	498.4	498.7
77	498.8	499.0
78	499.1	499.3
79	499.5	499.6
80	499.8	499.9
81	500.1	500.2
82	500.4	500.5
83	500.7	500.8
84	501.0	501.1
85	501.3	501.3
86	501.5	501.6
87	501.8	501.8
88	502.0	502.0
89	502.3	502.3
90	502.5	502.5
91	502.7	502.7
92	502.9	502.9
93	503.1	503.1
94	503.3	503.3
95a	503.5	503.5
96	503.7	503.7
97	503.9	503.8
98	504.1	504.0
99	504.2	504.2
100	504.4	504.3

Table A-4. Compass Deflection in Degrees for BW2 HVDC Onshore Export Cables with 6.6 ft (2 m) Separated Configuration Evaluated at 3.3 ft (1 m) above the Ground

	Cable Burial Depth (ft)	
Distance from Cable Centerline (ft)	4.4	13
-100	-0.1	-0.3
-99	-0.1	-0.3
-98	-0.1	-0.3
-97	-0.1	-0.3
-96	-0.1	-0.3
-95	-0.1	-0.3
-94	-0.2	-0.3
-93	-0.2	-0.3
-92	-0.2	-0.3
-91	-0.2	-0.3
-90	-0.2	-0.4
-89	-0.2	-0.4
-88	-0.2	-0.4
-87	-0.2	-0.4
-86	-0.2	-0.4
-85	-0.2	-0.4
-84	-0.2	-0.4
-83	-0.2	-0.4
-82	-0.2	-0.5
-81	-0.2	-0.5
-80	-0.2	-0.5
-79	-0.3	-0.5
-78	-0.3	-0.5
-77	-0.3	-0.5
-76	-0.3	-0.6
-75	-0.3	-0.6
-74	-0.3	-0.6
-73	-0.3	-0.6
-72	-0.3	-0.7
-71	-0.4	-0.7
-70	-0.4	-0.7
-69	-0.4	-0.7
-68	-0.4	-0.8
-67	-0.4	-0.8
-66	-0.4	-0.8

Table A-4. Compass Deflection in Degrees for BW2 HVDC Onshore Export Cables with 6.6 ft (2 m) Separated Configuration Evaluated at 3.3 ft (1 m) above the Ground

	Cable Burial Depth (ft)	
Distance from Cable Centerline (ft)	4.4	13
-65	-0.5	-0.9
-64	-0.5	-0.9
-63	-0.5	-0.9
-62	-0.5	-1.0
-61	-0.5	-1.0
-60	-0.6	-1.1
-59	-0.6	-1.1
-58	-0.6	-1.2
-57	-0.7	-1.2
-56	-0.7	-1.3
-55	-0.7	-1.3
-54	-0.8	-1.4
-53	-0.8	-1.5
-52	-0.9	-1.5
-51	-0.9	-1.6
-50	-1.0	-1.7
-49	-1.0	-1.8
-48	-1.1	-1.9
-47	-1.1	-2.0
-46	-1.2	-2.1
-45	-1.3	-2.2
-44	-1.4	-2.3
-43	-1.5	-2.4
-42	-1.6	-2.5
-41	-1.7	-2.7
-40	-1.8	-2.8
-39	-1.9	-3.0
-38	-2.0	-3.1
-37	-2.2	-3.3
-36	-2.3	-3.5
-35	-2.5	-3.7
-34	-2.7	-3.9
-33	-2.9	-4.1
-32	-3.1	-4.4
-31	-3.4	-4.6

Table A-4. Compass Deflection in Degrees for BW2 HVDC Onshore Export Cables with 6.6 ft (2 m) Separated Configuration Evaluated at 3.3 ft (1 m) above the Ground

	Cable Burial Depth (ft)	
Distance from Cable Centerline (ft)	4.4	13
-30	-3.6	-4.9
-29	-3.9	-5.1
-28	-4.3	-5.4
-27	-4.6	-5.7
-26	-5.0	-6.0
-25	-5.4	-6.3
-24	-5.9	-6.7
-23	-6.4	-7.0
-22	-6.9	-7.3
-21	-7.5	-7.7
-20	-8.2	-8.0
-19	-8.8	-8.4
-18	-9.5	-8.7
-17	-10.3	-9.1
-16	-11.0	-9.4
-15	-11.8	-9.7
-14	-12.6	-9.9
-13	-13.4	-10.2
-12	345.8	-10.3
-11	345.1	-10.5
-10	344.5	-10.5
-9	343.9	-10.5
-8	343.4	-10.3
-7	343.0	-10.1
-6	342.8	-9.7
-5	342.7	-9.0
-4	342.9	-8.2
-3	343.5	-7.0
-2	344.7	-5.3
-1	-12.1	-3.1
0	0.0	0.0
1	110.9	4.2
2	144.2	10.0
3	149.4	17.7
4	151.0	27.6

Table A-4. Compass Deflection in Degrees for BW2 HVDC Onshore Export Cables with 6.6 ft (2 m) Separated Configuration Evaluated at 3.3 ft (1 m) above the Ground

	Cable Burial Depth (ft)	
Distance from Cable Centerline (ft)	4.4	13
5	151.5	39.1
6	151.4	50.6
7	150.7	60.2
8	149.6	66.9
9	147.9	70.5
10	145.6	71.4
11	142.2	69.9
12	137.5	66.7
13	130.6	62.1
14	120.4	56.6
15	105.5	50.7
16	85.8	44.9
17	65.0	39.4
18	47.9	34.4
19	35.7	30.1
20	27.4	26.3
21	21.7	23.0
22	17.5	20.3
23	14.5	17.9
24	12.2	15.9
25	10.4	14.2
26	8.9	12.7
27	7.8	11.4
28	6.8	10.3
29	6.0	9.3
30	5.4	8.5
31	4.8	7.7
32	4.3	7.1
33	3.9	6.5
34	3.5	6.0
35	3.2	5.5
36	2.9	5.1
37	2.7	4.7
38	2.5	4.4
39	2.3	4.0

Table A-4. Compass Deflection in Degrees for BW2 HVDC Onshore Export Cables with 6.6 ft (2 m) Separated Configuration Evaluated at 3.3 ft (1 m) above the Ground

	Cable Burial Depth (ft)	
Distance from Cable Centerline (ft)	4.4	13
40	2.1	3.8
41	1.9	3.5
42	1.8	3.3
43	1.7	3.1
44	1.6	2.9
45	1.5	2.7
46	1.4	2.5
47	1.3	2.4
48	1.2	2.2
49	1.1	2.1
50	1.1	2.0
51	1.0	1.9
52	0.9	1.8
53	0.9	1.7
54	0.8	1.6
55	0.8	1.5
56	0.7	1.4
57	0.7	1.4
58	0.7	1.3
59	0.6	1.2
60	0.6	1.2
61	0.6	1.1
62	0.5	1.1
63	0.5	1.0
64	0.5	1.0
65	0.5	0.9
66	0.5	0.9
67	0.4	0.9
68	0.4	0.8
69	0.4	0.8
70	0.4	0.8
71	0.4	0.7
72	0.3	0.7
73	0.3	0.7
74	0.3	0.6

Table A-4. Compass Deflection in Degrees for BW2 HVDC Onshore Export Cables with 6.6 ft (2 m) Separated Configuration Evaluated at 3.3 ft (1 m) above the Ground

	Cable Burial Depth (ft)	
Distance from Cable Centerline (ft)	4.4	13
75	0.3	0.6
76	0.3	0.6
77	0.3	0.6
78	0.3	0.6
79	0.3	0.5
80	0.3	0.5
81	0.2	0.5
82	0.2	0.5
83	0.2	0.5
84	0.2	0.4
85	0.2	0.4
86	0.2	0.4
87	0.2	0.4
88	0.2	0.4
89	0.2	0.4
90	0.2	0.4
91	0.2	0.4
92	0.2	0.3
93	0.2	0.3
94	0.2	0.3
95a	0.2	0.3
96	0.1	0.3
97	0.1	0.3
98	0.1	0.3
99	0.1	0.3
100	0.1	0.3

APPENDIX B—INPUT DATA FOR ALTERNATING CURRENT MAGNETIC FIELD AND ELECTRIC FIELD CALCULATIONS

Table B-1. Input Data for BW1 HVAC Onshore Interconnection Cables Magnetic Field and Electric Field Calculations, for a Duct Bank Burial Depth of 8 ft (2.4 m).

Bundle	X (ft)	Y (ft)	Conductor Diameter (in)	Spacing (in)	Current (A)	Voltage Phasing	Ph-Ph Voltage (kV)
1	-5	-10.75	2.5	0	2379	0	138
2	-3	-10.75	2.5	0	2379	120	138
3	-3	-8.75	2.5	0	2379	240	138
4	-12	-10.75	2.5	0	2379	0	138
5	-12	-10.75	2.5	0	2379	120	138
6	-12	-8.75	2.5	0	2379	240	138
7	-3	-10.75	2.5	0	2379	0	138
8	-5	-10.75	2.5	0	2379	120	138
9	-5	-8.75	2.5	0	2379	240	138
10	21.17	-10.75	2.5	0	2379	0	138
11	23.17	-10.75	2.5	0	2379	120	138
12	23.17	-8.75	2.5	0	2379	240	138
13	25.17	-10.75	2.5	0	2379	0	138
14	27.17	-10.75	2.5	0	2379	120	138
15	27.17	-8.75	2.5	0	2379	240	138
16	29.12	-10.75	2.5	0	2379	0	138
17	31.12	-10.75	2.5	0	2379	120	138
18	31.12	-8.75	2.5	0	2379	240	138
19	-31.17	-10.75	2.5	0	2379	0	138
20	-29.17	-10.75	2.5	0	2379	120	138
21	-29.17	-8.75	2.5	0	2379	240	138
22	-27.17	-10.75	2.5	0	2379	0	138
23	-25.17	-10.75	2.5	0	2379	120	138
24	-25.17	-8.75	2.5	0	2379	240	138
25	-23.17	-10.75	2.5	0	2379	0	138
26	-21.17	-10.75	2.5	0	2379	120	138
27	-21.17	-8.75	2.5	0	2379	240	138

Table B-2. Input Data for BW1 HVAC Onshore Interconnection Cables Magnetic Field and Electric Field Calculations, for a Duct Bank Burial Depth of 3 ft (0.9 m).

Bundle	X (ft)	Y (ft)	Conductor Diameter (in)	Spacing (in)	Current (A)	Voltage Phasing	Ph-Ph Voltage (kV)
1	-5	-5.75	2.5	0	2379	0	138
2	-3	-5.75	2.5	0	2379	120	138
3	-3	-3.75	2.5	0	2379	240	138
4	-12	-5.75	2.5	0	2379	0	138
5	-12	-5.75	2.5	0	2379	120	138
6	-12	-3.75	2.5	0	2379	240	138
7	-3	-5.75	2.5	0	2379	0	138
8	-5	-5.75	2.5	0	2379	120	138
9	-5	-3.75	2.5	0	2379	240	138
10	21.17	-5.75	2.5	0	2379	0	138
11	23.17	-5.75	2.5	0	2379	120	138
12	23.17	-3.75	2.5	0	2379	240	138
13	25.17	-5.75	2.5	0	2379	0	138
14	27.17	-5.75	2.5	0	2379	120	138
15	27.17	-3.75	2.5	0	2379	240	138
16	29.12	-5.75	2.5	0	2379	0	138
17	31.12	-5.75	2.5	0	2379	120	138
18	31.12	-3.75	2.5	0	2379	240	138
19	-31.17	-5.75	2.5	0	2379	0	138
20	-29.17	-5.75	2.5	0	2379	120	138
21	-29.17	-3.75	2.5	0	2379	240	138
22	-27.17	-5.75	2.5	0	2379	0	138
23	-25.17	-5.75	2.5	0	2379	120	138
24	-25.17	-3.75	2.5	0	2379	240	138
25	-23.17	-5.75	2.5	0	2379	0	138
26	-21.17	-5.75	2.5	0	2379	120	138
27	-21.17	-3.75	2.5	0	2379	240	138

Table B-3. Input Data for BW1 HVAC Onshore Interconnection Cables Magnetic Field and Electric Field Calculations, For a Triple Circuit Overhead Configuration

Bundle	X (ft)	Y (ft)	Voltage Phasing	Ph-Ph Voltage (kV)	Conductor Diameter (in)	Current (A)
1	-8	23	0	138	1.468	1502
1	-7.5	23	120	138	1.468	1502
2	7.5	23	240	138	1.468	1502
2	8	23	0	138	1.468	1502
3	-7.5	32	120	138	1.468	1502
3	7.5	32	240	138	1.468	1502
4	8	32	0	138	1.468	1502
4	-8	32	120	138	1.468	1502
5	-7.5	41	240	138	1.468	1502
5	7.5	41	0	138	1.468	1502
6	8	41	120	138	1.468	1502
6	-7.5	41	240	138	1.468	1502
7	7.5	50	0	138	1.468	1502
7	8	50	120	138	1.468	1502
8	-8	50	240	138	1.468	1502
8	-7.5	50	0	138	1.468	1502
9	7.5	68	120	138	1.468	1502
9	7.5	68	240	138	1.468	1502

Table B-4. Input Data for BW1 HVAC Onshore Interconnection Cables Magnetic Field and Electric Field Calculations, For a Double Circuit Overhead Configuration

Bundle	X (ft)	Y (ft)	Voltage Phasing	Ph-Ph Voltage (kV)	Conductor Diameter (in)	Current (A)
1	-8	23	0	138	1.468	1502
1	-7.5	23	120	138	1.468	1502
2	7.5	23	240	138	1.468	1502
2	8	23	0	138	1.468	1502
3	-8	32	120	138	1.468	1502
3	-7.5	32	240	138	1.468	1502
4	7.5	32	0	138	1.468	1502
4	8	32	120	138	1.468	1502
5	-8	41	240	138	1.468	1502
5	-7.5	41	0	138	1.468	1502
6	7.5	41	120	138	1.468	1502
6	8	41	240	138	1.468	1502

Table B-5. Input Data for BW1 HVAC Onshore Interconnection Cables Magnetic Field and Electric Field Calculations, For a Single Circuit Overhead Configuration

Bundle	X (ft)	Y (ft)	Voltage Phasing	Ph-Ph Voltage (kV)	Conductor Diameter (in)	Current (A)
1	-8	23	0	138	1.468	1502
1	-7.5	23	120	138	1.468	1502
2	-8	32	240	138	1.468	1502
2	-7.5	32	0	138	1.468	1502
3	-8	41	120	138	1.468	1502
3	-7.5	41	240	138	1.468	1502

Table B-6. Input Data for BW2 HVAC Onshore Interconnection Cables Magnetic Field and Electric Field Calculations, for an Overhead Cable at 22 ft (6.7 m) Above Ground.

Bundle	X (ft)	Y (ft)	Voltage Phasing	Ph-Ph Voltage (kV)	Conductor Diameter (in)	Current (A)
1	-5	22	0	345	1.5	2631
2	0	22	120	345	1.5	2631
3	5	22	240	345	1.5	2631

Table B-7. Input Data for BW2 HVAC Onshore Interconnection Cables Magnetic Field and Electric Field Calculations, For a Triple Circuit Overhead Configuration

Bundle	X (ft)	Y (ft)	Voltage Phasing	Ph-Ph Voltage (kV)	Conductor Diameter (in)	Current (A)
1	-8	23	0	138	1.468	1502
1	-7.5	23	120	138	1.468	1502
2	7.5	23	240	138	1.468	1502
2	8	23	0	138	1.468	1502
3	-7.5	32	120	138	1.468	1502
3	7.5	32	240	138	1.468	1502
4	8	32	0	138	1.468	1502
4	-8	32	120	138	1.468	1502
5	-7.5	41	240	138	1.468	1502
5	7.5	41	0	138	1.468	1502
6	8	41	120	138	1.468	1502
6	-7.5	41	240	138	1.468	1502
7	7.5	50	0	138	1.468	1502
7	8	50	120	138	1.468	1502
8	-8	50	240	138	1.468	1502
8	-7.5	50	0	138	1.468	1502
9	7.5	68	120	138	1.468	1502
9	7.5	68	240	138	1.468	1502

Table B-8. Input Data for BW2 HVAC Onshore Interconnection Cables Magnetic Field and Electric Field Calculations, For a Double Circuit Overhead Configuration

Bundle	X (ft)	Y (ft)	Voltage Phasing	Ph-Ph Voltage (kV)	Conductor Diameter (in)	Current (A)
1	-8	23	0	138	1.468	1502
1	-7.5	23	120	138	1.468	1502
2	7.5	23	240	138	1.468	1502
2	8	23	0	138	1.468	1502
3	-8	32	120	138	1.468	1502
3	-7.5	32	240	138	1.468	1502
4	7.5	32	0	138	1.468	1502
4	8	32	120	138	1.468	1502
5	-8	41	240	138	1.468	1502
5	-7.5	41	0	138	1.468	1502
6	7.5	41	120	138	1.468	1502
6	8	41	240	138	1.468	1502

Table B-9. Input Data for BW2 HVAC Onshore Interconnection Cables Magnetic Field and Electric Field Calculations, For a Single Circuit Overhead Configuration

Bundle	X (ft)	Y (ft)	Voltage Phasing	Ph-Ph Voltage (kV)	Conductor Diameter (in)	Current (A)
1	-8	23	0	138	1.468	1502
1	-7.5	23	120	138	1.468	1502
2	-8	32	240	138	1.468	1502
2	-7.5	32	0	138	1.468	1502
3	-8	41	120	138	1.468	1502
3	-7.5	41	240	138	1.468	1502

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