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Deepwater Wind South Fork Wind Farm

Offshore Electric and Magnetic Field Assessment

Exponent
Engineering P.C.

Deepwater Wind South Fork Wind Farm

Offshore Electric and Magnetic Field Assessment

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Acronyms and Abbreviations

µV/m	Microvolts per meter
A	Amperes
AC	Alternating Current
DWSF	Deepwater Wind South Fork, LLC
EMF	Electric and magnetic fields
Exponent	Exponent Engineering, P.C.
G	Gauss
HDD	Horizontal directional drilling
Hz	Hertz
ICES	International Committee on Electromagnetic Safety
ICNIRP	International Commission on Non-Ionizing Radiation
IEEE	Institute of Electrical and Electronics Engineers
kV	Kilovolt
LIPA	Long Island Power Authority
mG	Milligauss
mm	Millimeter
mT	millitesla
mV/m	millivolts per meter
MW	Megawatt
NYPSC	New York Public Service Commission
ROW	Right of way
SFWF	South Fork Wind Farm
SFEC	South Fork Export Cable
SFEC-OCS	South Fork Export Cable on the Outer Continental Shelf
SFEC-NYS	South Fork Export Cable in New York State territorial waters
SFEC-Onshore	South Fork Export Cable on land
SNC-Lavalin Inc.	SNC-Lavalin
WNC	Winter normal conductor

Limitations

At the request of SNC-Lavalin Inc. (SNC-Lavalin) and Deepwater Wind South Fork, LLC, Exponent Engineering, P.C. (Exponent) modeled anticipated magnetic-field levels from the submarine transmission lines proposed for this Project.

This report summarizes the analysis performed to date and presents the findings resulting from that work. In the analysis, we have relied on transmission line design geometry, usage, specifications, and various other types of information provided by SNC-Lavalin. We cannot verify the correctness of this input data, and rely on the SNC-Lavalin for the data's accuracy. Although Exponent has exercised usual and customary care in the conduct of this analysis, the responsibility for the design and operation of the Project remains fully with the client. SNC-Lavalin has confirmed to Exponent that the data contained herein are not subject to Critical Energy Infrastructure Information restrictions.

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

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

Benjamin R.T. Cotts, Ph.D., P.E. (Licensed Electrical Engineer, California, #21277) and Kevin L. Graf, Ph.D., P.E. (Licensed Electrical Engineer, California, #21433), both employed by Exponent performed calculations of the magnetic and electric fields associated with the operation of the proposed Project. Joshua Phinney, Ph.D., P.E. (New York P.E., License No. 084129), also employed by Exponent, has reviewed this work.

Reviewed By:

Joshua Phinney, P.E.

Executive Summary

At the request of SNC-Lavalin Inc. and Deepwater Wind South Fork, LLC, Exponent modeled the magnetic fields and induced electric fields anticipated to be produced during operation of submarine transmission lines that are proposed to convey electricity generated by the South Fork Wind Farm to the East Hampton Substation. The modeling included the magnetic field from the submarine 34.5-kilovolt (kV) inter-array cables running between individual turbines and to an offshore substation and from the offshore 138-kV South Fork Export Cable between the proposed offshore substation and the coast of Long Island in Suffolk County, New York.

The proposed transmission lines were modeled for line loadings equal to the winter normal conductor (WNC) ratings as well as the assumed maximum 132-megawatt output of the wind farm turbines. The electric field from the submarine transmission cables is blocked by the cable armoring as well as the earth and therefore will not be a direct source of any electric field outside the cables. The oscillating magnetic field, however, will induce a small electric field in the nearby seawater and marine organisms. These fields were assessed for potential effects on key migratory marine species that inhabit the vicinity of the Project.

Modeling results under WNC conditions confirm that the maximum magnetic fields at 1 meter above the seabed are below 200 milligauss everywhere along the offshore portion of the Project and thus comply with the magnetic-field guidelines of the New York State Public Service Commission. Calculated magnetic-field levels are further found to be below reported thresholds for effects on the behavior of magnetosensitive fish, and calculated induced electric-field levels are found to be below reported detection thresholds of local electrosensitive fish.

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

Introduction

Project Description

Deepwater Wind South Fork, LLC (DWSF) proposes to construct the offshore South Fork Wind Farm (SFWF) assuming a maximum output of up to 132 megawatt (MW). It is assumed in this analysis that electricity will be generated by up to 15 offshore wind turbines and will be carried at a voltage of 34.5 kilovolts (kV) over inter-array cables to an offshore substation where the voltage will be converted to 138 kV. At this voltage, the electricity will be carried to land via the South Fork Export Cable (SFEC), where it will transition to an underground duct bank then to an onshore substation. At the onshore substation, voltage will be converted down to 69 kV to be carried to the existing Long Island Power Authority (LIPA) East Hampton Substation.

This report presents analysis of the offshore portion of the proposed route including the inter-array cable, the SFEC on the Outer Continental Shelf (SFEC-OCS) as well as the portion of the SFEC in New York State territorial waters (SFEC-NYS). The assessment of the magnetic fields from the onshore 138-kV and 69-kV underground cables (SFEC-Onshore cables) connecting the Project to the existing LIPA East Hampton Substation is provided in the companion report titled Deepwater Wind South Fork Wind Farm Onshore Electric and Magnetic Field Assessment.

At the request of SNC-Lavalin Inc. (SNC-Lavalin) and DWSF, Exponent Engineering P.C. (Exponent) modeled the 60-Hertz (Hz) magnetic field for four configurations of the offshore transmission cables. An overview of the offshore route showing the location of the short 34.5-kV inter-array cables and the longer 61-mile 138-kV offshore portion of the export cable is shown in Figure 1.

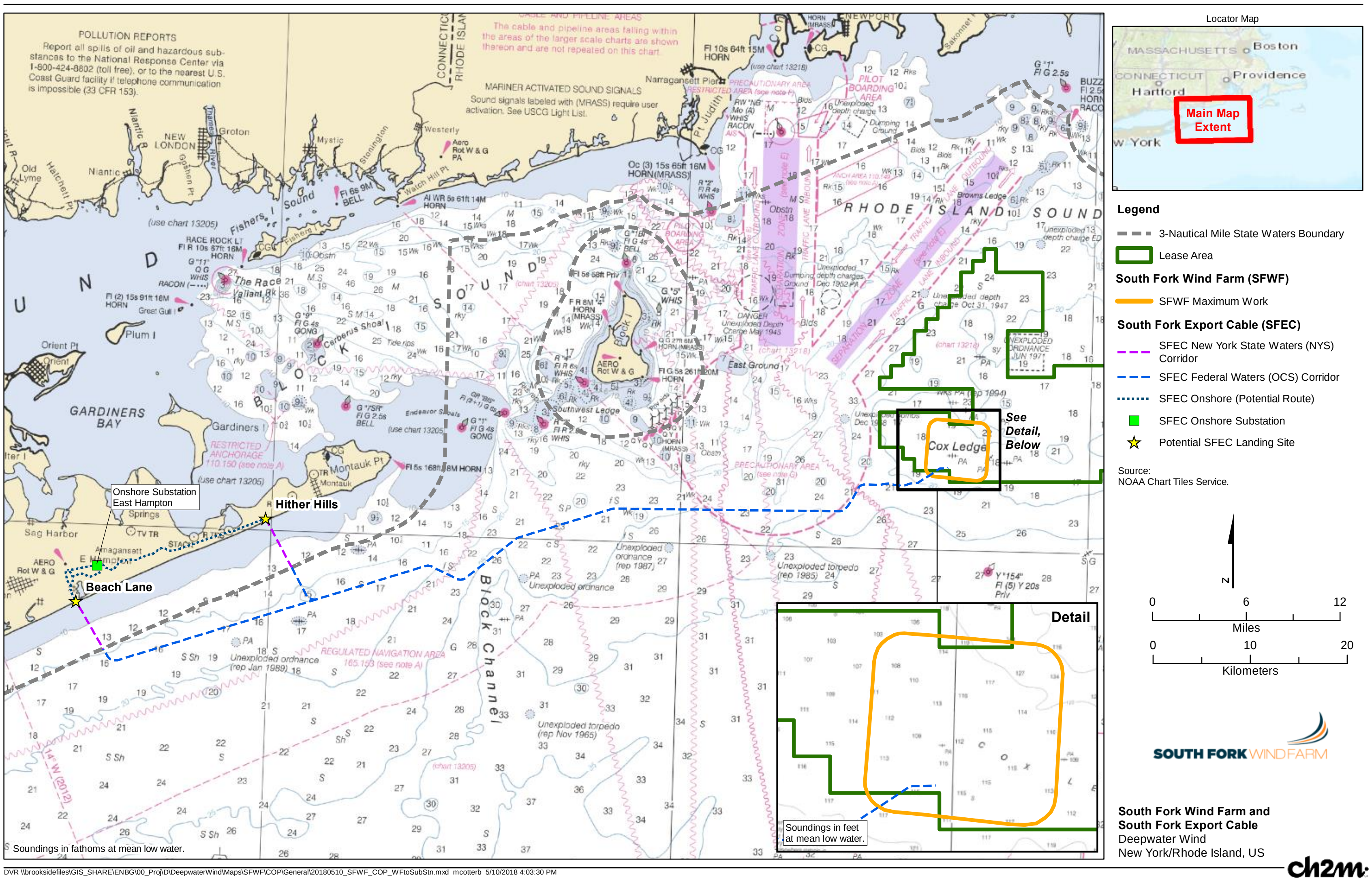

Figure 1. Overview of the proposed route of the SFEC.

Electric and Magnetic Fields

Like all wiring and equipment connected to the electrical system, the electric and magnetic fields (EMF) surrounding cables associated with the SFWF will oscillate at a frequency of 60 Hz. The magnetic field results from the flow of electricity along the cable and the magnetic flux density is reported in units of milligauss (mG), where 1 Gauss (G) = 1,000 mG. The magnetic field will be strongest at the surface of the cable and will decrease rapidly with distance from the cable. An electric field is created by the voltage applied to the conductors within the cable, but this electric field is entirely shielded from the marine environment by grounded metallic sheaths and steel armoring around the cable. The oscillating nature of the 60-Hz magnetic field, however, will induce a weak electric field around the cable that, similar to the magnetic field, will vary in strength based on the flow of electricity along the cable. This induced electric field is measured in units of millivolts per meter (mV/m).

Since load currents—expressed in units of amperes (A)—generate magnetic fields and induced electric fields around the conductors, measurements or calculations of these fields present a snapshot for the load conditions at only one moment in time. On a given day, throughout a week, or over the course of months or years, the field levels can change depending upon the power generated by the turbines, which depends on wind speed and operational status. One way to address the potential variability of this load is to perform calculations for the maximum output of the wind farm (assumed at 132 MW), which provides the maximum magnetic field expected for the proposed Project. The state of New York also requires that calculations of magnetic fields from transmission lines be performed for line loadings at the winter normal conductor (WNC) rating of the transmission line cable, which provides the maximum magnetic field that can be sustained continuously by the conductors.[1] Each of these two loading scenarios, 132 MW output of the SFWF and WNC rating of the cables, were used to calculate magnetic fields in this report.

[1] In contrast, a short-term emergency or long-term emergency rating of the cable may allow larger levels of current to pass through the cable, but this can occur only for a limited duration before the cable becomes damaged.

Relevant Standards

New transmission lines constructed in the state of New York operating at voltages above 100 kV must comply with the interim EMF limits published by the New York Public Service Commission (NYPSC). The magnetic field limit at the edge of the right of way (ROW) is 200 mG when modeled at WNC rating of the conductors (NYPSC, 1978, 1990).[2,3]

While the possibility of persons coming into close proximity to the transmission lines is limited to those who may be scuba diving at the seabed, in addition to the NYPSC limits, two international organizations provide guidance on human exposure to magnetic fields. This guidance is the result of extensive review and evaluations of relevant research of health and safety issues, and the limits they propose are designed to protect health and safety of persons in an occupational setting and for the general public. The International Committee on Electromagnetic Safety (ICES), which operates "under the rules and oversight of the Institute of Electrical and Electronics Engineers (IEEE) Standards Association Board,"[4] developed a maximum permissible exposure limit to magnetic fields of 9,040 mG for the general public. The International Commission on Non-Ionizing Radiation (ICNIRP), an independent organization that provides scientific advice and guidance on the health and environmental effects of non-ionizing radiation, determined a reference level limit for whole-body exposure to 60-Hz magnetic fields at 2,000 mG (ICES, 2002/2005, ICNIRP, 2010).

Marine Resources

In addition to the NYPSC EMF limits and those related to human exposure to EMF, EMF is also of environmental and ecological interest because of research showing that some marine species have specialized sensory receptors that are capable of detecting magnetic fields, electric fields, or both in the natural environment. Generally, fields detected by marine organisms include the static magnetic field of the earth (frequency of 0 Hz), the near 0-Hz electric fields

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2 The NYPSC also requires a not-to-exceed electric-field limit at the ROW edge of new transmission lines of 1.6 kilovolts per meter. Since the electric field from the submarine and underground transmission cables is blocked by the cable shielding as well as the earth, the Project will not be a direct source of any electric field.

3 Where no ROW is defined, the 200 mG limit applies at a distance of 50 feet from the centerline of transmission lines with a voltage of less than 230 kV

4 http://www.ices-emfsafety.org/

produced by ocean currents and fish movement in the earth's static magnetic field, and the electric fields produced by biological processes of fish with frequencies from 0 to about 10 Hz (Bedore and Kajiura, 2013). A more detailed assessment of EMF related to marine species is included later in this report.

Modeling Methodology and Assumptions

To evaluate the capability of such marine species to detect and respond to cable-generated magnetic fields and induced electric fields, Exponent calculated the 60-Hz fields from the proposed export cable at maximum theoretical loadings (using parameters specified in the permitting design and conservative modeling assumptions that overestimate the field levels measured after construction). Based on these data, the electric fields induced in seawater and in key electrosensitive marine species were calculated and compared with relevant detection thresholds.

Description of Offshore Cable Configurations

The proposed transmission line between the Project and the LIPA East Hampton Substation will consist of four offshore configurations. There are two primary offshore configurations, one for the 34.5-kV inter-array cable and one for the 138-kV SFEC.[5] Both the inter-array and SFEC are three-core cables with all three phase conductors contained within a single large cable. A cross-sectional drawing indicating the various components and dimensions of the offshore inter-array and SFEC cables is shown in Appendix A, Figure A-1.

The target burial depth of both cables is a nominal depth of 6 feet beneath the seabed, although where it is impossible to bury it (such as cable or pipeline crossings or where bedrock is encountered), the cable may lie upon the surface of the seabed for short areas. In these cases, the cables may self-bury in fine sediments to some extent; however, it is anticipated that these portions of the cable where burial depth is not achieved will be covered with protective concrete mattresses. These concrete mattresses can vary in thickness from 150 millimeters (mm) (~6 inches) to 229 mm (~9 inches). For the purposes of this study, the minimum thickness of 150 mm was assumed for modeling. These mattresses will not attenuate the calculated magnetic fields; their only effect on the magnetic-field calculations is in effectively changing the cable

[5] The Project is presently in the permitting phase. Modeling configuration information provided by SNC-Lavalin is considered preliminary and may be subject to change. If alternative higher voltage levels are considered for the export or inter-array cables, calculated magnetic-field levels and induced electric-field levels would be similar to or lower than values presented in this report assuming other aspects of the configuration (cable geometry, power levels, etc.) remain unchanged.

burial depth to 150 mm. The magnetic-field levels of the offshore inter-array and SFEC cable therefore are calculated both at the deeper range of the target burial depth (6 feet) as well as for the surface-laid configuration with a 150 mm-thick covering.

At the sea-to-shore landing of the 138-kV SFEC, the SFEC will be installed via horizontal directional drilling (HDD). As shown in Appendix A, Figure A-2, burial depth over this portion of the route is expected to be significantly greater than in other portions of the route, with most of the HDD at least 30 feet beneath the seabed and beach and a maximum of about 60 feet beneath the dunes. The three-core cable will connect to an underground transition vault onshore where it will be spliced to the three single-core 138-kV SFEC-Onshore cables that continue to the new onshore substation. Over the last 100 to 200 feet before entering the transition vault, the burial depth decreases to a minimum of approximately 7 feet. The magnetic-field level from the cable at ground level will be much lower over the HDD portion of the cable due to the greater burial depth.

Table 1. Summary of offshore modeling configurations

Configuration	1a	1b	2a	2b
Description	SFEC		Inter-Array Cable	
Voltage (kV)	138		34.5	
Loading at 132 MW Output (A)	706		708	
Loading at WNC Rating (A)	755		723	
Cable Type	3-core, 8.47" OD		3-core, 6.18" OD	
Conductor	3 x 2000 MCM		3 x 1600 MCM	
Installation Type	Buried	Surface-laid (Mattress Covered)	Buried	Surface-laid (Mattress Covered)
Burial Depth (to top of cable/duct bank)	6-feet	Mattress (150 mm)	6-feet	Mattress (150 mm)
Height of evaluation	Seabed and 1 meter above seabed			
Minimum ROW Width (feet)	No formal ROW; evaluated at ±50 feet*.			

* Consistent with the NYPSC Statement of Interim Policy on Magnetic Fields of Major Electric Transmission Facilities under Article VII (NYPSC, 1990).

Magnetic Field

SNC-Lavalin provided data to Exponent regarding the preliminary cable and duct bank design, as well as the loading for each proposed transmission line configuration. These input data are included in Appendix B. From these data, Exponent developed models of the four offshore configurations of the cables for computation of the magnetic fields. The magnetic fields were calculated from the current flow, phasing, and conductor configurations. The magnetic-field levels offshore were calculated at the seabed surface, as well as at a height of 1 meter (3.28 feet) above the seabed, in accordance with IEEE Std. 0644-1994 and IEEE Std. C95.3.1-2010 (IEEE, 1994, 2010). Consistent with the NYPSC Statement of Interim Policy on Magnetic Fields of Major Electric Transmission Facilities under Article VII (NYPSC, 1978, 1990), magnetic-field levels are reported in units of mG as the maximum root-mean-square flux density value.

Magnetic-field levels were calculated using computer algorithms developed by the Bonneville Power Administration, an agency of the U.S. Department of Energy (BPA, 1991). These algorithms have been shown to accurately predict magnetic fields near overhead and underground transmission lines but are expected to overestimate the magnetic-field levels from the offshore cables.

All magnetic-field calculations are made assuming that the conductors of the transmission line are parallel to one another and infinite in extent. Additionally, the models assume that there is no attenuation of magnetic fields from any surrounding material (e.g., seabed, earth, grout mattresses, etc.) and that there are no unbalanced currents flowing along the outer sheaths of the cables. Finally, the effect of the cable armoring (ferromagnetic shielding and induced eddy currents) to reduce the magnetic field outside the cable was not included. These modeling assumptions were made to ensure that the calculated magnetic-field levels will overestimate the actual field level at any specified loading.

The cable armoring will reduce the magnetic-field level outside the cable due to ferromagnetic shielding (flux shunting) as well as eddy currents. The magnitude of attenuation is determined by the specific design of the cable as well as its magnetic permeability (i.e., higher permeability will attenuate the magnetic field by shunting). The eddy currents induced in conductive sheathing materials will also reduce magnetic-field levels outside the cable by creating a magnetic field that partially cancels the magnetic field from the conductors within the cable. A previous study has shown that flux shunting accounted for an almost 2-fold reduction in the magnetic field, with a much smaller reduction attributable to eddy currents (Silva, 2006). In addition, for the offshore SFEC three-core cables, the three conductors are helically twisted inside the cable during manufacturing. This helical twisting of the conductors further increases the mutual cancellation of the magnetic fields from each of the three conductors and field levels decrease more rapidly with distance, resulting in further reduction in the magnetic field (Pettersson and Schönborg, 1997).

Induced Electric Field in Seawater

While the electric field created by the voltage applied to the conductors within the transmission line cables is entirely shielded by grounded metallic sheaths and steel armoring around each cable, the oscillating magnetic fields will induce a small electric field in the seawater. These induced electric fields may be detectable by certain electrosensitive marine organisms. The electric-field levels induced in seawater are calculated with finite element analysis simulations in COMSOL Multiphysics 5.3a using material properties summarized in Table 2. The simulated cable configurations are identical to those discussed above for the magnetic-field calculations. We again assume there is no unbalanced sheath current, no field reduction from the cable armoring, and no effect due to the helical twisting of the conductors. These modeling assumptions are made to ensure that the calculated field levels will overestimate the actual field level for a given loading.

Table 2. Material properties used for calculating induced 60-Hz electric field levels in seawater

Material	Conductivity (S/m)	Relative Permittivity	Relative Permeability	Reference
Seawater	5	72	1	Chave et al., 1990; Somaraju and Trumpf, 2006
Seabed	1.1	30	1	Chave et al., 1990; Hulbert et al., 1992; Cihlar and Ulaby, 1974
Concrete	0.04	200	1	Wilson, 1986

Induced Electric Fields in Marine Organisms

In addition to the ambient EMF produced by the operating 60-Hz submarine cable, the oscillating magnetic field will induce a weak electric field within the body of a marine organism. These electric fields may be detectable by certain electrosensitive marine organisms. As such, the magnitude of the electric field induced in marine organisms swimming over the offshore cable segments can be calculated by modeling key species as homogeneous ellipsoids. In general, a larger electric field will be induced in a larger animal. However, the specific detection thresholds for electrosensitive species are also important in determining the likelihood that a specific species will be capable of detecting and responding to the 60-Hz cable.

Calculated values of magnetic and induced electric fields from the offshore cable segments are presented in the section below.

Model Results

Calculated Magnetic-Field Levels

The results of the magnetic-field modeling for a 6-foot burial depth at the assumed maximum output of the SFWF are shown below in Figure 2 and Figure 3 for the export cable and inter-array cable, respectively. A summary of calculated magnetic-field levels at the seabed is shown in Table 3. Complete output results for magnetic-field calculations for both the 6-foot burial and mattress-covered configurations are provided in Appendix C, including results at the assumed maximum output of the SFWF and the WNC rating.

At the assumed maximum output (132 MW) of the SFWF, the calculated magnetic-field levels are 30 mG or less at the seabed and 13 mG or less at 1 meter above the seabed for sections with a 6-foot burial depth. If the SFWF could exceed its rated capacity, then magnetic-field levels would be slightly higher (1 to 2 mG higher) because the capacity of the cable at WNC rating is slightly higher than the capacity of the windfarm (see Appendix C). Over small areas where the cables may potentially be laid on the seabed and covered by protective mattresses, the magnetic-field levels would be higher, but would decrease very quickly with distance. For distances beyond 25 feet from the cable centerline, the magnetic-field levels calculated for the mattress-covered configuration fall to within <0.5 mG of the fields calculated when the SFEC is buried to a depth of 6 feet.

At the SFEC sea-to-shore transition where HDD will be used the magnetic-field levels are calculated to be far lower than elsewhere along the route due to the very deep burial depth of the cable (see Appendix A, Figure A-2). The maximum calculated magnetic-field level at WNC loading (directly above the HDD cable) is 0.3 mG at a burial depth of 62 feet, 1.8 mG at a burial depth of 22 feet, and 11 mG at a burial depth of 7 feet.

Table 3. Modeled magnetic-field level (mG) at the seabed for assumed maximum output (132 MW) of the SFWF

Section	Burial Depth	Loading	–75 feet	–50 feet	–25 feet	Max	+25 feet	+50 feet	+75 feet
SFEC	6 feet	132 MW	0.2	0.5	1.8	30	1.8	0.5	0.2
Inter-Array Cable	6 feet	132 MW	0.1	0.3	1.2	21	1.2	0.3	0.1

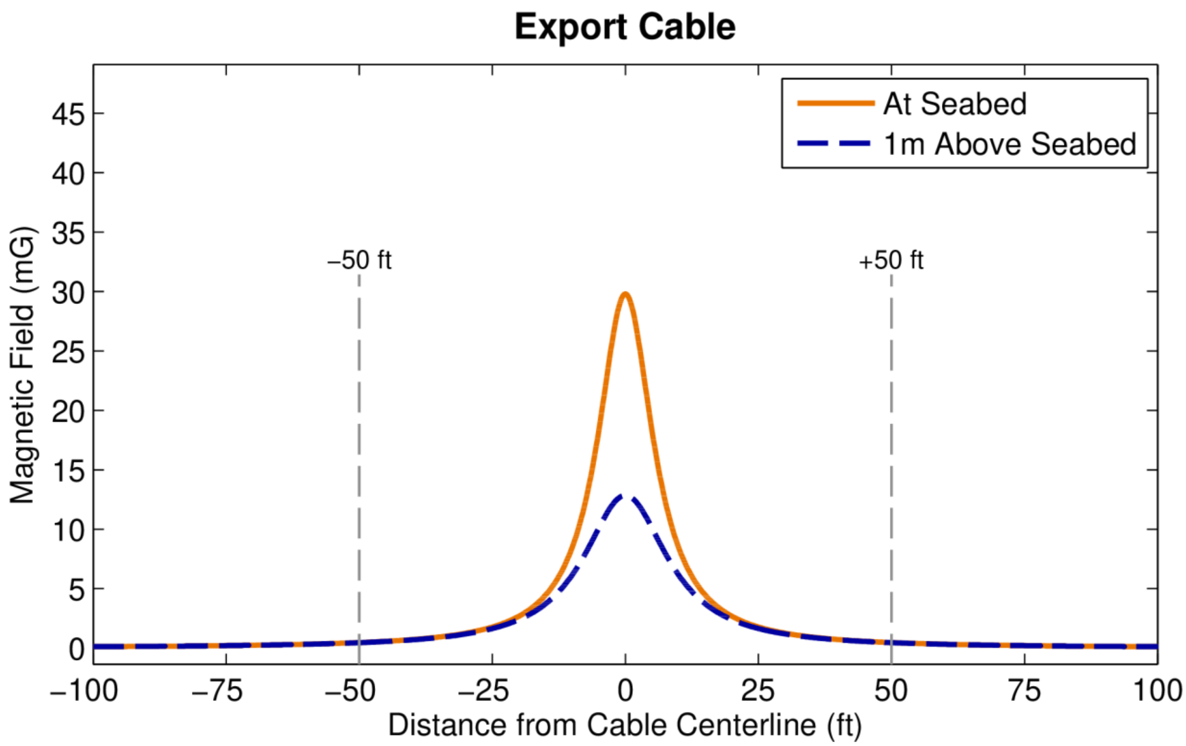

Figure 2. Magnetic-field levels for the 138-kV export cable at assumed maximum output (132 MW) of the SFWF.

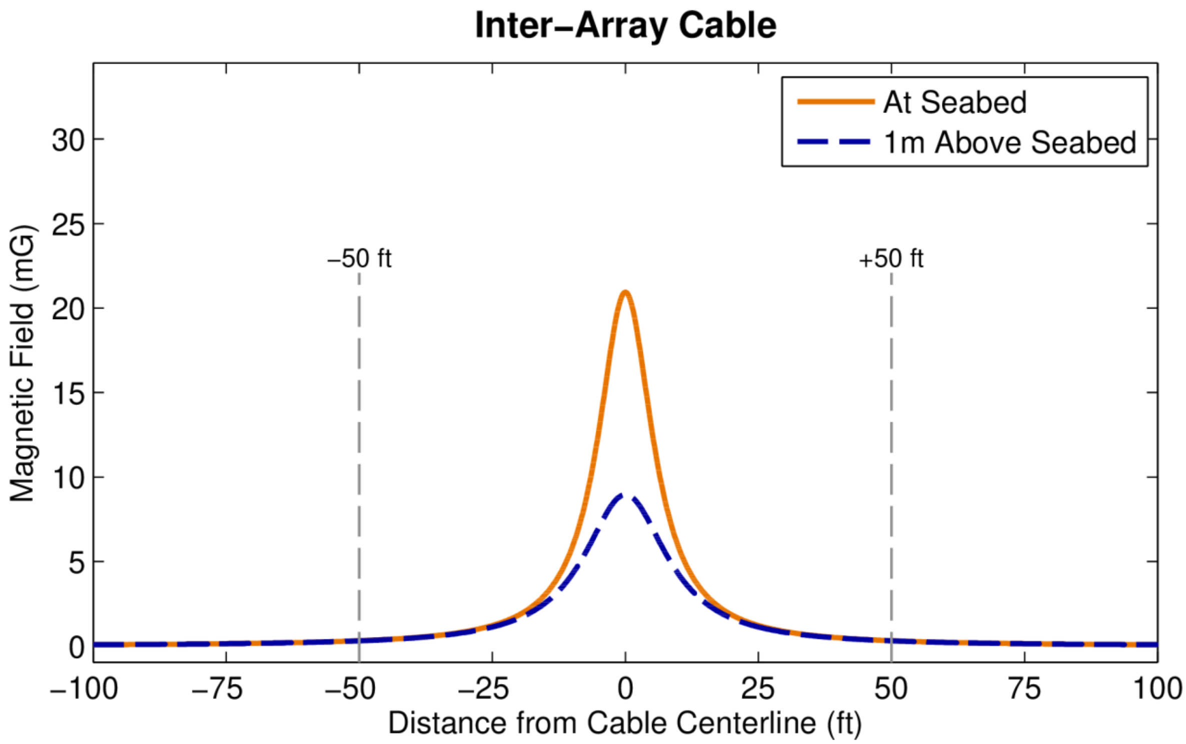

Figure 3. Magnetic-field levels for the 34.5-kV inter-array cable at assumed maximum output (132 MW) of the SFWF.

Calculated Induced Electric Field Levels in Seawater

The electric-field induced in seawater is shown below in Figure 4 and Figure 5 for the 6-foot burial depth portions of the SFEC and inter-array cable, respectively. A summary of electric-field levels at the seabed is shown in Table 4. The calculated electric-field levels are 2.1 mV/m or less at the seabed and 1.4 mV/m or less at 1 meter above the seabed where sections of the cable are buried at 6 feet. If over short distances the cables must be surface laid and covered by protective mattresses, the electric-field levels would be higher (17 mV/m or less at the seabed and 3.2 mV/m or less 1 meter above the seabed), but would decrease very quickly with distance; within 25 feet of the centerline, the calculated electric-field levels fall to <0.1 mV/m of the electric-field at the 6-foot burial depth.

Table 4. Modeled induced electric-field levels (mV/m) in seawater at the seabed for assumed maximum output (132 MW) of the SFWF

Section	Burial Depth	Loading	–75 feet	–50 feet	–25 feet	Max	+25 feet	+50 feet	+75 feet
Export Cable	6 feet	132 MW	0.2	0.3	0.5	2.1	0.5	0.2	0.1
Inter-Array Cable	6 feet	132 MW	0.1	0.2	0.4	1.4	0.3	0.1	0.1

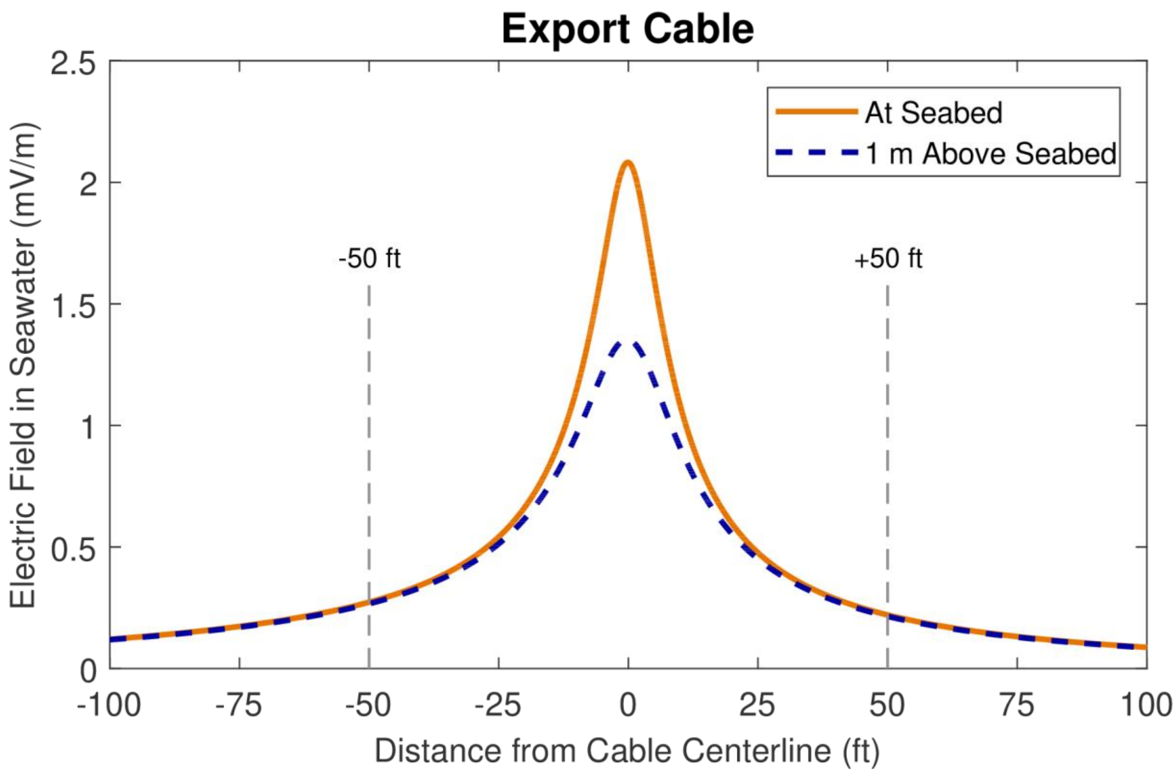

Figure 4. Electric-field levels in seawater for the SFEC 138-kV export cable at assumed maximum output (132 MW) of the SFWF.

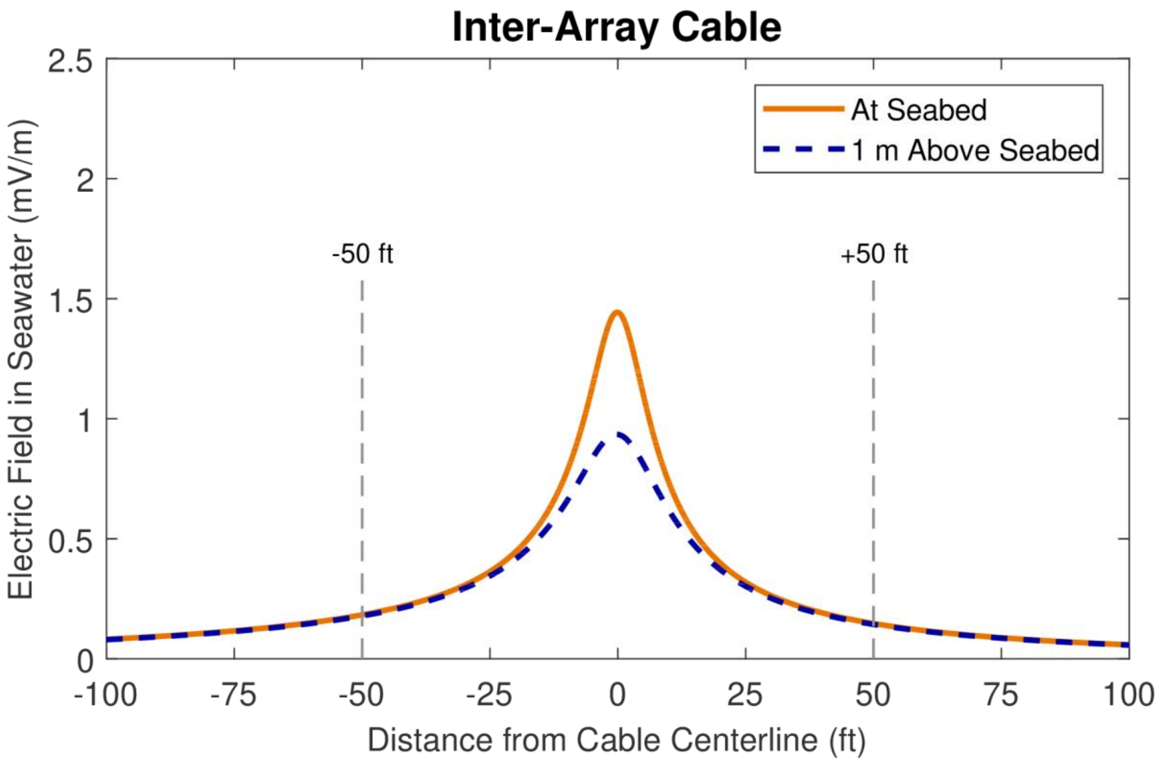

Figure 5. Electric-field levels in seawater for the 34.5-kV inter-array cable at assumed maximum output (132 MW) of the SFWF.

Calculated Induced Electric Field Levels in Marine Organisms

The results of the electric field induced in marine organisms for a 6-foot burial depth at the assumed maximum output of the SFWF are summarized below in Table 5. The calculated electric-field levels induced in marine organisms are 0.48 mV/m or less. Calculated electric-field levels induced in each marine organism scale linearly with the magnetic-field level and will therefore decrease rapidly with distance from the cables; within 25 feet of the centerline, calculated electric-field levels in marine organisms at the seabed fall to less than 10% of these highest levels.

Table 5. Modeled induced electric-field levels (mV/m) in marine organisms for assumed maximum output (132 MW) of the SFWF

Section	Burial Depth	Loading	Location	Atlantic Sturgeon	Dogfish	Sand Tiger Shark
SFEC	6 feet	132 MW	At Seabed	0.34	0.19	0.48
			1 meter Above Seabed	0.15	0.08	0.20
Inter-Array Cable	6 feet	132 MW	At Seabed	0.24	0.13	0.33
			1 meter Above Seabed	0.10	0.06	0.14

Description of Bony Fish Species in Project Area and Exposure to EMF

The Project area is characterized by a robust fish community, composed of a diversity of demersal and pelagic fish (Appendix D, Table D-1). Based on available information, adult and juvenile life stages of more than 20 species of demersal fish utilize some portion of the offshore Project area where the SFWF and cables will be located. This group includes commercially important species, such as cod, halibut, red hake, striped bass, and flounder, as well as key prey species like sand eel. In addition, some commercially important pelagic fish species have been observed to inhabit the Project area, including alewife, menhaden, mackerel, tuna and butterfish. The Atlantic sturgeon, is protected under the Endangered Species Act, and several other species are designated as Species of Concern by the National Oceanic and Atmospheric Administration for the greater Atlantic region, including alewife (*Alosa pseudoharengus*), Atlantic bluefin tuna (*Thunnus thynnus*), Atlantic halibut (*Hippoglossus hippoglossus*), and blueback herring (*Alosa aestivalis*)[6].

Bony fish species expected to inhabit the SFWF project area use different habitats throughout their range and life cycles, such as sea grass beds, rocky structures, mussel beds, sandy or gravel substrates, or open surface waters. Given that these habitat types are not all present in the Project area, some fish species may not be found within the Project area regularly throughout the year. Furthermore, some fish species live in deeper water and so, frequently reside in habitats outside the Project area. As such, populations of different bony fish species will encounter the Project site and Project EMF with different regularity, depending on their behaviors, distributions, and preferred habitats.

Appendix D, Table D-1, contains a list of key bony fish species known to inhabit the SFWF area, along with important information regarding their behavior, distribution, and size.

[6] https://www.greateratlantic.fisheries.noaa.gov/protected/pcp/soc/index.html

Magnetosensitivity and Electrosensitivity

A broad range of fish species, including salmonids, tuna, herrings, carp, and mackerel, contain small particles of magnetite, a strongly magnetic and naturally-occurring mineral, in their bones and organs (Harrison et al., 2002). Magnetite particles are considered to be a key component of receptors that allow fish to utilize the earth's geomagnetic fields as an environmental cue (Hanson and Westerberg, 1987; Walker et al., 1998; Öhman et al., 2007; Tanski et al., 2011); this ability is of particular value to fish species that undergo long and targeted migrations. It is thought that geomagnetic cues are utilized in combination with other cues, such as temperature, light, current strength and direction, and olfactory signals, to assist in the location of spawning sites and other key habitats. Hence, magneto-sensitive fish are uniquely attuned to detect changes in the geomagnetic field as a common environmental cue.

Yet, as previously noted, the earth's geomagnetic field (0 Hz) is different than the AC fields produced by 60-Hz submarine cables. For many of these species, it is not clear if exposure to EMF levels at a frequency of 60 Hz from such cables is associated with biological impacts, since the necessary research has not been conducted on the many thousands of ocean fish species. Given that magnetic field responses, however, have been studied for species that are representative of a wide range of fish species, it is reasonable to assume that such responses, where observed, would be similar to those reported for other non-tested fish species, given that the environmental cue to which this diverse group of fishes are responding (the geomagnetic field) is the same.

In addition, certain categories of fish including sturgeon (family Acipenseridae) and the related paddlefish (family Polyodontidae) exhibit unique and sensitive electroreceptors called ampullae of Lorenzini on the snout and gills, which allow for the detection of electric-fields down to 500 microvolts per meter (µV/m) (Bouyoucos et al., 2013). These species are therefore capable of detecting and responding to variations in the ambient electric field produced by potential prey. Because of this ability, sturgeon species have been reported to respond to low frequency alternating current (AC) electric signals (Gill et al., 2012).

Development of Species Groups

In order to assess the potential for different bony fish species to encounter Project-associated EMF, the identified species were grouped into different categories based on the behaviors and habits that influence the likelihood of contacting the cable route. First, species were separated into demersal/benthic and pelagic habitat preferences. Since the strongest magnetic fields produced by submarine cables occur in close proximity to the cable and decrease rapidly with distance, the areas of greatest exposure are largely constrained to a few meters around the cable route. Therefore, researchers have reported that demersal, bottom-dwelling species, are most likely to be exposed to the strongest magnetic field intensities (Bull and Helix 2011, Love et al. 2015). For this reason, many pelagic and epipelagic fish species, especially those with broad or oceanic distributions, are not expected to encounter the project cable routes with the same frequency as a demersal species with the same distributions; hence, bony fish species were separated into "demersal" and "pelagic" groups (i.e., those that live in close contact with the sea bottom and those that inhabit the water column). Then, species within these groups were assessed for the likelihood that individuals would regularly reside within the Project area. This was based on both range and general habitat preferences reported for bony fish species; for instance, a species that most commonly inhabits nearshore habitats is more likely to encounter EMF from a cable than a species that prefers far offshore oceanic habitats along the edge of the continental shelf and deeper.

Another criterion considered was evidence of migratory behaviors, given that migration within the marine environment is accomplished by an integration of multiple cues, including perception of the geomagnetic field for some species. Hence, researchers have commonly investigated whether the migratory species that use such geomagnetic cues might be confounded by the magnetic fields produced by submarine cables, which might result in disrupted migration and fragmented populations. Many of the bony fish species identified as inhabiting the Project area exhibit migratory behaviors.

Based on the above considerations, bony fish were categorized into the following four groups:

- Group 1: Nearshore demersal bony fish—Atlantic sturgeon, cunner (*Tautogolabrus adspersus*), monkfish (*Lophius americanus*), red hake (*Urophycis chuss*), sand lance (*Ammodytes americanus*), striped bass (*Morone saxatilis*) , summer flounder (*Paralichthys* *dentatus*), windowpane flounder (*Scophthalmus aquosus*), winter flounder (*Pseudopleuronectes americanus*), and yellowtail flounder (*Limanda ferruginea*);

- Group 2: Nearshore pelagic bony fish—alewife, American eel (*Anguilla rostrata*), American shad (*Alosa sapidissima*), Atlantic bonito (*Sarda sarda*), Atlantic menhaden (*Brevoortia tyrannus*), blueback herring, bluefish (*Pomatomus saltatrix*), spot (*Leiostomus xanthurus*), and weakfish (*Cynoscion regalis*);

- Group 3: Broadly distributed demersal bony fish—Atlantic halibut, black sea bass (*Centropristis striata*), haddock (*Melanogrammus aeglefinus*), ocean pout (*Macrozoarces americanus*), pollock (*Pollachius virens*), scup (*Stenotomus chrysops*), sea raven (*Hemitripterus americanus*), tautog (*Tautoga onitis*), tilefish (*Lopholatilus chamaeleonticeps*), whiting (*Merluccius bilinearis*), and wolffish (*Anarhichas lupus*);

- Group 4: Broadly distributed pelagic bony fish-- albacore tuna (*Thunnus alalunga*), American plaice (*Hippoglossoides platessoides*), Atlantic mackerel (*Scomber scombrus*), bluefin tuna, butterfish (*Peprilus triacanthus*), conger eel (*Conger oceanicus*), skipjack tuna (*Katsuwonus pelamis*), and yellowfin tuna (*Thunnus albacares*)

Evidence from laboratory studies concerning the specific behavioral and physiological effects of 50/60-Hz EMF, as well as field data from 50/60-Hz AC submarine cables and associated wind farms were assessed for the above species groupings. The sensitivities of sturgeon, eel, and salmon to AC magnetic fields have been previously investigated and reported in the scientific literature.

Given the limitations of laboratory facilities and the difficulty of maintaining many fish species in laboratory conditions, it has not been feasible to test the effects of EMF on many of the fish species of interest. Furthermore, much of the scientific research regarding the effects of EMF on fish has focused on static magnetic fields that mimic the earth's geomagnetic field; such research cannot be utilized to predict fish responses to EMF produced by an AC source. The available research on AC EMF, however, does present a range of effects and response thresholds for a diverse group of fish, and this can be used to predict the likely responses and response thresholds of magnetosensitive fish. The commonality of the environmental cue (the geomagnetic field) means that the sensory detection mechanisms developed over eons across a wide range of fish species are expected to result in a narrow and highly conserved range of detection thresholds and responses. In addition to data from laboratory studies, field studies at offshore wind farm and submarine cable sites provide additional information on potential effects to fish populations, including flounder, hake, eel, and herring species.

Only a single bony fish species in the project area, Atlantic sturgeon, has been identified as electrosensitive; hence, the sensory capability of this species to detect electric fields was compared to the calculated levels of electric field induced in sea water and fish.

Evaluation of EMF Exposures to Bony Fish

Literature Review of Laboratory AC EMF Exposure Assessments

As compared to the number of studies conducted with static magnetic fields, relatively few studies have been conducted using AC magnetic fields, and many of these studies have focused on low frequency (i.e., <10 Hz) fields that are common to the marine environment. The available literature can be categorized into physiological studies, which focus on the effects of exposure to AC EMF on biochemical or physiological homeostasis, and behavioral studies that examine the impact of such fields on the behavior of individuals.

Evidence from scientific research suggests that development of early fish life stages is not adversely affected by exposure to AC EMF. The development of medaka (*Oryzias latipes*) embryos exposed to a 1.0 G magnetic field produced by a 60-Hz power source was observed to be significantly delayed compared to unexposed control embryos, with an average developmental delay of 18 hours. There were no significant effects, however, on hatching rate or the incidence of developmental abnormalities, indicating no long-term population-level effects (Cameron et al., 1985). Rainbow trout (*Oncorhynchus mykiss*) embryos were exposed in laboratory settings to electric fields of variable strengths (5 to 5,000 mV/m) generated by an AC source with no observable effects to development (Brouard et al., 1996). Further, chronic, two-month long exposures to AC electric fields between 5 and 500 mV/m also indicated no adverse effects on trout fry and fingerling growth and survival (Brouard et al., 1996). Given these findings and because fish eggs and larvae are largely passively dispersed via current and experience very high rates of natural mortality (Dalhberg, 1979), it is not expected that early life stages would experience significant exposure to cable-associated EMF or result in population-level impacts. More importantly, early fish life stages are understood to be generally more sensitive to environmental stressors than adult fish. As such, this study likely provides a conservative assessment of the effects of AC EMF on fish development. Given that no effects were observed in fish embryos and larvae, even during chronic exposures, it can therefore be concluded that field exposures to the AC EMF will not result in adverse developmental or growth effects in resident fish species.

In addition to developmental effects, the potential impacts of AC magnetic fields on fish biochemistry also have been studied, though infrequently. Brook trout (*Salvelinus fontinalis*) exposed to a 0.4 G magnetic field with a frequency of 1 Hz, exhibited increased nocturnal production of melatonin (Lerchl et al., 1998). While authors did not identify the mechanism of this response, they noted that such increased melatonin levels may indicate a generalized stress response. It is not expected, however, that increased melatonin levels or any other general stress response would result in injury to fish resources. Furthermore, this response occurred following exposure to a low frequency magnetic field that is within the range of frequencies encountered in the natural environment, according to data presented in (Normandeau et al. (2011).

As studied in carefully controlled laboratory studies, the bulk of the scientific literature does not demonstrate that 50/ 60-Hz EMF has adverse effects on adult bony fish. Richardson et al. (1970) exposed both Atlantic salmon and American eel to 60-75 Hz AC power sources that produced a 500 mG magnetic field and observed fish swimming behaviors. The scientists reported that neither species changed their behaviors in response to the AC magnetic field; hence, the authors concluded that AC power sources operating at 60-75 Hz are unlikely to adversely impact the behavior or activity of either Atlantic salmon or American eel (Richardson et al., 1970).

Behavioral experiments also have been conducted with electrosensitive fish species, sterlet (*Acipenser ruthenus*) and Russian sturgeon (*Acipenser gueldenstaedtii*), where fish were exposed to both low frequency (1-18 Hz) and 50 Hz AC electric fields at intensities of 20 mV/m to less than 60 mV/m (Basov, 1999). At 50 Hz, exposure to lower intensities (20 mV/m) resulted in increased fish orientation towards the field, followed by search and foraging behaviors in the vicinity of the field source. Electrosensitive pallid sturgeon (*Scaphirhynchus* *albus*) were exposed to either 24,500 mG or ~18,000 mG magnetic fields produced by a 60-Hz AC power source in a mesocosm setting composed of 22 x 7 x 1.5 meter net pens within a larger pond system (Bevelhimer et al., 2015); this is in contrast to the 3 x 0.3 x 0.35 meter tanks used by Basov (1999). It was determined that sturgeons' position and movement was not significantly affected by the AC EMF, as the majority of trials indicated no change in swim behavior or orientation response to the artificial magnetic field (Bevelhimer et al., 2015).

Other studies conducted in the same laboratory evaluated AC magnetic field detection in lake sturgeon (*Acipenser fulvescens*) and red ear sunfish (*Lepomis microlophus*). During an approximately two-day exposure to an AC electromagnet with a maximum field strength of 1,657,800 mG, red ear sunfish demonstrated preference for shelters nearest to the electromagnet (Bevelhimer et al., 2013). Under similar exposure conditions, lake sturgeon exhibited significantly different swimming behaviors, including slowing and gliding, sudden stops near the EMF source, pectoral fin flares, and body spasms; careful modulation of the source intensity indicated that the threshold detection level for lake sturgeon was between 10,000 and 20,000 mG. More critically, when exposed red ear sunfish and lake sturgeon were removed from the artificial EMF environment, normal swimming behaviors were re-established; authors also reported no evident long-term impacts in the months following the exposure.

In 2015, a pair of studies released by the Marine Scotland Science agency examined the effects of 50-Hz magnetic fields on Atlantic salmon (*Salmo salar*) and European eels (Armstrong et al., 2015; Orpwood et al. 2015). The effects of 50-Hz magnetic fields on Atlantic salmon behavior were determined at three field strengths (1.3, 11.4 and 950 mG). Neither field strength nor the sequence in which the salmon were exposed to the different field strengths had any significant impact on swim behavior, which led the authors to conclude that salmon behavior is not adversely affected by 50-Hz magnetic fields (Armstrong et al., 2015). European eel (*Anguilla anguilla*) swim behavior was examined during exposure to an AC magnetic field of 960 mG. During a series of trials, eel swimming behavior and passage through the laboratory tank was unaffected by the presence of the AC magnetic field (Orpwood et al., 2015).

Evidence from Field Studies

In addition to laboratory studies designed to elucidate the behavioral effects and detection thresholds of fish to AC magnetic fields, a series of field studies have been conducted along AC submarine cables and at offshore wind farms that utilize AC transmission cables. Data and information from these studies provide important information regarding the possible field effects that such cables have on populations of resident fish.

Love et al. (2016) examined the effects of operating AC cables on resident marine communities off the California coast, providing key data concerning the reactions of magnetosensitive fish and electric-field sensitive elasmobranchs to operating AC cables under realistic field conditions. This study was comprised of multi-year surveys sites with both energized and un-energized (35 kV) <u>unburied</u> AC submarine cables and was designed to determine how the energized cables might alter the distribution, presence, and numbers of resident fish species. Over three years of data collection, more than 40 species were observed in various cable and natural habitats located in areas distant from energized and un-energized cables, including multiple rockfish species, perch, California halibut (*Paralichthys californicus*), sanddab (*Citharichthys sordidus*), and seaperch (Love et al., 2016). The authors concluded that there were greater numbers of several fish species along cable routes compared to the control, which was versus a similar natural sea bottom habitat. These increased densities, however, were observed to be the result of the physical presence of unburied cables, since aggregations of fish were observed at both energized and un-energized cables. The measured magnetic fields at the energized cables ranged from 730 to 1100 mG. Here, the cables acted as vertical habitat, which attracted and aggregated fish. Love et al. (2016) concluded from their research that there is no evidence the 60-Hz magnetic field produced by the energized cables impacted fish behavior, distribution, or abundances.

Similarly, the effect of wind farm operations (including energized 50/60 Hz AC transmission cables) on the populations and distributions of resident fish species has been previously assessed at other wind farm sites. In general, the nature of such investigations necessitates a comprehensive survey approach, which included pre-construction and post-construction surveys not only at the wind farm site, but also within a reference area that allows for detection of long-term trends not related to installation of wind turbines and cables. For instance, nearly ten years of pre- and post-construction data were collected at the Horns Rev Offshore Wind Farm site and a reference area near Denmark. Analysis of this data indicated "no general significant changes in the abundance or distribution patterns of pelagic and demersal fish," except for the localized increases of hard ground associated species around wind turbine footings (Leonhard et al., 2011). Fish species evaluated through these surveys included herring, cod, sole, mackerel, sand eel, and various flounder and flatfish. Fish surveys conducted at the Thorntonbank Wind Farm in Belgium reported some temporary increases and decreases in some fish and invertebrate species; however, authors noted that these were merely residual effects from construction activities on fish populations (Vandendriessche et al., 2015). At the Wolfe Island wind farm site in Lake Ontario, Dunlop et al. (2016) examined the effects of the AC submarine transmission cable on fish distributions in Lake Ontario through a series of electrofishing and acoustic surveys; this fish community included populations of American eel, which is projected to occur at the SFWF site. Based on these surveys, no significant population-level effects were observed for fish populations in the vicinity of the cable route; hence, authors concluded that there was "little to no effect of the Wolfe Island submarine cable on local fish communities" (Dunlop et al 2016).

While investigations into the effects of construction of the Nysted wind farm (Denmark) found no difference in pre- and post-construction abundances of key fish species, study authors did note "asymmetries in the catches" of a few species on either side of the transmission cable route (Vattenfall and Skov-og, 2006). Given that there was no baseline data, post-construction data could not be compared against fish distributions at the site before cable installation. Although EMF levels from the cable were not measured, authors did attempt to correlate these "asymmetries" to the energy load of the cable and could find no influence of cable loading on fish distributions. Furthermore, there was no evidence that the presence of the cable acted as a barrier to migration and movement (Vattenfall and Skov-og, 2006). Hence, it cannot be reasonably concluded that these "asymmetries" are related to cable EMF (and not differences in localized sediment grain size or currents), and moreover, these differences do not constitute an adverse population-level effect to resident fish.

In summary, studies and surveys conducted at offshore AC cable and wind farm sites have demonstrated that fish distributions and abundances are not altered by the presence of 50/60 Hz magnetic fields. This is borne out by several comprehensive reviews, including a recent assessment by Copping et al. (2016) that concluded "to date there has been no evidence to show that EMFs at the levels expected from MRE [Marine Renewable Energy] devices will cause an effect (whether negative or positive) on any species." These data further support the findings from laboratory studies that indicate no effects of AC magnetic and induced electric fields on fish species.

Evaluation of Fish Sensitivities to Magnetic and Induced Electric Fields

Magnetic Field

The magnetic fields calculated from the proposed SFWF cables are summarized in Table 3. The maximum strength determined for the buried SFWF cables is 30 mG at the seabed immediately over the cable. This value is over 16 times lower than the 60-Hz, 500 mG magnetic field that elicited no response from either Atlantic salmon or American eel (Richardson et al., 1970). The reported threshold for detection for lake sturgeon was between 10,000 and 20,000 mG, which is roughly 1,000 times higher than the conservative estimates of the SFWF magnetic field based on calculations.

Electric Field Induced in Seawater

The maximum electric field induced in the seawater around the buried cables is calculated to be 2.1 mV/m at the seabed directly above the 138-kV export cable. From there, induced electric fields decrease with distance from the cable to a level of 0.2 mV/m at 75 feet from the cable route (Table 4). These calculated induced electric fields in seawater can be compared to the threshold for behavioral responses in Russian sturgeon and sterlet—20 mV/m by Basov et al. (1999). The maximum calculated electric field in seawater over the cable is approximately 10 times lower than the reported threshold value for an Atlantic sturgeon inhabiting the Project area and so no effects or behavioral responses due to the induced electric fields in seawater are projected.

Electric Field Induced in Atlantic Sturgeon

Induced electric-field strengths also were calculated using an Atlantic sturgeon model (an ellipsoid 6 foot long with a maximum girth of 2.5 feet) to represent exposures to large elasmobranchs.[7] Results from these calculations are shown in Table 5. Again, the maximum value for buried cables is projected to occur at the seabed over the offshore 138-kV export cable. This maximum induced electric field strength predicted using the Atlantic sturgeon model (0.34 mV/m) or in seawater is considerably less than the 20 mV/m electric field reported to cause threshold responses in Russian sturgeon and sterlet (Basov et al 1999).

The scientific data reviewed above do not indicate that EMF from the buried 60-Hz cables as part of the SFWF Project would have any adverse effect on the populations or distributions of bony fish in the Project area.

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7 Girth was determined using a standard length-girth-weight relationship for the related lake sturgeon (http://files.dnr.state.mn.us/areas/fisheries/baudette/lksweight.pdf).

Description of Elasmobranch Species in Project Area and Exposure to EMF

Elasmobranchs are cartilaginous fish, such as skates, sharks, and rays are common in coastal and oceanic environments. Based on available site-specific information, approximately 13 different elasmobranch species are expected to utilize the SFWF Project area to varying degrees (Appendix D, Table D-1). Only the smaller skate and dogfish species are commercially or recreationally harvested and are most commonly found in the nearshore demersal environments. Most of the elasmobranch species listed in Table D-1 that inhabit the Project site are large pelagic shark species that tend to be broadly distributed and highly mobile; given these habits, it is expected that the abundance of such species is low within the Project area.

Demersal elasmobranchs known to inhabit the Project area prefer sandy, muddy, or gravelly substrates. Pelagic elasmobranchs species are found in a larger range of water depths in both nearshore and offshore oceanic habitats; these species also tend to be significantly larger than the demersal species (Appendix D, Table D-1).

Magnetosensitivity and Electrosensitivity

As a group, elasmobranchs are capable of detecting low frequency (1-10 Hz) bioelectric fields emitted by fish and other marine organisms; under laboratory conditions, they have also been observed to react to simulated electric fields with frequencies and intensities similar to bioelectric fields (Bedore and Kajiura, 2013). This ability allows these marine predators to accurately locate potential prey, and in some cases, identify potential mates (Dunlap et al., 2010). In a review of the literature concerning elasmobranch EMF sensitivity, Bedore and Kajiura (2013) reported detection thresholds and distances for several such species; in general, sensitivity was between 20 to 50 nanovolts per centimeter (20 to 50 µV/m) and prey detection distance was less than 50 cm for the majority of species tested (Bedore and Kajiura, 2013). This suggests that predators must be in very close proximity to detect EMF, as feeding strikes at adjacent prey are more likely to be successful.

Elasmobranch Species Groups

To best assess the potential that various elasmobranch species will encounter and be affected by Project-related EMF, identified species were grouped into demersal and pelagic categories; it was determined that these would be sufficient to assess the likely capability of elasmobranchs to detect and respond to EMF produced by the SFWF cables:

- Demersal elasmobranchs—little skate (*Leucoraja erinacea*), smooth dogfish (*Mustelus canis*), spiny dogfish (*Squalus acanthias*), and winter skate (*Leucoraja ocellata*).
- Pelagic elasmobranchs—basking shark (*Cetorhinus maximus*), blue shark (*Prionace glauca*), common thresher shark (*Alopias vulpinus*), dusky shark (*Carcharhinus obscurus*), sandbar shark (*Carcharhinus plumbeus*), sand tiger shark (*Carcharias taurus*), shortfin mako shark (*Isurus oxyrinchus*), tiger shark (*Galeocerdo cuvieri*), and white shark (*Carcharodon carcharias*).

The information in Appendix D, Table D-1 was used to evaluate the likelihood that resident elasmobranch populations will encounter the inter-array and export cable routes. Specific life history characteristics, including a large depth distribution or affinity for deeper depths, a significant geographical range, and association with hard substrates, may indicate that a species is less likely to be exposed to EMF from the submarine cables.

The induced electric field produced when an elasmobranch passes through the 60-Hz magnetic field produced by the SFWF cables, was calculated for a representative species from the demersal and pelagic groups. For the demersal group, the model was based on a 1-meter long smooth dogfish. Since smooth dogfish are one of the larger demersal elasmobranchs at the site, this model is expected to be appropriately conservative given that the electric field induced within an organism increases in strength with organism size. Although pelagic elasmobranchs were considered less likely to inhabit the cable route, an induced electric field model was constructed for this group as well, based on a large 2.5-meter sand tiger shark. This species was chosen because, in contrast to other pelagic elasmobranch species in the Project area, it is regularly found in nearshore areas similar to those along the proposed SFEC route.

Evaluation of EMF Exposure to Elasmobranchs

Literature Review of Laboratory AC EMF Exposure Assessments

Elasmobranchs can detect static electric fields of less than 0.01 mV/m (Kajiura and Holland, 2002), as well as low frequency (less than 20 Hz) electric fields. These fields approximate those generated by potential prey items, and therefore this ability is likely used to aid in the detection and location of prey (Bedore and Kajiura 2013). In terms of higher frequency (50-60 Hz) electric fields, these would be detected only if elasmobranch sensitivity was the same at high frequencies as it is for the static or low frequency electric fields, which is not the case. The scientific literature indicates that the ability of elasmobranchs to detect electric fields decreases dramatically as the frequency is increased above approximately 5 Hz or less, which is estimated to be the peak sensitivity range for elasmobranchs. For instance, an increase in the electric field frequency from approximately 1 Hz to 10 Hz caused a concurrent 100-fold increase in the response thresholds of skates (~0.1 to 10 µV/cm; or 0.01 mV/m to 1 mV/m) (Andrianov et al., 1984). Similarly, bamboo shark embryos exhibited freeze responses when exposed to low frequency (<20 Hz) electrical stimuli. The strongest responses occurred within the range of signals produced by species that prey upon shark embryos (approximately 0.1-20 Hz) and decreased as frequency increased up to 20 Hz, at which point no response was observed (Kempster et al., 2013). This provides further evidence that elasmobranch EMF detection abilities are limited to static or low frequency (i.e., <20 Hz). In a series of experiments with the catshark, *Scyliorhinus canicula*, Kimber et al. (2011) demonstrated that this species demonstrated stronger reactions to a low-frequency (2 Hz) electrical field over a static (0 Hz) field and concluded that this preference likely results because low frequency AC electric signals are associated with fish prey, while static fields are more likely to be emitted by invertebrates.

A benthic elasmobranch, draughtsboard shark (*Cephaloscyllium isabellum*), was exposed to a 50-Hz AC source (maximum magnetic strength of 14,300 mG under laboratory conditions for a total of 72 observations). Based on observations of behavioral responses, it was concluded that this species did not exhibit significant behavioral changes in response to the active cable and normal behavior was observed throughout all exposures, even when individuals were induced into a foraging response by the introduction of olfactory stimuli (Orr, 2016). It was concluded that the presence of 50-Hz cables in the marine environment would not distract or attract foraging elasmobranchs.

Evidence from Field Studies

The responses of elasmobranchs have rarely been assessed in natural ocean conditions. The multi-year study, however, conducted by Love et al. (2016) at submarine AC cable sites in the ocean off the coast of California specifically assessed the distribution and responses of resident elasmobranchs to the unburied energized and un-energized cables, given these species' known sensitivity to EMF. One of the specific objectives of the study was the evaluation of effects of energized cables (730 to 1,100 mG) on the behavior of elasmobranch species compared to inactive, de-energized cables that produce no EMF. After the survey data were analyzed, authors determined that there was no evidence that "energized power cables in this study were either attracting or repelling these fishes [Elasmobranchs]" and that "energized cables are either unimportant to these organisms [Elasmobranchs] or that at least other environmental factors take precedence" (Love et al., 2016). It was noted that the study area contained a high diversity of elasmobranchs, and yet no clear pattern of distribution was noted, suggesting that elasmobranchs will not form aggregations around such submarine cables.

Evaluation of Sensitivities to Calculated SFWF Magnetic and Induced Electric Fields

Magnetic Field

Based on evidence from Love et al. (2016), elasmobranch magnetic-field detection thresholds likely exceed 1,000 mG, when produced by a 60-Hz AC source. Under laboratory conditions, elasmobranchs did not respond to 14 mG, 50-Hz magnetic fields (Orr 2015), which supports the conclusion that elasmobranch species will not detect magnetic fields produced by SFWF cables at 1 meter above the seabed along the cable route. Although calculated magnetic-field strengths at the seabed exceed the highest 50-Hz magnetic-field strength tested by Orr (2015), there is no evidence that these are detectable by resident elasmobranchs, especially considering that magnetic fields up to 1,100 mG had no observable impact on elasmobranchs in an ocean environment. Taken together, this research indicates that the magnetic fields associated with the buried SFWF Project cable (maximum strength 30 mG: Table 3) would not be detectable by resident elasmobranchs.

Electric Field Induced in Elasmobranch species

Induced electric fields were calculated using two models, smooth dogfish (a demersal elasmobranch) and a sand tiger shark (a pelagic elasmobranch often found in nearshore waters). The dogfish model was based on an ellipsoid with a 1-meter length and a maximum girth of 0.4 meters; the sand tiger shark was modeled on an ellipsoid of 2.5-meter length and a 1-meter girth. Although research indicates that these species can detect an electric field of 0.01 mV/m produced by a 10-Hz power source, the threshold of detection increases significantly as the frequency of the power source increases (Andrianov et al., 1984). In fact, Kempster et al. (2012) found that late stage bamboo shark embryos did not respond to electric-field intensities of 0.21 mV/m produced by a 20-Hz power source. These data do not indicate that electric fields induced by the 60-Hz cable will be detectable by the large demersal and pelagic elasmobranchs predicted to inhabit the SFWF cable routes.

Electric Field Induced in Seawater

Results from the modeling of induced electric-field levels in seawater indicated that values at the 138-kV export cable were the highest, and ranged from a maximum of 2.1 mV/m at the seabed above the cable site and decreased to 0.2 mV/m at a distance of 75 feet (Table 4). Based on the findings reported by Andrianov et al. (1984) and Kempster et al. (2012), the electric-field sensitivities of elasmobranchs decrease rapidly as the frequency of the source increases. Given this, and that the detection threshold for sharks exceeded. 0.21 mV/m when produced by a 20-Hz source (Kempster et al., 2012), it is not expected that elasmobranchs in the Project area would respond to induced electric fields in seawater produced by the SFWF cables..

Description of Marine Invertebrate Species in Project Area and Exposure to EMF

As a group, marine invertebrates constitute a diverse group of organisms, including small sediment dwelling worms and crustaceans, bivalves such as mussels and clams, large epibenthic crustaceans, and pelagic invertebrates like squid that spend time as epibenthic predators. The SFWF Project area provides habitat for diverse benthic and epibenthic invertebrate communities, composed of individuals within eight different phyla or classes. Within this group, are many economically and ecologically important shellfish species, including lobsters, crabs, clams, oysters and squid (Appendix D, Table D-2). Also present are sediment in faunal communities characterized by small worms and crustaceans that provide a key food source for many important fish species.

Invertebrate species that inhabit the SFWF Project area are associated with a variety of habitats, and some communities are strongly structured by sediment characteristics like grain size and organic content. In addition, a few key invertebrate species, such as squid and American lobster, undergo seasonal migrations or movements. As such, invertebrate species expected to inhabit the site are likely to encounter the cable route and associated EMF at different rates, given variable habitat preferences and mobility.

Magnetosensitivity

Compared to fish and elasmobranchs, relatively little is known about the response of marine invertebrates to AC EMF, and how this might affect migration, orientation, or prey identification. Aquatic crustaceans, a group that includes commercially important crab and lobster species, have been observed to use geomagnetic fields to guide orientation and migration, which suggests that this group of organisms is capable of detecting static magnetic fields (Ugolini and Pezzani, 1995; Cain et al., 2005; Boles and Lohmann, 2003; Lohmann et al. 1995). The ability to detect geomagnetic fields, however, is likely integrated with other environmental cues, including slope, light, currents, and water temperature. Furthermore, Project cables will produce AC magnetic fields, which differ from the static geomagnetic fields to which magnetosensitive marine invertebrates are attuned.

Development of Species Groups

Populations of mobile and migratory invertebrates, such as lobsters, crabs, and adult squid, are more likely to move through the cable route area and utilize geomagnetic cues in support of large scale movements; this group of species also contains many of the commercially important invertebrate species. Conversely, invertebrate species with limited mobility, such as mussels, clams, polychaetes, and amphipods, are not likely to have developed a need for detecting the earth's static magnetic field or bioelectric field and would not be affected by Project-associated EMF; although these species would be the most disturbed by the physical installation of the cable on a short-term basis. Hence, the benthic invertebrates identified as inhabiting the Project area have been split into two general groups based on relative mobility and habitat preferences:

- Large, mobile epibenthic invertebrates: American lobster (*Homarus americanus*), Atlantic rock crab (*Cancer irroratus*), horseshoe crab (*Limulus polyphemus*), Jonah crab (*Cancer borealis*), longfin squid (*Loligo pealeii*), northern shortfin squid (*Illex illecebrosus*).
- Small sediment-dwelling invertebrates (infauna), bivalves and gastropods: examples include amphipods, polychaetes, Atlantic sea scallop (*Plactopecten magellanicus*), ocean quahog (*Artica islandica*), *Nucula proxima*, waved astarte (*Astarte undata*), chestnut astarte (*A. castanea*), Atlantic surf clam, and sand dollar (*Echinarachnius parma*).

For the purposes of this evaluation, only the first species group will be assessed, given their commercial importance and significant mobility that is expected to bring these species into contact with the cable route.

Evaluation of EMF Exposure to Benthic Invertebrates

Literature Review of Laboratory AC EMF Exposure Assessments

Although the responses of marine benthic invertebrates, especially large crustaceans, to static and geomagnetic fields are well documented (Ugolini and Pezzani 1995; Cain et al., 2005; Boles and Lohmann, 2003), much less is known about response to AC magnetic fields. A series of laboratory assessments of the effects of AC EMF, however, have been conducted with sea urchin embryos with focus on the potential impacts to normal development, rather than behavioral effects.

For instance, exposure of sea urchin *(Strongylocentrotus purpuratus,)* embryos, to a 3.4 millitesla (mT; 34,000 mG) AC magnetic field was found to alter the time to first and second cell division (Levin and Ernst, 1995); however, when embryos were exposed to a 1.7 mT (17,000 mG) field, development was not affected, and no mortality was reported following either exposure. Similarly, Cameron et al. (1993) reported developmental delays in early-stage *S. purpuratus* sea urchin following exposure to a 500 mG, 60-Hz magnetic field, though this only occurred during a specific timeframe of development. The mechanism of this effect was suggested to be reduced histone production during exposure to the 60-Hz magnetic field. Developmental delays in sea urchin embryos were also observed by Zimmerman et al. (1990) following a 23-hour exposure to a 60-Hz magnetic field at 1,000 mG.

Although these results demonstrate some level of response to 60-Hz EMF by benthic invertebrates, the observed developmental responses are unlikely to occur in the field and are also not predicted to result in significant population-level effects, given that survival was apparently unaffected. The findings also demonstrate that the sensitive embryonic life stage may be only mildly affected by exposure to 60-Hz EMF, at magnetic-field strengths much higher than what would be expected at Project cables.

Evidence from Field Studies

Given the relative paucity of laboratory data concerning the effects of 50/60-Hz EMF on benthic invertebrates, data from field studies constitute the best source of evidence to assess population-level effects. These demonstrate that impacts on benthic invertebrate behavior or distribution are not expected due to the presence of energized cables.

A series of studies with caged rock crabs (*Metacarcinus anthonyi* and *Cancer productus*) were conducted to assess potential behavioral effects at unburied energized and un-energized AC cables off the coast of southern California (Love et al., 2015). These studies were designed to determine whether caged crabs would alter positions relative to cables based on energized state; measured magnetic fields in test cages averaged between 462 mG and 800 mG adjacent to the energized cable, and decreased to below 9 mG at the far end of the cages; the magnetic-field level was less than 2 mG in cages surrounding the un-energized cable (Love et al., 2015). Based on these field observations, the authors concluded that there was no significant effect of the magnetic fields on crab orientation inside the cages, and therefore the energized AC cables did not attract or repel crabs. This finding also has implications for the related crustacean, American lobster (*Homarus americanus*), which is a commercially important species in the New England area. Further, removal of caged crabs during the survey due to predation by local octopuses did not differ between cages located near energized and un-energized cables (Love et al., 2015). This strongly suggests that cephalopod (octopus and squid) activity also may not be notably affected by 60 Hz AC EMF from submarine cables.

In a separate study, the potential effects of AC submarine cables on crab distributions and harvests were assessed at a site near San Juan Island, Washington. The study was designed to allow Dungeness crabs and red rock crabs to express their detection and preference for AC magnetic fields by selecting between traps located on either side of a heavily-loaded AC cable (measured intensity between 138 and 1168 mG) (Love et al., 2017). The scientists concluded that the magnetic field produced by the cable had no effect on crab location around the cable, and thus did not act as a barrier to crab movement or adversely influence the catchability of crabs.

Evaluation of Crustacean Sensitivities to Calculated SFWF Magnetic Field

The results of field studies conducted around 60-Hz AC submarine cables do not show that the distributions and abundances of large, mobile crustaceans would be affected by the SFWF Project. This conclusion is supported by both the Love et al. (2015) and Love et al. (2017) studies that reported crustacean behavior is not impacted by the presence of energized cables, and that EMF produced by AC cables at levels of 138 and 1,168 mG does not constitute a barrier to movement of migration. The maximum magnetic-field strength calculated for the buried SFWF Project cables is 30 mG, far less than magnetic fields observed to have no effect on crab movement and distribution in field studies conducted at unburied cable sites (Love et al., 2015, 2017). Furthermore, some inference can be made from the apparent lack of cable energization effects on crab predation by octopus. Given that crabs along energized and un-energized cables were lost (presumably though octopus predation) from cages in equal numbers (Love et al., 2015), it can be concluded that cable EMF did not significantly deter or attract predatory octopus, though caution should be taken in drawing conclusions from this given that the study was not designed to examine predation rates. In addition, a recent study reported that the static magnetic field from a direct current submarine cable in Long Island Sound was only associated with subtle responses of the American lobster (and Little skate) populations around the cable and that this magnetic field, which is clearly within the detection capabilities of these species did not constitute a barrier to their movements across the cable (Hutchison et al., 2018). Hence, responses of such species to 60-Hz fields from an AC cable would be even weaker, if they occurred at all.

In summation, the evidence from field surveys provides significant support for the conclusion that large benthic and epibenthic invertebrates would not be affected by the installation of the SFWF Project cables. Effects on sea urchin embryonic development observed in laboratory studies were minor and were only documented to occur after exposure to magnetic fields between 500 and 34,000 mG, much higher than magnetic fields expected to be produced by Project cables.

Description of Marine Mammal and Sea Turtle Species in Project Area and Exposure to EMF

A variety of marine mammals and sea turtles are expected to be regularly found within the SFWF project region; these include various whale, dolphin, and seal species as well as the leatherback sea turtle (*Dermochelys coriacea*) and loggerhead sea turtle (*Caretta caretta*).[8] Commonly observed marine mammals include fin (*Balaenoptera physalus*), sperm (*Physeter microcephalus*), humpback (*Megaptera novaeangliae*), minke (*B. acutorostrata)*, and North Atlantic right (*Eubalaena glacialis*) whales; Atlantic white-sided (*Lagenorhynchus acutus*), common bottlenose (*Tursiops truncata)*, short-beaked common (*Delphinus delphis*) and Risso's (*Grampus griseus)* dolphins; harbor porpoise (*Phocoena phocoena*); and gray (*Halichoerus grypus*), harbor (*Phoca vitulina concolor*), and harp (*Phagophilus groenlandicus*) seals (Appendix D, Table D-3). Marine mammals are protected under the Marine Mammal Protection Act, and a subset of the whale species, as well as both sea turtle species expected to inhabit the Project area, are protected under the Endangered Species Act. Many of these species are characterized by significant migrations and broad distributions; hence, site use may be intermittent, irregular, or seasonal. As such, marine mammals and sea turtles are considered jointly given the similarity of site use, distributions, surface breathing, and protection under federal regulations.

Magnetosensitivity

Based on available information, it has been hypothesized that cetaceans (whales and dolphins) might have some sensitivity to the static geomagnetic field (Normandeau et al., 2011). This was based on the observed presence of magnetite in cetacean species, migratory behaviors, and that many stranding sites are characterized by specific geographical features. No studies of detection or other responses of cetaceans, however, have been performed because the sizes and protected status of these species precludes their use in controlled laboratory research. In theory,

[8] While green sea turtles (*Chelonia mydas*) and Kemp's ridley sea turtles (*Lepidochelys kempii*) have been previously observed in the region, these observations have been infrequent and as such, it was determined that these species are unlikely to occur in the Project area.

whales and dolphins may have a sensory range that can detect the static geomagnetic field of approximately 500 mG (Normandeau et al., 2011). Hatchling and juvenile loggerhead turtles have been observed to use the earth's geomagnetic field to orient swim directions (Lohmann et al., 1999; Lohmann et al., 2001). Adult loggerhead turtles may also utilize such geomagnetic features during migrations to nesting areas (Lohmann et al., 1999). Similarly, the global migratory paths of green sea turtles track with geomagnetic abnormalities, and analysis indicates that turtles prefer routes through areas of low geomagnetic variability (da Silva and de Araujo, 2011).

Marine mammals and sea turtle species that feed on benthic organisms are more likely to encounter the submarine cable route and the highest Project-associated EMF at the sediment surface above the cable. Although since these species must surface to breathe, such behavior is expected to limit time spent near any cable. Furthermore, the broad scale of sea turtle and marine mammal migrations and the generally low density of individuals within a given area are also expected to lower the likelihood that individuals will regularly encounter the cable route and Project-associated EMF. This broad distribution and movement means that the Project area represents a very small portion of the available habitat for migratory marine mammals and sea turtles.

Evidence from Field Studies

Given the size and protected status of marine mammals and sea turtles, laboratory experiments to determine detection thresholds for 50/60-Hz AC magnetic fields are impractical. Furthermore, the typically wide dispersal and migratory ranges of these species means that their densities around studied cable sites might be too low to observe responses. Hence, the potential effects of 60-Hz AC cables on abundances and distributions of these marine organisms only have been assessed through results of studies conducted at wind farm sites. Since marine mammals, such as dolphins, porpoises, and whales can be surveyed via tracking of echolocation occurrence and duration, such species have been preferentially surveyed as part of wind farm studies. Given that sea turtles are more difficult to survey using noninvasive methods, these species have not been assessed at offshore wind farm sites.

The populations of three marine mammals, the harbor porpoise (*Phocoena phocoena*), the harbor seal (*Phoca vitulina*), and the grey seal (*Halichoerus grypus*), were tracked in the vicinity of the Horns Rev and Nysted wind farms (Denmark) before, during, and after construction. Although construction activities (especially pile driving) had temporary effects on local distributions of seals, there were no observed long-term effects on their distribution caused by operation of the wind farm (Edren et al., 2010). This suggests that although construction activities and noises may displace local marine mammal species, these effects are temporary and the presence of the energized cable does not prevent establishment of baseline population distributions.

Harbor porpoises were observed to respond differently at the Nysted wind farm than at other wind farm sites in the same area. During the construction phase at Nysted, multiple metrics pertaining to porpoise abundance were observed to significantly decrease during construction and slowly recovered during the operational phase (Teilmann and Carstensen, 2012). Similar surveys conducted at the Horns Rev and Egmond aan Zee wind farms found reduced use of the wind farm areas by local marine mammals during the construction phase, but these effects did not persist into the operational phase as demonstrated at the Nysted site. At the Horns Rev site, populations remained unaltered from baseline conditions during the operational phase; however, at the Egmond aan Zee wind farm site, a significant increase of porpoise activity was noted during the operational phase, which may have been a result of the wind farm providing a vessel-free sanctuary zone for porpoises (Teilmann and Carstensen, 2012). These authors noted that the generally lower densities of marine mammals at the Nysted wind farm site might be the result of lower quality feeding grounds.

In conclusion, there is no substantive or reliable evidence that marine mammals are adversely affected by the EMF from submarine cables. Population surveys from offshore wind farms do not indicate widespread alterations of marine mammal communities during operation, although construction activities do result in temporary displacements. For sea turtles, there are no available laboratory data regarding detection of AC magnetic fields and field population surveys of these species have not been conducted at submarine AC cable sites or at offshore windfarms. However, sea turtles are only known to be sensitive to the earth's static geomagnetic field. Based on data from other geo-magnetosensitive species, geo-magnetosensitivity does not indicate an ability to detect and respond to the AC magnetic fields projected to occur within the Project area. Subsequently, there is no evidence that sea turtles would be adversely affected by EMF from the Project cables.

Conclusions

Modeling of the magnetic field at WNC ratings shows that the magnetic field at 1 meter above the seabed is below 200 mG everywhere along this offshore portion of the Project. The calculated magnetic-field levels are still further below the ICNIRP reference level of 2,000 mG and the ICES maximum permissible exposure limit of 9,040 mG. Thus, calculations of the magnetic field in accordance with the New York State Public Service Commission's magnetic-field standards demonstrate compliance of the Project with this standard.

Many marine species, including some fish, invertebrates, elasmobranchs, sea turtles and marine mammals, have developed the ability to detect and respond to magnetic fields, electric fields, or both at frequencies common in the marine environment; these include the static geomagnetic field of the earth and low frequency (~0 to 10 Hz) fields. Scientific research on these exposures is not directly applicable to understanding the potential effects of 50/60 Hz fields produced by submarine AC cables; instead, potential effects must be inferred from available research regarding the effects of EMF with frequencies of 50/60 Hz on such organisms.

Analysis of the results from magnetic-field modeling were compared to information from the scientific literature regarding the physiological effects, detection thresholds, and behavioral responses of key species and species groups expected to inhabit the Project area, including resident and migratory bony fish, elasmobranchs, and marine invertebrates. The results of these assessments indicate the following conclusions about magnetic fields from SFWF cables:

- Calculated magnetic-field levels are below thresholds at which effects on behavior in magnetosensitive fish are reported. Test species include known migratory species, like salmon and eel, which indicate that fish migrations will not be disrupted by the operating cable;

- Physiological effects on fish detrimental to their health are not expected to occur as a result of exposure to the calculated magnetic-field levels, as such effects were minor and demonstrated to occur after exposure to much stronger magnetic fields than projected at the Project site;

- Elasmobranch species inhabiting the Project area are not expected to detect the magnetic fields associated with the Project's 60-Hz AC cables based on data from laboratory studies and field surveys conducted at AC cable sites; and,

- Field surveys regarding the behavior of large crab species at 60-Hz AC submarine cable sites indicate that the Project's calculated magnetic-field levels will not affect the distribution and movement of large epibenthic crustaceans. Ancillary data and observations from these field studies may also suggest that cephalopod predation is similarly unaffected by the presence of 60-Hz AC cables.

- Available evidence for marine mammals and sea turtles does not indicate that these species are capable of detecting the magnetic fields associated with the Project's 60-Hz AC cables. In particular, marine mammal surveys conducted at offshore windfarm sites indicate no adverse long-term impacts to these species.

Furthermore, evidence from multi-year biological surveys at pre-existing offshore windfarm sites indicates no long-term or large-scale impacts on the distribution or abundances of fish or marine mammal species, despite some temporary adverse effects during construction. The observed recovery of baseline abundances and distributions following the cessation of construction activities provides evidence that EMF produced by cables does not prevent re-habitation by important fish and marine mammals.

In order to assess potential adverse effects on electrosensitive species known to inhabit the Project area (i.e., elasmobranchs and sturgeon), results from the various induced electric field models were compared to detection thresholds reported in the scientific literature. The results of these assessments indicated the following regarding induced electric fields from the SFWF cables:

- Induced electric fields calculated in seawater and in large fish both at the seabed and 1 meter above the seabed above the cable are notably lower than electric-field detection thresholds reported for sturgeon in the scientific literature. This indicates that sturgeon at the site will not detect the induced electric field generated by the magnetic field from the SFWF submarine cables.

- The evidence from laboratory and field studies considered together demonstrates that elasmobranchs are not likely to be able to detect induced electric fields from the SFWF cables.

In summary, the modeling of magnetic field and induced electric fields at the Project site was used in the analysis of the available scientific literature on the sensitivity of marine species to EMF. This analysis indicates that the EMF associated with the operational, buried submarine cable will not be detected by bony fish, elasmobranch, or invertebrate species. Given that these calculated values are below the thresholds of detection reported in the scientific literature, behavioral effects impacting regional abundances and distributions of such species are not expected. Additional field data from 50/60 Hz submarine cable sites and offshore windfarms support this conclusion, indicating no distributional or behavioral effects on resident fish, elasmobranchs, invertebrates or marine mammals. It should be noted that these conclusions are in line with the findings of a previous comprehensive review of the ecological impacts of Marine Renewable Energy (MRE) projects, where it was determined that "to date there has been no evidence to show that EMFs at the levels expected from MRE devices will cause an effect (whether negative or positive) on any species" (Copping et al., 2016). Given these findings and the findings presented herein, it is not expected that marine populations within the Project area would be adversely affected by EMF from the cable.

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Appendix A

Cable Configurations and Duct Bank Cross Sections

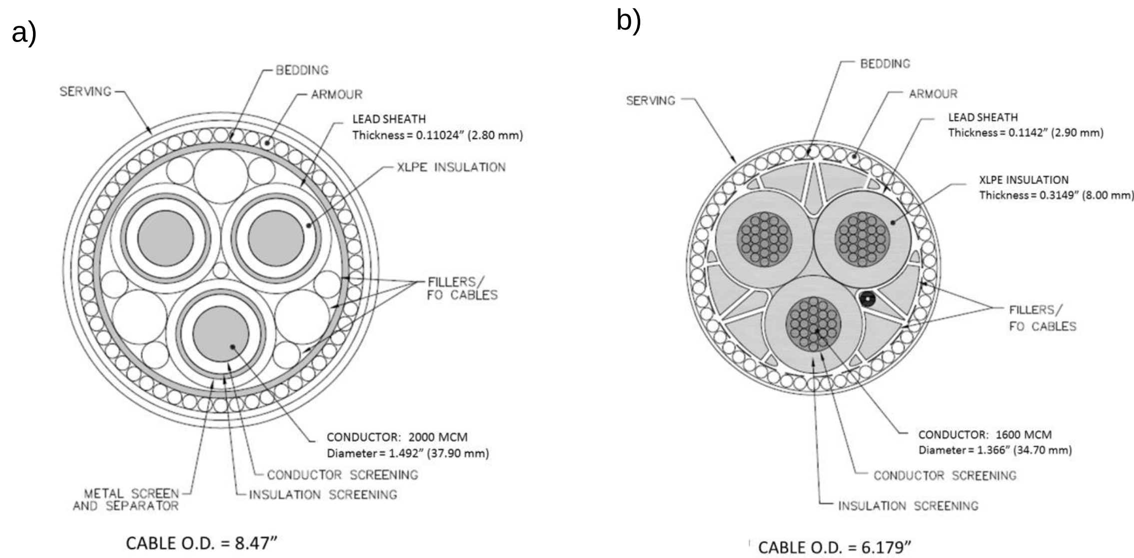

Figure A-1. Cross section of the offshore three-core cables for a) the 138-kV SFEC and b) the 34.5-kV inter-array cable.

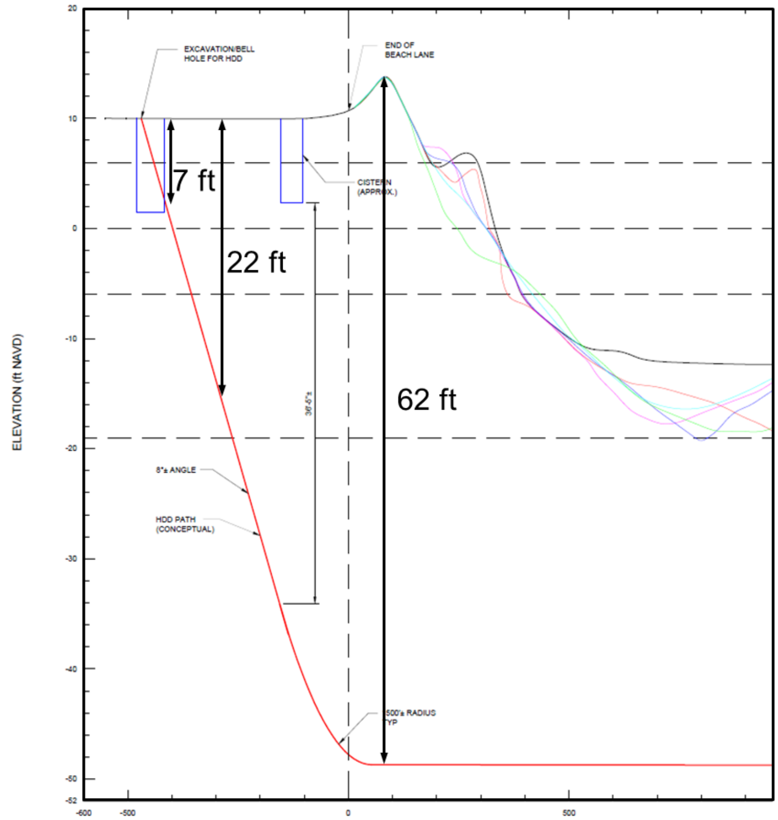

Figure A-2. Depiction of the approximate burial depth of the SFEC where it is installed via HDD at the shore landing/beach.

Appendix B

Input Data for Transmission Line Magnetic-Field Calculations

Table B-1. XS-1a: Offshore 138 kV SFEC, 6-foot burial depth at 132 MW

Bundle	x-feet	y-feet	number cond	cond dia (inches)	Bundle Separation (in)	l-n voltage (kV)	V Phase	Current (A)	Line Voltage (nominal)	Current Phase
1	0	-6.18	1	1.49	0	79.67	0	706	138	0
2	-0.15	-6.44	1	1.49	0	79.67	240	706	138	240
3	0.15	-6.44	1	1.49	0	79.67	120	706	138	120

Table B-2. XS-1a: Offshore 138 kV SFEC, 6-foot burial depth at WNC rating

Bundle	x-feet	y-feet	number cond	cond dia (inches)	Bundle Separation (in)	l-n voltage (kV)	V Phase	Current (A)	Line Voltage (nominal)	Current Phase
1	0	-6.18	1	1.49	0	79.67	0	755	138	0
2	-0.15	-6.44	1	1.49	0	79.67	240	755	138	240
3	0.15	-6.44	1	1.49	0	79.67	120	755	138	120

Table B-3. XS-1b: Offshore 138 kV SFEC, Mattress Cover at 132 MW

Bundle	x-feet	y-feet	number cond	cond dia (inches)	Bundle Separation (in)	l-n voltage (kV)	V Phase	Current (A)	Line Voltage (nominal)	Current Phase
1	0	-0.68	1	1.49	0	79.67	0	706	138	0
2	-0.15	-0.93	1	1.49	0	79.67	240	706	138	240
3	0.15	-0.93	1	1.49	0	79.67	120	706	138	120

Table B-4. XS-1b: Offshore 138 kV SFEC, Mattress Cover at WNC rating

Bundle	x-feet	y-feet	number cond	cond dia (inches)	Bundle Separation (in)	l-n voltage (kV)	V Phase	Current (A)	Line Voltage (nominal)	Current Phase
1	0	-0.68	1	1.49	0	79.67	0	755	138	0
2	-0.15	-0.93	1	1.49	0	79.67	240	755	138	240
3	0.15	-0.93	1	1.49	0	79.67	120	755	138	120

Table B-5. XS-2a: Offshore 34.5 kV inter-array cable 6-foot burial depth at 132 MW

Bundle	x-feet	y-feet	number cond	cond dia (inches)	Bundle Separation (in)	l-n voltage (kV)	V Phase	Current (A)	Line Voltage (nominal)	Current Phase
1	0	-6.14	1	1.37	0	19.92	0	708	34.5	0
2	-0.10	-6.32	1	1.37	0	19.92	240	708	34.5	240
3	0.10	-6.32	1	1.37	0	19.92	120	708	34.5	120

Table B-6. XS-2a: Offshore 34.5 kV inter-array cable 6-foot burial depth at WNC rating

Bundle	x-feet	y-feet	number cond	cond dia (inches)	Bundle Separation (in)	l-n voltage (kV)	V Phase	Current (A)	Line Voltage (nominal)	Current Phase
1	0	-6.14	1	1.37	0	19.92	0	723	34.5	0
2	-0.10	-6.32	1	1.37	0	19.92	240	723	34.5	240
3	0.10	-6.32	1	1.37	0	19.92	120	723	34.5	120

Table B-7. XS-2b: Offshore 34.5 kV inter-array cable, Mattress Cover at 132 MW

Bundle	x-feet	y-feet	number cond	cond dia (inches)	Bundle Separation (in)	l-n voltage (kV)	V Phase	Current (A)	Line Voltage (nominal)	Current Phase
1	0	-0.63	1	1.37	0	19.92	0	708	34.5	0
2	-0.10	-0.85	1	1.37	0	19.92	240	708	34.5	240
3	0.10	-0.85	1	1.37	0	19.92	120	708	34.5	120

Table B-8. XS-2b: Offshore 34.5 kV inter-array cable, Mattress Cover at WNC rating

Bundle	x-feet	y-feet	number cond	cond dia (inches)	Bundle Separation (in)	l-n voltage (kV)	V Phase	Current (A)	Line Voltage (nominal)	Current Phase
1	0	-0.63	1	1.37	0	19.92	0	723	34.5	0
2	-0.10	-0.85	1	1.37	0	19.92	240	723	34.5	240
3	0.10	-0.85	1	1.37	0	19.92	120	723	34.5	120

Appendix C

Output Results for Transmission Line Magnetic-Field Calculations

Table C-1. Calculated Output Results for Magnetic Field Offshore Calculations (Major Axis, mG)

	138-kV Offshore (6-foot Burial)		138-kV Offshore (Mattress Covered)		34.5 kV Offshore (6-foot Burial)		34.5-kV Offshore (Mattress Covered)	
Dist (ft)	**132 MW Load**	**WNC Rating**	**132 MW Load**	**WNC Rating**	**132 MW Load**	**WNC Rating**	**132 MW Load**	**WNC Rating**
-500	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-499	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-498	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-497	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-496	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-495	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-494	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-493	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-492	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-491	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-490	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-489	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-488	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-487	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-486	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-485	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-484	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-483	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-482	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-481	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-480	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-479	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-478	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-477	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-476	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-475	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-474	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-473	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-472	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-471	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-470	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-469	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-468	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-467	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-466	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-465	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-464	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-463	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10

	138-kV Offshore (6-foot Burial)		138-kV Offshore (Mattress Covered)		34.5 kV Offshore (6-foot Burial)		34.5-kV Offshore (Mattress Covered)	
Dist (ft)	132 MW Load	WNC Rating	132 MW Load	WNC Rating	132 MW Load	WNC Rating	132 MW Load	WNC Rating
-462	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-461	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-460	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-459	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-458	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-457	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-456	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-455	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-454	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-453	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-452	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-451	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-450	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-449	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-448	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-447	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-446	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-445	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-444	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-443	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-442	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-441	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-440	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-439	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-438	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-437	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-436	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-435	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-434	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-433	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-432	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-431	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-430	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-429	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-428	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-427	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-426	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-425	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10

	138-kV Offshore (6-foot Burial)		138-kV Offshore (Mattress Covered)		34.5 kV Offshore (6-foot Burial)		34.5-kV Offshore (Mattress Covered)	
Dist (ft)	132 MW Load	WNC Rating	132 MW Load	WNC Rating	132 MW Load	WNC Rating	132 MW Load	WNC Rating
-424	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-423	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-422	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-421	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-420	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-419	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-418	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-417	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-416	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-415	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-414	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-413	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-412	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-411	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-410	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-409	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-408	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-407	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-406	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-405	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-404	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-403	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-402	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-401	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-400	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-399	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-398	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-397	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-396	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-395	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-394	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-393	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-392	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-391	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-390	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-389	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-388	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-387	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10

	138-kV Offshore (6-foot Burial)		138-kV Offshore (Mattress Covered)		34.5 kV Offshore (6-foot Burial)		34.5-kV Offshore (Mattress Covered)	
Dist (ft)	132 MW Load	WNC Rating	132 MW Load	WNC Rating	132 MW Load	WNC Rating	132 MW Load	WNC Rating
-386	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-385	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-384	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-383	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-382	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-381	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-380	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-379	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-378	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-377	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-376	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-375	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-374	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-373	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-372	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-371	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-370	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-369	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-368	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-367	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-366	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-365	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-364	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-363	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-362	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-361	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-360	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-359	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-358	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-357	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-356	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-355	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-354	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-353	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-352	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-351	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-350	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-349	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10

	138-kV Offshore (6-foot Burial)		138-kV Offshore (Mattress Covered)		34.5 kV Offshore (6-foot Burial)		34.5-kV Offshore (Mattress Covered)	
Dist (ft)	132 MW Load	WNC Rating	132 MW Load	WNC Rating	132 MW Load	WNC Rating	132 MW Load	WNC Rating
-348	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-347	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-346	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-345	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-344	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-343	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-342	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-341	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-340	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-339	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-338	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-337	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-336	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-335	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-334	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-333	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-332	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-331	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-330	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-329	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-328	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-327	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-326	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-325	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-324	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-323	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-322	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-321	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-320	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-319	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-318	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-317	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-316	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-315	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-314	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-313	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-312	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-311	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10

Dist (ft)	138-kV Offshore (6-foot Burial) 132 MW Load	138-kV Offshore (6-foot Burial) WNC Rating	138-kV Offshore (Mattress Covered) 132 MW Load	138-kV Offshore (Mattress Covered) WNC Rating	34.5 kV Offshore (6-foot Burial) 132 MW Load	34.5 kV Offshore (6-foot Burial) WNC Rating	34.5-kV Offshore (Mattress Covered) 132 MW Load	34.5-kV Offshore (Mattress Covered) WNC Rating
-310	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-309	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-308	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-307	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-306	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-305	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-304	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-303	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-302	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-301	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-300	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-299	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-298	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-297	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-296	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-295	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-294	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-293	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-292	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-291	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-290	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-289	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-288	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-287	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-286	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-285	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-284	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-283	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-282	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-281	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-280	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-279	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-278	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-277	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-276	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-275	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-274	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-273	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10

	138-kV Offshore (6-foot Burial)		138-kV Offshore (Mattress Covered)		34.5 kV Offshore (6-foot Burial)		34.5-kV Offshore (Mattress Covered)	
Dist (ft)	132 MW Load	WNC Rating	132 MW Load	WNC Rating	132 MW Load	WNC Rating	132 MW Load	WNC Rating
-272	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-271	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-270	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-269	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-268	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-267	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-266	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-265	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-264	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-263	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-262	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-261	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-260	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-259	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-258	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-257	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-256	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-255	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-254	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-253	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-252	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-251	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-250	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-249	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-248	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-247	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-246	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-245	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-244	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-243	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-242	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-241	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-240	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-239	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-238	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-237	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-236	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-235	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10

	138-kV Offshore (6-foot Burial)		138-kV Offshore (Mattress Covered)		34.5 kV Offshore (6-foot Burial)		34.5-kV Offshore (Mattress Covered)	
Dist (ft)	132 MW Load	WNC Rating	132 MW Load	WNC Rating	132 MW Load	WNC Rating	132 MW Load	WNC Rating
-234	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-233	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-232	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-231	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-230	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-229	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-228	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-227	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-226	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-225	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-224	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-223	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-222	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-221	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-220	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-219	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-218	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-217	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-216	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-215	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-214	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-213	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-212	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-211	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-210	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-209	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-208	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-207	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-206	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-205	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-204	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-203	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-202	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-201	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-200	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-199	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-198	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-197	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10

Dist (ft)	138-kV Offshore (6-foot Burial) 132 MW Load	138-kV Offshore (6-foot Burial) WNC Rating	138-kV Offshore (Mattress Covered) 132 MW Load	138-kV Offshore (Mattress Covered) WNC Rating	34.5 kV Offshore (6-foot Burial) 132 MW Load	34.5 kV Offshore (6-foot Burial) WNC Rating	34.5-kV Offshore (Mattress Covered) 132 MW Load	34.5-kV Offshore (Mattress Covered) WNC Rating
-196	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-195	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-194	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-193	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-192	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-191	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-190	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-189	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-188	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-187	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-186	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-185	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-184	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-183	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-182	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-181	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-180	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-179	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-178	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-177	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-176	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-175	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-174	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-173	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-172	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-171	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-170	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-169	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-168	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-167	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-166	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-165	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-164	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-163	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-162	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-161	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-160	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-159	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10

Dist (ft)	138-kV Offshore (6-foot Burial) 132 MW Load	138-kV Offshore (6-foot Burial) WNC Rating	138-kV Offshore (Mattress Covered) 132 MW Load	138-kV Offshore (Mattress Covered) WNC Rating	34.5 kV Offshore (6-foot Burial) 132 MW Load	34.5 kV Offshore (6-foot Burial) WNC Rating	34.5-kV Offshore (Mattress Covered) 132 MW Load	34.5-kV Offshore (Mattress Covered) WNC Rating
-158	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-157	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-156	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-155	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-154	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-153	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-152	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-151	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-150	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-149	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-148	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-147	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-146	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-145	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-144	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-143	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-142	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-141	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-140	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-139	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-138	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-137	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-136	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-135	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-134	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-133	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-132	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-131	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-130	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-129	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-128	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-127	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-126	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-125	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-124	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-123	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-122	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-121	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10

Dist (ft)	138-kV Offshore (6-foot Burial) 132 MW Load	138-kV Offshore (6-foot Burial) WNC Rating	138-kV Offshore (Mattress Covered) 132 MW Load	138-kV Offshore (Mattress Covered) WNC Rating	34.5 kV Offshore (6-foot Burial) 132 MW Load	34.5 kV Offshore (6-foot Burial) WNC Rating	34.5-kV Offshore (Mattress Covered) 132 MW Load	34.5-kV Offshore (Mattress Covered) WNC Rating
-120	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-119	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-118	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-117	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-116	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-115	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-114	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-113	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-112	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-111	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-110	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-109	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-108	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-107	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-106	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-105	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-104	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-103	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-102	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-101	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-100	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
-99	0.12	0.13	0.12	0.13	0.08	0.08	0.10	0.11
-98	0.12	0.13	0.12	0.13	0.08	0.08	0.11	0.11
-97	0.12	0.13	0.12	0.13	0.08	0.09	0.11	0.11
-96	0.13	0.13	0.13	0.14	0.09	0.09	0.11	0.11
-95	0.13	0.14	0.13	0.14	0.09	0.09	0.11	0.12
-94	0.13	0.14	0.13	0.14	0.09	0.09	0.12	0.12
-93	0.13	0.14	0.14	0.14	0.09	0.09	0.12	0.12
-92	0.14	0.15	0.14	0.15	0.09	0.10	0.12	0.12
-91	0.14	0.15	0.14	0.15	0.10	0.10	0.12	0.13
-90	0.14	0.15	0.14	0.15	0.10	0.10	0.13	0.13
-89	0.15	0.16	0.15	0.16	0.10	0.10	0.13	0.13
-88	0.15	0.16	0.15	0.16	0.10	0.11	0.13	0.13
-87	0.15	0.16	0.15	0.17	0.11	0.11	0.13	0.14
-86	0.16	0.17	0.16	0.17	0.11	0.11	0.14	0.14
-85	0.16	0.17	0.16	0.17	0.11	0.11	0.14	0.14
-84	0.16	0.18	0.17	0.18	0.11	0.12	0.14	0.15
-83	0.17	0.18	0.17	0.18	0.12	0.12	0.15	0.15

	138-kV Offshore (6-foot Burial)		138-kV Offshore (Mattress Covered)		34.5 kV Offshore (6-foot Burial)		34.5-kV Offshore (Mattress Covered)	
Dist (ft)	132 MW Load	WNC Rating	132 MW Load	WNC Rating	132 MW Load	WNC Rating	132 MW Load	WNC Rating
-82	0.17	0.18	0.17	0.19	0.12	0.12	0.15	0.15
-81	0.18	0.19	0.18	0.19	0.12	0.12	0.16	0.16
-80	0.18	0.19	0.18	0.20	0.12	0.13	0.16	0.16
-79	0.19	0.20	0.19	0.20	0.13	0.13	0.16	0.17
-78	0.19	0.20	0.19	0.21	0.13	0.13	0.17	0.17
-77	0.19	0.21	0.20	0.21	0.13	0.14	0.17	0.18
-76	0.20	0.21	0.20	0.22	0.14	0.14	0.18	0.18
-75	0.21	0.22	0.21	0.22	0.14	0.14	0.18	0.18
-74	0.21	0.23	0.21	0.23	0.14	0.15	0.19	0.19
-73	0.22	0.23	0.22	0.23	0.15	0.15	0.19	0.20
-72	0.22	0.24	0.23	0.24	0.15	0.16	0.20	0.20
-71	0.23	0.24	0.23	0.25	0.16	0.16	0.20	0.21
-70	0.24	0.25	0.24	0.26	0.16	0.16	0.21	0.21
-69	0.24	0.26	0.25	0.26	0.17	0.17	0.21	0.22
-68	0.25	0.27	0.25	0.27	0.17	0.17	0.22	0.22
-67	0.26	0.27	0.26	0.28	0.18	0.18	0.23	0.23
-66	0.26	0.28	0.27	0.29	0.18	0.19	0.23	0.24
-65	0.27	0.29	0.28	0.30	0.19	0.19	0.24	0.25
-64	0.28	0.30	0.29	0.31	0.19	0.20	0.25	0.25
-63	0.29	0.31	0.29	0.32	0.20	0.20	0.26	0.26
-62	0.30	0.32	0.30	0.33	0.20	0.21	0.26	0.27
-61	0.31	0.33	0.31	0.34	0.21	0.22	0.27	0.28
-60	0.32	0.34	0.32	0.35	0.22	0.22	0.28	0.29
-59	0.33	0.35	0.34	0.36	0.23	0.23	0.29	0.30
-58	0.34	0.36	0.35	0.37	0.23	0.24	0.30	0.31
-57	0.35	0.38	0.36	0.38	0.24	0.25	0.31	0.32
-56	0.36	0.39	0.37	0.40	0.25	0.26	0.32	0.33
-55	0.38	0.40	0.39	0.41	0.26	0.26	0.34	0.34
-54	0.39	0.42	0.40	0.43	0.27	0.27	0.35	0.36
-53	0.40	0.43	0.42	0.44	0.28	0.28	0.36	0.37
-52	0.42	0.45	0.43	0.46	0.29	0.29	0.38	0.38
-51	0.44	0.47	0.45	0.48	0.30	0.31	0.39	0.40
-50	0.45	0.48	0.47	0.50	0.31	0.32	0.41	0.41
-49	0.47	0.50	0.49	0.52	0.32	0.33	0.42	0.43
-48	0.49	0.52	0.51	0.54	0.34	0.34	0.44	0.45
-47	0.51	0.55	0.53	0.56	0.35	0.36	0.46	0.47
-46	0.53	0.57	0.55	0.59	0.37	0.37	0.48	0.49
-45	0.56	0.59	0.58	0.62	0.38	0.39	0.50	0.51

Dist (ft)	138-kV Offshore (6-foot Burial) 132 MW Load	138-kV Offshore (6-foot Burial) WNC Rating	138-kV Offshore (Mattress Covered) 132 MW Load	138-kV Offshore (Mattress Covered) WNC Rating	34.5 kV Offshore (6-foot Burial) 132 MW Load	34.5 kV Offshore (6-foot Burial) WNC Rating	34.5-kV Offshore (Mattress Covered) 132 MW Load	34.5-kV Offshore (Mattress Covered) WNC Rating
-44	0.58	0.62	0.60	0.64	0.40	0.41	0.52	0.53
-43	0.61	0.65	0.63	0.67	0.42	0.42	0.55	0.56
-42	0.63	0.68	0.66	0.71	0.44	0.44	0.57	0.59
-41	0.66	0.71	0.69	0.74	0.46	0.47	0.60	0.61
-40	0.69	0.74	0.73	0.78	0.48	0.49	0.63	0.65
-39	0.73	0.78	0.76	0.82	0.50	0.51	0.66	0.68
-38	0.77	0.82	0.81	0.86	0.53	0.54	0.70	0.71
-37	0.80	0.86	0.85	0.91	0.55	0.56	0.74	0.75
-36	0.85	0.91	0.90	0.96	0.58	0.59	0.78	0.80
-35	0.89	0.96	0.95	1.01	0.61	0.63	0.82	0.84
-34	0.94	1.01	1.00	1.07	0.65	0.66	0.87	0.89
-33	1.00	1.07	1.06	1.14	0.68	0.70	0.92	0.94
-32	1.05	1.13	1.13	1.21	0.72	0.74	0.98	1.00
-31	1.12	1.19	1.20	1.29	0.77	0.78	1.05	1.07
-30	1.19	1.27	1.28	1.37	0.82	0.83	1.12	1.14
-29	1.26	1.35	1.37	1.47	0.87	0.89	1.19	1.22
-28	1.34	1.44	1.47	1.57	0.92	0.94	1.28	1.30
-27	1.43	1.53	1.58	1.69	0.99	1.01	1.37	1.40
-26	1.53	1.64	1.70	1.82	1.05	1.08	1.48	1.51
-25	1.64	1.76	1.84	1.96	1.13	1.15	1.59	1.63
-24	1.76	1.89	1.99	2.13	1.21	1.24	1.73	1.76
-23	1.90	2.03	2.16	2.31	1.30	1.33	1.87	1.91
-22	2.05	2.19	2.36	2.52	1.41	1.44	2.04	2.09
-21	2.21	2.36	2.58	2.76	1.52	1.55	2.24	2.28
-20	2.40	2.56	2.83	3.03	1.65	1.68	2.46	2.51
-19	2.60	2.78	3.13	3.34	1.79	1.83	2.71	2.77
-18	2.83	3.03	3.47	3.71	1.95	1.99	3.01	3.07
-17	3.09	3.31	3.86	4.13	2.13	2.18	3.35	3.42
-16	3.39	3.62	4.33	4.64	2.33	2.38	3.76	3.84
-15	3.72	3.98	4.89	5.23	2.56	2.62	4.24	4.33
-14	4.10	4.38	5.56	5.95	2.82	2.88	4.82	4.92
-13	4.52	4.84	6.38	6.82	3.12	3.18	5.52	5.64
-12	5.00	5.35	7.37	7.88	3.45	3.52	6.39	6.52
-11	5.54	5.93	8.61	9.21	3.83	3.91	7.46	7.62
-10	6.15	6.58	10.17	10.87	4.25	4.34	8.81	9.00
-9	6.83	7.30	12.15	13.00	4.72	4.82	10.54	10.76
-8	7.57	8.10	14.73	15.75	5.24	5.35	12.78	13.05
-7	8.38	8.96	18.11	19.37	5.81	5.93	15.72	16.06

	138-kV Offshore (6-foot Burial)		138-kV Offshore (Mattress Covered)		34.5 kV Offshore (6-foot Burial)		34.5-kV Offshore (Mattress Covered)	
Dist (ft)	132 MW Load	WNC Rating	132 MW Load	WNC Rating	132 MW Load	WNC Rating	132 MW Load	WNC Rating
-6	9.23	9.87	22.61	24.18	6.40	6.54	19.66	20.07
-5	10.10	10.80	28.60	30.59	7.01	7.16	24.93	25.46
-4	10.94	11.70	36.52	39.05	7.61	7.77	31.94	32.61
-3	11.70	12.51	46.51	49.74	8.14	8.32	40.87	41.73
-2	12.31	13.16	57.78	61.79	8.58	8.76	51.06	52.14
-1	12.71	13.59	67.59	72.29	8.86	9.04	60.04	61.31
0	12.84	13.74	71.65	76.62	8.95	9.14	63.78	65.13
1	12.71	13.59	67.59	72.29	8.86	9.04	60.04	61.31
2	12.31	13.16	57.78	61.79	8.58	8.76	51.06	52.14
3	11.70	12.51	46.51	49.74	8.14	8.32	40.87	41.73
4	10.94	11.70	36.52	39.05	7.61	7.77	31.94	32.61
5	10.10	10.80	28.60	30.59	7.01	7.16	24.93	25.46
6	9.23	9.87	22.61	24.18	6.40	6.54	19.66	20.07
7	8.38	8.96	18.11	19.37	5.81	5.93	15.72	16.06
8	7.57	8.10	14.73	15.75	5.24	5.35	12.78	13.05
9	6.83	7.30	12.15	13.00	4.72	4.82	10.54	10.76
10	6.15	6.58	10.17	10.87	4.25	4.34	8.81	9.00
11	5.54	5.93	8.61	9.21	3.83	3.91	7.46	7.62
12	5.00	5.35	7.37	7.88	3.45	3.52	6.39	6.52
13	4.52	4.84	6.38	6.82	3.12	3.18	5.52	5.64
14	4.10	4.38	5.56	5.95	2.82	2.88	4.82	4.92
15	3.72	3.98	4.89	5.23	2.56	2.62	4.24	4.33
16	3.39	3.62	4.33	4.64	2.33	2.38	3.76	3.84
17	3.09	3.31	3.86	4.13	2.13	2.18	3.35	3.42
18	2.83	3.03	3.47	3.71	1.95	1.99	3.01	3.07
19	2.60	2.78	3.13	3.34	1.79	1.83	2.71	2.77
20	2.40	2.56	2.83	3.03	1.65	1.68	2.46	2.51
21	2.21	2.36	2.58	2.76	1.52	1.55	2.24	2.28
22	2.05	2.19	2.36	2.52	1.41	1.44	2.04	2.09
23	1.90	2.03	2.16	2.31	1.30	1.33	1.87	1.91
24	1.76	1.89	1.99	2.13	1.21	1.24	1.73	1.76
25	1.64	1.76	1.84	1.96	1.13	1.15	1.59	1.63
26	1.53	1.64	1.70	1.82	1.05	1.08	1.48	1.51
27	1.43	1.53	1.58	1.69	0.99	1.01	1.37	1.40
28	1.34	1.44	1.47	1.57	0.92	0.94	1.28	1.30
29	1.26	1.35	1.37	1.47	0.87	0.89	1.19	1.22
30	1.19	1.27	1.28	1.37	0.82	0.83	1.12	1.14
31	1.12	1.19	1.20	1.29	0.77	0.78	1.05	1.07

Dist (ft)	138-kV Offshore (6-foot Burial) 132 MW Load	138-kV Offshore (6-foot Burial) WNC Rating	138-kV Offshore (Mattress Covered) 132 MW Load	138-kV Offshore (Mattress Covered) WNC Rating	34.5 kV Offshore (6-foot Burial) 132 MW Load	34.5 kV Offshore (6-foot Burial) WNC Rating	34.5-kV Offshore (Mattress Covered) 132 MW Load	34.5-kV Offshore (Mattress Covered) WNC Rating
32	1.05	1.13	1.13	1.21	0.72	0.74	0.98	1.00
33	1.00	1.07	1.06	1.14	0.68	0.70	0.92	0.94
34	0.94	1.01	1.00	1.07	0.65	0.66	0.87	0.89
35	0.89	0.96	0.95	1.01	0.61	0.63	0.82	0.84
36	0.85	0.91	0.90	0.96	0.58	0.59	0.78	0.80
37	0.80	0.86	0.85	0.91	0.55	0.56	0.74	0.75
38	0.77	0.82	0.81	0.86	0.53	0.54	0.70	0.71
39	0.73	0.78	0.76	0.82	0.50	0.51	0.66	0.68
40	0.69	0.74	0.73	0.78	0.48	0.49	0.63	0.65
41	0.66	0.71	0.69	0.74	0.46	0.47	0.60	0.61
42	0.63	0.68	0.66	0.71	0.44	0.44	0.57	0.59
43	0.61	0.65	0.63	0.67	0.42	0.42	0.55	0.56
44	0.58	0.62	0.60	0.64	0.40	0.41	0.52	0.53
45	0.56	0.59	0.58	0.62	0.38	0.39	0.50	0.51
46	0.53	0.57	0.55	0.59	0.37	0.37	0.48	0.49
47	0.51	0.55	0.53	0.56	0.35	0.36	0.46	0.47
48	0.49	0.52	0.51	0.54	0.34	0.34	0.44	0.45
49	0.47	0.50	0.49	0.52	0.32	0.33	0.42	0.43
50	0.45	0.48	0.47	0.50	0.31	0.32	0.41	0.41
51	0.44	0.47	0.45	0.48	0.30	0.31	0.39	0.40
52	0.42	0.45	0.43	0.46	0.29	0.29	0.38	0.38
53	0.40	0.43	0.42	0.44	0.28	0.28	0.36	0.37
54	0.39	0.42	0.40	0.43	0.27	0.27	0.35	0.36
55	0.38	0.40	0.39	0.41	0.26	0.26	0.34	0.34
56	0.36	0.39	0.37	0.40	0.25	0.26	0.32	0.33
57	0.35	0.38	0.36	0.38	0.24	0.25	0.31	0.32
58	0.34	0.36	0.35	0.37	0.23	0.24	0.30	0.31
59	0.33	0.35	0.34	0.36	0.23	0.23	0.29	0.30
60	0.32	0.34	0.32	0.35	0.22	0.22	0.28	0.29
61	0.31	0.33	0.31	0.34	0.21	0.22	0.27	0.28
62	0.30	0.32	0.30	0.33	0.20	0.21	0.26	0.27
63	0.29	0.31	0.29	0.32	0.20	0.20	0.26	0.26
64	0.28	0.30	0.29	0.31	0.19	0.20	0.25	0.25
65	0.27	0.29	0.28	0.30	0.19	0.19	0.24	0.25
66	0.26	0.28	0.27	0.29	0.18	0.19	0.23	0.24
67	0.26	0.27	0.26	0.28	0.18	0.18	0.23	0.23
68	0.25	0.27	0.25	0.27	0.17	0.17	0.22	0.22
69	0.24	0.26	0.25	0.26	0.17	0.17	0.21	0.22

	138-kV Offshore (6-foot Burial)		138-kV Offshore (Mattress Covered)		34.5 kV Offshore (6-foot Burial)		34.5-kV Offshore (Mattress Covered)	
Dist (ft)	132 MW Load	WNC Rating	132 MW Load	WNC Rating	132 MW Load	WNC Rating	132 MW Load	WNC Rating
70	0.24	0.25	0.24	0.26	0.16	0.16	0.21	0.21
71	0.23	0.24	0.23	0.25	0.16	0.16	0.20	0.21
72	0.22	0.24	0.23	0.24	0.15	0.16	0.20	0.20
73	0.22	0.23	0.22	0.23	0.15	0.15	0.19	0.20
74	0.21	0.23	0.21	0.23	0.14	0.15	0.19	0.19
75	0.21	0.22	0.21	0.22	0.14	0.14	0.18	0.18
76	0.20	0.21	0.20	0.22	0.14	0.14	0.18	0.18
77	0.19	0.21	0.20	0.21	0.13	0.14	0.17	0.18
78	0.19	0.20	0.19	0.21	0.13	0.13	0.17	0.17
79	0.19	0.20	0.19	0.20	0.13	0.13	0.16	0.17
80	0.18	0.19	0.18	0.20	0.12	0.13	0.16	0.16
81	0.18	0.19	0.18	0.19	0.12	0.12	0.16	0.16
82	0.17	0.18	0.17	0.19	0.12	0.12	0.15	0.15
83	0.17	0.18	0.17	0.18	0.12	0.12	0.15	0.15
84	0.16	0.18	0.17	0.18	0.11	0.12	0.14	0.15
85	0.16	0.17	0.16	0.17	0.11	0.11	0.14	0.14
86	0.16	0.17	0.16	0.17	0.11	0.11	0.14	0.14
87	0.15	0.16	0.15	0.17	0.11	0.11	0.13	0.14
88	0.15	0.16	0.15	0.16	0.10	0.11	0.13	0.13
89	0.15	0.16	0.15	0.16	0.10	0.10	0.13	0.13
90	0.14	0.15	0.14	0.15	0.10	0.10	0.13	0.13
91	0.14	0.15	0.14	0.15	0.10	0.10	0.12	0.13
92	0.14	0.15	0.14	0.15	0.09	0.10	0.12	0.12
93	0.13	0.14	0.14	0.14	0.09	0.09	0.12	0.12
94	0.13	0.14	0.13	0.14	0.09	0.09	0.12	0.12
95	0.13	0.14	0.13	0.14	0.09	0.09	0.11	0.12
96	0.13	0.13	0.13	0.14	0.09	0.09	0.11	0.11
97	0.12	0.13	0.12	0.13	0.08	0.09	0.11	0.11
98	0.12	0.13	0.12	0.13	0.08	0.08	0.11	0.11
99	0.12	0.13	0.12	0.13	0.08	0.08	0.10	0.11
100	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
101	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
102	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
103	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
104	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
105	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
106	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
107	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10

Dist (ft)	138-kV Offshore (6-foot Burial) 132 MW Load	138-kV Offshore (6-foot Burial) WNC Rating	138-kV Offshore (Mattress Covered) 132 MW Load	138-kV Offshore (Mattress Covered) WNC Rating	34.5 kV Offshore (6-foot Burial) 132 MW Load	34.5 kV Offshore (6-foot Burial) WNC Rating	34.5-kV Offshore (Mattress Covered) 132 MW Load	34.5-kV Offshore (Mattress Covered) WNC Rating
108	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
109	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
110	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
111	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
112	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
113	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
114	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
115	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
116	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
117	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
118	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
119	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
120	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
121	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
122	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
123	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
124	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
125	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
126	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
127	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
128	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
129	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
130	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
131	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
132	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
133	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
134	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
135	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
136	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
137	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
138	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
139	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
140	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
141	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
142	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
143	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
144	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
145	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10

Dist (ft)	138-kV Offshore (6-foot Burial) 132 MW Load	138-kV Offshore (6-foot Burial) WNC Rating	138-kV Offshore (Mattress Covered) 132 MW Load	138-kV Offshore (Mattress Covered) WNC Rating	34.5 kV Offshore (6-foot Burial) 132 MW Load	34.5 kV Offshore (6-foot Burial) WNC Rating	34.5-kV Offshore (Mattress Covered) 132 MW Load	34.5-kV Offshore (Mattress Covered) WNC Rating
146	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
147	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
148	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
149	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
150	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
151	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
152	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
153	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
154	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
155	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
156	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
157	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
158	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
159	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
160	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
161	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
162	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
163	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
164	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
165	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
166	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
167	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
168	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
169	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
170	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
171	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
172	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
173	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
174	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
175	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
176	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
177	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
178	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
179	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
180	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
181	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
182	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
183	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10

	138-kV Offshore (6-foot Burial)		138-kV Offshore (Mattress Covered)		34.5 kV Offshore (6-foot Burial)		34.5-kV Offshore (Mattress Covered)	
Dist (ft)	**132 MW Load**	**WNC Rating**	**132 MW Load**	**WNC Rating**	**132 MW Load**	**WNC Rating**	**132 MW Load**	**WNC Rating**
184	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
185	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
186	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
187	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
188	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
189	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
190	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
191	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
192	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
193	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
194	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
195	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
196	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
197	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
198	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
199	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
200	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
201	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
202	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
203	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
204	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
205	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
206	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
207	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
208	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
209	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
210	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
211	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
212	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
213	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
214	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
215	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
216	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
217	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
218	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
219	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
220	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
221	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10

	138-kV Offshore (6-foot Burial)		138-kV Offshore (Mattress Covered)		34.5 kV Offshore (6-foot Burial)		34.5-kV Offshore (Mattress Covered)	
Dist (ft)	132 MW Load	WNC Rating	132 MW Load	WNC Rating	132 MW Load	WNC Rating	132 MW Load	WNC Rating
222	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
223	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
224	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
225	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
226	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
227	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
228	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
229	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
230	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
231	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
232	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
233	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
234	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
235	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
236	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
237	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
238	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
239	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
240	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
241	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
242	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
243	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
244	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
245	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
246	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
247	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
248	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
249	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
250	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
251	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
252	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
253	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
254	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
255	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
256	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
257	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
258	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
259	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10

	138-kV Offshore (6-foot Burial)		138-kV Offshore (Mattress Covered)		34.5 kV Offshore (6-foot Burial)		34.5-kV Offshore (Mattress Covered)	
Dist (ft)	132 MW Load	WNC Rating	132 MW Load	WNC Rating	132 MW Load	WNC Rating	132 MW Load	WNC Rating
260	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
261	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
262	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
263	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
264	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
265	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
266	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
267	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
268	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
269	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
270	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
271	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
272	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
273	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
274	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
275	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
276	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
277	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
278	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
279	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
280	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
281	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
282	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
283	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
284	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
285	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
286	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
287	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
288	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
289	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
290	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
291	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
292	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
293	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
294	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
295	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
296	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
297	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10

Dist (ft)	138-kV Offshore (6-foot Burial) 132 MW Load	138-kV Offshore (6-foot Burial) WNC Rating	138-kV Offshore (Mattress Covered) 132 MW Load	138-kV Offshore (Mattress Covered) WNC Rating	34.5 kV Offshore (6-foot Burial) 132 MW Load	34.5 kV Offshore (6-foot Burial) WNC Rating	34.5-kV Offshore (Mattress Covered) 132 MW Load	34.5-kV Offshore (Mattress Covered) WNC Rating
298	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
299	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
300	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
301	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
302	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
303	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
304	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
305	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
306	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
307	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
308	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
309	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
310	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
311	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
312	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
313	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
314	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
315	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
316	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
317	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
318	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
319	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
320	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
321	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
322	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
323	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
324	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
325	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
326	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
327	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
328	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
329	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
330	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
331	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
332	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
333	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
334	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
335	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10

	138-kV Offshore (6-foot Burial)		138-kV Offshore (Mattress Covered)		34.5 kV Offshore (6-foot Burial)		34.5-kV Offshore (Mattress Covered)	
Dist (ft)	132 MW Load	WNC Rating	132 MW Load	WNC Rating	132 MW Load	WNC Rating	132 MW Load	WNC Rating
336	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
337	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
338	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
339	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
340	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
341	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
342	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
343	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
344	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
345	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
346	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
347	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
348	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
349	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
350	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
351	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
352	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
353	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
354	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
355	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
356	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
357	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
358	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
359	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
360	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
361	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
362	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
363	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
364	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
365	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
366	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
367	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
368	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
369	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
370	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
371	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
372	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
373	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10

	138-kV Offshore (6-foot Burial)		138-kV Offshore (Mattress Covered)		34.5 kV Offshore (6-foot Burial)		34.5-kV Offshore (Mattress Covered)	
Dist (ft)	132 MW Load	WNC Rating	132 MW Load	WNC Rating	132 MW Load	WNC Rating	132 MW Load	WNC Rating
374	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
375	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
376	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
377	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
378	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
379	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
380	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
381	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
382	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
383	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
384	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
385	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
386	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
387	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
388	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
389	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
390	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
391	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
392	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
393	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
394	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
395	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
396	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
397	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
398	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
399	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
400	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
401	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
402	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
403	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
404	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
405	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
406	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
407	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
408	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
409	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
410	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
411	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10

Dist (ft)	138-kV Offshore (6-foot Burial) 132 MW Load	138-kV Offshore (6-foot Burial) WNC Rating	138-kV Offshore (Mattress Covered) 132 MW Load	138-kV Offshore (Mattress Covered) WNC Rating	34.5 kV Offshore (6-foot Burial) 132 MW Load	34.5 kV Offshore (6-foot Burial) WNC Rating	34.5-kV Offshore (Mattress Covered) 132 MW Load	34.5-kV Offshore (Mattress Covered) WNC Rating
412	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
413	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
414	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
415	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
416	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
417	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
418	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
419	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
420	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
421	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
422	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
423	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
424	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
425	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
426	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
427	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
428	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
429	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
430	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
431	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
432	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
433	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
434	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
435	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
436	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
437	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
438	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
439	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
440	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
441	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
442	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
443	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
444	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
445	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
446	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
447	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
448	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
449	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10

Dist (ft)	138-kV Offshore (6-foot Burial) 132 MW Load	138-kV Offshore (6-foot Burial) WNC Rating	138-kV Offshore (Mattress Covered) 132 MW Load	138-kV Offshore (Mattress Covered) WNC Rating	34.5 kV Offshore (6-foot Burial) 132 MW Load	34.5 kV Offshore (6-foot Burial) WNC Rating	34.5-kV Offshore (Mattress Covered) 132 MW Load	34.5-kV Offshore (Mattress Covered) WNC Rating
450	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
451	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
452	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
453	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
454	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
455	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
456	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
457	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
458	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
459	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
460	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
461	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
462	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
463	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
464	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
465	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
466	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
467	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
468	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
469	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
470	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
471	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
472	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
473	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
474	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
475	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
476	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
477	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
478	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
479	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
480	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
481	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
482	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
483	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
484	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
485	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
486	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
487	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10

	138-kV Offshore (6-foot Burial)		138-kV Offshore (Mattress Covered)		34.5 kV Offshore (6-foot Burial)		34.5-kV Offshore (Mattress Covered)	
Dist (ft)	132 MW Load	WNC Rating	132 MW Load	WNC Rating	132 MW Load	WNC Rating	132 MW Load	WNC Rating
488	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
489	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
490	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
491	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
492	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
493	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
494	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
495	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
496	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
497	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
498	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
499	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10
500	0.12	0.12	0.12	0.13	0.08	0.08	0.10	0.10

Appendix D

List of Key Marine Species Known to Inhabit the SFWF area

Table D-1. Characteristics of ecological and economically important finfish and elasmobranch species inhabiting the South Fork Windfarm project area

Group	Species	Demersal or Pelagic	Range/Habitat	Size at first reproduction (cm)[1]	Size (common length)[1]
Elasmobranch	Little Skate (*Leucoraja erinacea)*	Demersal/Benthic	Gravel and sand substrates at less than 233 to 298 feet (71 to 91 m).	32	
Elasmobranch	**Smooth Dogfish (*Mustelus canis*)**	**Demersal/Benthic**	**Nearshore but occasionally to 870 to 990 feet (145 to 165 m)**	**102**	**100**
Elasmobranch	Spiny Dogfish (*Squalus acanthias*)	Demersal/Benthic	Sand and mud substrates at depths ranging from 3 to 1,640 feet (1 to 500 m)	81	100
Elasmobranch	Winter Skate (*Leucoraja ocellata*)	Demersal/Benthic	Sand or gravel substrates from 3 to 1,312 feet (1 to 400 m).	73	
Elasmobranch	Basking Shark (*Cetorhinus maximus*)	Pelagic	Coastal and offshore; sometimes inshore	500	700
Elasmobranch	Blue shark (*Prionace glauca*)	Pelagic	Nearshore and offshore, surface dwelling	206	335
Elasmobranch	Common Thresher Shark (*Alopias vulpinus*)	Pelagic	Nearshore and offshore, but more common nearshore	303	450
Elasmobranch	Dusky Shark (*Carcharhinus obscurus*)	Pelagic	Nearshore and offshore	235	250
Elasmobranch	**Sandbar Shark (*Carcharhinus plumbeus*)**	**Pelagic**	**Mostly at 65 to 213 feet (20 to 65 m) deep but also found in harbors and estuaries**	**126**	**200**
Elasmobranch	Sand Tiger Shark (*Carcharias taurus*)	Pelagic	Surf zone and nearshore ranging in depths from 6 to 626 feet (2 to 191 m)	220	250
Elasmobranch	Shortfin Mako Shark (*Isurus oxyrinchus*)	Pelagic	Throughout the water column with a maximum depth 2,427 feet (740 m).		
Elasmobranch	White Shark (*Carcharodon carcharias*)	Pelagic	Nearshore and offshore, near the surface.	450	
Fish	Atlantic Cod (*Gadus morhua*)[b]	Demersal/Benthic	Rocky slopes of ledges at depths between 131 and 426 feet (40 and 130 m); also midwater.	63	

Group	Species	Demersal or Pelagic	Range/Habitat	Size at first reproduction (cm)[1]	Size (common length)[1]
Fish	Atlantic Halibut (*Hippoglossus hippoglossus*)[b]	Demersal/Benthic	Coastal areas (juveniles) and depths of 328 to 2,296 feet (100 to 700 m; adults) over sand, gravel and fine substrates.		
Fish	**Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*)**	**Demersal/Benthic**	**Nearshore marine environments; with long migrations**	**190**	**250**
Fish	Black Sea Bass (*Centropristis striata*)	Demersal/Benthic	Reef areas at depths of 65 to 787 feet (30 to 240 m)	19	30
Fish	Cunner (*Tautogolabrus adspersus*)	Demersal/Benthic	Eel grass and structures at depths 13 to 23 feet (4 to 7 m).		
Fish	Haddock (*Melanogrammus aeglefinus*)	Demersal/Benthic	Pebble gravel substrate at depths of 131 to 492 feet (40 to 150 m).	35	35
Fish	Monkfish (*Lophius americanus*)	Demersal/Benthic	Sand/shell, gravel or mud substrates at depths 82 to 656 feet (25 to 200 m).	47	90
Fish	Ocean Pout (*Macrozoarces americanus*)	Demersal/Benthic	Bottom habitats with rocky structures to 656 feet (200 m) deep.	30	
Fish	Pollock (*Pollachius virens*)	Demersal/Benthic	Various water column depths to at least 600 feet (182 m) deep.	39.1	60
Fish	Red Hake (*Urophycis chuss*)	Demersal/Benthic	Shell substrate between low tide line to less than 393 feet (120 m)	26	
Fish	Sand Lance (*Ammodytes americanus*)	Demersal/Benthic	Throughout water column over sandy substrates		
Fish	Scup (*Stenotomus chrysops*)	Demersal/Benthic	Eel grass, mussel beds, and silty/sandy substrates at a depth range less than 98 feet (30 m).	16	25
Fish	Sea Raven (*Hemitripterus americanus*)	Demersal/Benthic	Rock, pebble, sand or clay substrate from 300 to 630 feet (91 to 192 m) deep.		
Fish	Striped Bass (*Morone saxatilis*)	Demersal/Benthic	Open waters along rocky shores and sandy beaches.		120
Fish	Summer Flounder (*Paralichthys dentatus*)	Demersal/Benthic	Sandy substrates from shoreline to 82 feet (25 m) deep.	28	

Group	Species	Demersal or Pelagic	Range/Habitat	Size at first reproduction (cm)[1]	Size (common length)[1]
Fish	Tautog (*Tautoga onitis*)	Demersal/Benthic	Complex hard bottom substrate to depths of 82 to 989 feet (25 to 30 m).	18	
Fish	Tilefish (*Lopholatilus chamaeleonticeps*)	Demersal/Benthic	Between 262 to 590 foot (80- to 180-m) depth		
Fish	Whiting (*Merluccius bilinearis*)[b]	Demersal/Benthic	Between 65 and1066 feet (20 to 325 m).	23	37
Fish	Windowpane Flounder (*Scophthalmus aquosus*)	Demersal/Benthic	Sand substrates from nearshore to less than 246 feet (75 m)	22	
Fish	Winter Flounder (*Pseudopleuronectes americanus*)	Demersal/Benthic	Rock, cobble, boulder or sand-shell substrate in less than 98 feet (30 m) depths	27	
Fish	Wolffish (*Anarhichas lupus*)	Demersal/Benthic	Complex structure at depth range of 131 to 787 feet (40 to 240 m).	60	
Fish	Yellowtail Flounder (*Limanda ferruginea*)	Demersal/Benthic	Sand and mud substrates between 16 and 1,181 feet (5 to 360 m).	30	
Fish	Albacore Tuna (*Thunnus alalunga*)	Pelagic	Deepwater habitats; depth range of 0 to 1,968 feet (0 to 600 m).	85	100
Fish	Alewife (*Alosa pseudoharengus*)	Pelagic	Shorelines near estuaries.	11	30
Fish	American Eel (*Anguilla rostrata*)	Pelagic	Freshwater, coastal, and marine waters.	37	50
Fish	American Plaice (*Hippoglossoides platessoides*)	Pelagic	Over sand and gravel substrates around 328-feet (100-m) deep	35	
Fish	American Shad (*Alosa sapidissima*)	Pelagic	Open ocean	49	62
Fish	Atlantic Bonito (*Sarda sarda*)	Pelagic	Nearshore and offshore open waters	37	50
Fish	Atlantic Mackerel (*Scomber scombrus)*	Pelagic	Nearshore areas 164 to 229 feet (50 to 70 m) deep (juveniles) and offshore areas 32 to 1,115 feet (10 to 340 m) deep (adults.	29	30

Group	Species	Demersal or Pelagic	Range/Habitat	Size at first reproduction (cm)[1]	Size (common length)[1]
Fish	Atlantic Menhaden (*Brevoortia tyrannus*)	Pelagic	Nearshore and offshore	18	
Fish	Blueback Herring (*Alosa aestivalis*)	Pelagic	High energy environments; gravel seafloors.		28
Fish	Bluefin Tuna (*Thunnus thynnus*)	Pelagic	Nearshore and offshore.	97	200
Fish	Bluefish (*Pomatomus saltatrix*)	Pelagic	Nearshore to offshore	30	60
Fish	Butterfish (*Peprilus triacanthus*)	Pelagic	Surface waters from continental shelf to bays, or surface waters to depths of 885 to 1,377 feet (270 to 420 m).	12	20
Fish	Conger Eel (*Conger oceanicus*)	Pelagic	Coastal waters to the edge of the continental shelf, 90 to 260m deep		100
Fish	Skipjack Tuna (*Katsuwonus pelamis*)	Pelagic	Epipelagic, open ocean	40	80
Fish	Spot (*Leiostomus xanthurus*)	Pelagic	Coastal, nearshore, and offshore continental shelf areas.		25
Elasmobranch	Tiger Shark (Galeocerdo cuvieri)	Pelagic	Coastal, nearshore, and offshore continental shelf areas	350	500
Fish	Weakfish (*Cynoscion regalis*)	Pelagic	Nearshore sandy shores and estuaries.	23	50
Fish	Yellowfin Tuna (*Thunnus albacares*)	Pelagic	Epipelagic, oceanic fish in upper 328 feet (100 m)	103	150

1 Information from fishbase.org

Table D-2. Characteristics of ecological and economically important bivalve and shellfish species inhabiting the South Fork Windfarm project area

Species	Life Stage Present	Preferred Habitat	Potential Time of Year in Region
American lobster (*Homarus americanus*)	All	Rocky habitat, but may burrow in sand or mud	Year-round
Atlantic rock crab (*Cancer irroratus*)	All	Rocky, gravelly, or sandy substrate; common in waters less than 65 feet (20 m) deep.	Year-round
Atlantic sea scallop (*Plactopecten magellanicus*)	All	Sand, gravel, shells, and other rocky habitat to depths of 656 feet (200 m).	Year-round
Atlantic surf clam (*Spisula solidissima*)	All	Medium grained sand at depths from 26 to 216 feet (8 to 66 m)	Year-round
Channeled whelk (*Busycotypus canaliculatus*)	All	Sandy and fine sediments in nearshore and offshore environments	Year-round
Eastern oyster (*Crassostera virginica*)	All	Hard bottom or shell substrates to a depth of 36 feet (11 m)	Year-round
Horseshoe crab (*Limulus polyphemus*)	All	Depths shallower than 98 feet (30 m) but also occurs in depths greater than 656 feet (200 m).	Year-round
Jonah crab (*Cancer borealis*)	Adults	Rocky areas at depths ranging from 164 to 984 feet (50 to 300 m)	Year-round
Longfin squid (*Loligo pealeii*)	All	Demersal habitats in inshore areas and offshore depths between 328 and 550 feet (100 and 168 m)	May-November
Northern quahog clam (*Mercinaria mercinaria*)	All	Mud and sandy substrates to depths up to 50 feet (15 m)	Year-round
Northern shortfin squid (*Illex illecebrosus*)	Adults	Depths ranging from 328 to 656 feet (100 to 200 m) and also nearshore habitats shallower than 60 feet (18 m).	Year-round
Ocean quahog clam (*Artica islandica*)	Juveniles and Adults	Medium and fine grain substrates at depths ranging from 82 and 200 feet (25 and 61 m)	Year-round

Table D-3. Characteristics of marine mammal species that commonly inhabit the South Fork Windfarm project area

Common Name	Scientific Name	Endangered?	Seasonal Presence	Occurrence in Region
Fin Whale	*Balaenoptera physalus*	Yes	Year-round	Common
Humpback Whale	*Megaptera novaeangliae*		Year-round	Common
Minke Whale	*Balaenoptera acutorostrata*		Spring/ Summer	Common
North Atlantic Right Whale	*Eubalaena glacialis*	Yes	Year-round	Common
Sei Whale	*Balaenoptera borealis*	Yes	Spring/ Summer	Regular
Sperm Whale	*Physeter macrocephalus*	Yes	Summer	Common
Atlantic Spotted Dolphin	*Stenella frontalis*		Year-round	Regular
Atlantic White-sided Dolphin	*Lagenorhynchus acutus*		Fall/ winter	Common
Common Bottlenose Dolphin	*Tursiops truncata*		Winter/ spring / summer	Common
Long-finned Pilot Whale	*Globicephala melas*		Spring	Common
Risso's Dolphin	*Grampus griseus*		All-year	Common
Short-beaked Common Dolphin	*Delphinus delphis*		All-year	Common
White Beaked Dolphin	*Lagenorhynchus albirostris*		All-year	Regular
Harbor Porpoise	*Phocoena phocoena*		All-year	Common
Gray Seal	*Halichoerus grypus*		Winter/ spring/ summer	Common
Harbor Seal	*Phoca vitulina concolor*		All-year	Common
Harp Seal	*Phagophilus groenlandicus*		Winter/ spring/ summer	Common
Hooded Seal	*Cystophora cristata*		Summer/ fall	Regular