displaced. Nevertheless, as described in Section 5.1 of Volume I, the export cables are expected to use technology (such as a distributed temperature system [DTS], distributed acoustic sensing [DAS] system and/or online partial discharge [OLPD] monitoring) to constantly monitor cable temperature at points along their length to help identify anomalous conditions (i.e., potential changes in cable burial depth). The inter-array cables and inter-link cables (if used) may also use DTS, DAS, or OLPD. Cable surveys will be performed at regular intervals to identify any damage or issues associated with potential scour and depth of burial (see Section 5.4.4 of Volume I). In the unlikely event that cable damage or displacement occurs, the cables will be repaired as soon as possible. Cable repair activities will be similar to cable installation activities (although they would be isolated to a smaller area).

Catastrophic damage to Project onshore concrete duct bank and splice vaults, which are buried underground, is extremely unlikely but may occur due to severe weather or other natural events (see Section 9.2.2). There is also a remote possibility that the duct bank or splice vaults could be damaged by an unrelated construction project. If the duct bank or splice vaults are damaged, any overlying cover would be excavated, and the damaged section would be repaired. If needed, this repair work will be similar to the initial installation process, but the extent of the activities and associated temporary effects would be smaller.

9.2.6 Terrorist Attacks

Although extremely unlikely, the Project's facilities could be targeted by terrorists. The effects of a terrorist attack would depend on the magnitude and location of the attack; given the dispersed nature of the Project offshore facilities, it is unlikely that an attack would affect all offshore structures. Terrorist attacks could cause spills/discharges or significant infrastructure damage to the WTGs, OSSs, offshore cables, onshore interconnection cables, or onshore substations and/or converter stations, which are described in Sections 9.2.3, 9.2.4, and 9.2.5. The response to such incidents is covered in the Project's Facility Security Plan and ERP.

9.3 Electromagnetic Fields and Human Health

This section describes EMFs and human health in relation to the Projects' onshore facilities. All onshore EMF levels are expected to be well below guidelines protective of public health. The potential effects of EMF from the Projects' offshore facilities on marine life are discussed in Sections 4.5 Benthic Resources, 4.6 Finfish, Invertebrates, and Essential Fish Habitat, 4.7 Marine Mammals, and 4.8 Sea Turtles.

EMFs consist of two component fields: electric fields and magnetic fields. These fields are created by positive and negative electric charges. EMFs are produced by electric power and by natural sources. People experience EMFs during daily living from sources such as household wiring, electric devices (e.g., hair dryers, vacuum cleaners), and appliances. All people experience the Earth's natural magnetic field as well. In the northern United States, the Earth's steady direct current (DC) magnetic field is about 550 milligauss (mG).

Electric field strength is a function of voltage (the "pressure" that drives the flow of electricity). It is measured in kilovolts per meter (kV/m). Electric fields are generated by the flow of current through transmission cables and decline rapidly with distance from the source. Atlantic Shores is proposing to install the Projects' onshore interconnection cables underground. Importantly, electric fields from underground cables are readily blocked by the cable sheath and intervening concrete, soil, and other materials.[77] Accordingly, underground transmission cables such as those proposed by Atlantic Shores do not create a risk of public exposure to *electric fields*. Therefore, this section is focused on the low-level *magnetic fields* that will be produced by the Projects' underground onshore interconnection cables and other onshore facilities.

Magnetic fields are produced by electric current, which is the flow of electric charges (normally measured in amperes [amps or A]). Magnetic fields are measured in mG and decline rapidly with distance from a power source. Common household items have magnetic fields in the range of 10 to 600 mG, depending on the distance from the source. Individuals also occasionally experience much higher levels of magnetic fields from medical imaging devices (e.g., magnetic resonance imaging [MRI] uses a magnetic field of 30,000,000 mG).

The following sections describe human health considerations associated with potential magnetic fields generated from the Projects.

9.3.1 EMF Standards and Guidelines

The U.S. alternating current (AC) electrical power grid operates at 60 cycles per second (60 hertz [Hz]). There are no Federal standards or guidelines for 60 Hz EMF exposure from power lines and related facilities. A number of states have issued guidelines or standards for EMF levels, typically within and at the edge of utility transmission rights-of-way (ROWs). These State guidelines or standards generally are based on historically acceptable EMF levels within and at the boundaries of transmission ROWs. Typically, these EMF standards include limits for electric fields and limits for magnetic fields. The New Jersey Board of Public Utilities (NJBPU) has a State guideline for electric fields[78] but not for magnetic fields.

The primary guidance with respect to EMF exposure from power lines and related facilities has been developed by national and world health organizations; these guidelines are designed to be protective against any adverse health effects. The International Commission on Non-Ionizing Radiation Protection (ICNIRP) has published guidelines on magnetic and electric field exposure which have been endorsed by the World Health Organization. For the general public, with the assumption of continuous exposure, ICNIRP recommends limiting one's exposure to magnetic fields to 2,000 mG for variable fields (i.e., AC). For steady magnetic fields (i.e., DC), ICNIRP (2010) recommends limiting magnetic fields to 5,000 mG (ICNIRP 2010). These guidelines, and similar

[77] More precisely, as stated in the EMF assessment (see page three of Appendix II-I), "The electric field from the shielded power cables is blocked by the grounded cable armoring as well as the earth and therefore, the shielded cables will not be a direct source of any electric field outside the cables."

[78] See for example NJBPU Docket No. E013111047 dated November 21, 2014; https://www.bpu.state.nj.us/bpu/pdf/boardorders/2014/20141121/11-21-14-2C.pdf.

guidelines established by other organizations, are widely considered to be highly conservative and adequately protective of health and safety.

Atlantic Shores conducted an extensive EMF assessment, including modeling of magnetic field levels in the immediate vicinity of the landfall sites, the underground onshore interconnection cables, and the onshore substations and/or converter stations (see Appendix II-I). The detailed EMF assessment also includes modeling for the offshore elements of the Projects (i.e., export cables, inter-link cables, inter-array cables, and OSSs). As described in Section 4.5 of Volume I, Atlantic Shores is considering three transmission options:

- **Option 1–HVAC Transmission.** In this option, each Project would utilize HVAC cables, and each Project would be installed within its own ECC and its own onshore ROW.
- **Option 2–HVDC Transmission.** In this option, each Project would utilize HVDC cables, and each Project would be installed within its own ECC and its own onshore ROW.
- **Option 3–HVAC and HVDC Transmission.** In this option, one Project would utilize HVAC cables, and the other Project would utilize HVDC cables.

The full range of cable options (230–275 kilovolts [kV] high voltage alternating current [HVAC] cables, 320–525 kV high voltage direct current [HVDC] cables, and/or combined HVAC and HVDC cables) as well as all representative arrangements (duct banks, onshore HDDs) were analyzed. This work provided the quantitative basis for the summaries of magnetic levels and comparisons to relevant health protective guidelines, which are described in Sections 9.3.2 through 9.3.4.

9.3.2 Landfall Sites (via Horizontal Directional Drilling)

As described in Section 4.7 of Volume I, the offshore-to-onshore transition between the submarine export cables and the underground onshore interconnection cables will occur at two landfall sites. The Monmouth Landfall Site is located within a disturbed portion of the southeast corner of the Army National Guard Training Center (NGTC) in the Borough of Sea Girt in Monmouth County, New Jersey. The underground transition vaults (one per export cable) will be located in the southeast corner of the NGTC property in a previously disturbed area. The Atlantic Landfall Site will be located on a parcel of land that is currently used as a public parking lot bounded by Pacific, South Belmont, and South California Avenues and California Avenue within Atlantic City in Atlantic County, New Jersey (see Figure 4.8-1 in Volume I). This landfall site will include underground transition vaults associated with the Atlantic export cables (one per export cable).

The offshore-to-onshore cable transition will be accomplished by HDD. At the landfall sites, HDD bores will be completed for each of the export cables coming ashore. The export cables will be pulled through HDD conduits inserted into the bore holes and jointed to the onshore interconnection cables in underground transition vaults (one per export cable) located near the onshore HDD entrance/exit point. The HDD trajectory for each bore is expected to be approximately 1,969 feet (ft) (600 meters [m]) long at the Atlantic Landfall Site and approximately 3,281 ft (1,000 m) long at the Monmouth Landfall Site. The trajectory of the bores will be a gently sloped arc which will pass beneath the beach and the intertidal zone. The preliminary HDD designs for the Atlantic Landfall Site and the Monmouth Landfall Site are provided on Figures 4.8-1 and 4.8-2 of Volume I, respectively.

To assess EMF at the landfall sites, the Projects' cables were conservatively modeled using a full load current of 1,200 amps at 230 or 275 kV. The modeling results are provided in Appendix II-I as Cases 29 and 31, respectively (see Figures 4-76 and 4-80 of Appendix II-I). For ease of reference, the 230 kV case is provided as Figure 9.3-1. The maximum modeled magnetic field at the seabed at each landfall site is shown as approximately 1 amperes/meter (A/m) or approximately 12.5 mG. There are four peaks depicted in the magnetic field cross-section, corresponding to the four export cables being brought ashore via HDD at each landfall site. The peak values fall off very quickly with lateral distance from the cable centerlines. The modeled peak value of 12.5 mG is less than 1% of the ICNIRP health-protective magnetic field guidance of 2,000 mG. The results for the 275 kV case are similar.

9.3.3 Onshore Interconnection Cables

Underground electric power cables have been used for many decades in urban environments and are the preferred means for onshore transmission in the offshore wind arena. The Projects' onshore interconnection cables will travel underground from the landfall sites primarily along existing roadways, utility ROWs, and/or bike paths to the new onshore substation and/or converter station sites. From the onshore substations and/or converter stations, the onshore interconnection cables will continue to the proposed points of interconnection (POIs). The Larrabee Onshore Interconnection Cable Route connects the Monmouth Landfall Site to the existing Larrabee Substation POI. The Larrabee Onshore Interconnection Cable route will include a new substation and/or converter station at the Lanes Pond Road Site or the Randolph Road Site or the interconnection to a substation and/or converter station at the Brook Road Site developed under the New Jersey Board of Public Utilities (NJBPU) State Agreement Approach (SAA). The Cardiff Onshore Interconnection Cable Route connects the Atlantic Landfall Site to the existing Cardiff Substation POI. The Cardiff Onshore Interconnection Cable route will also include an additional substation and/or converter station option at Fire Road Site. As described in Section 4.8 of Volume I, the Cardiff and Larrabee Onshore Interconnection Cable Routes are approximately 12 mi long for the Larrabee Onshore Interconnection Cable Route and 14 mi (19 km) long for the Cardiff Onshore Interconnection Cable Route. Along each route, the onshore interconnection cables will be installed in buried concrete duct banks, with each cable housed in a high-density polyethylene (HDPE) or Polyvinyl Chloride (PVC) conduit. Typical cover over the buried duct bank (e.g., along roadway ROWs) will be approximately 3 ft (0.9 m).[79] The onshore interconnection cables will employ HVAC technology (up to four circuits for each Project consisting of up to twelve

[79] The maximum coverage over the top of the cable conduits could be up to 30 ft (9 m) in some specialty installation scenarios.

230 kV to 275 kV cables), HVDC technology (one circuit for each Project consisting of two 320 kV to 525 kV cables), and/or a combined HVAC/HVDC arrangement (four 275 kV HVAC circuits for one Project and one 525 kV HVDC circuit for the other Project).

As detailed in Appendix II-I, the HVAC underground onshore interconnection cables were modeled using a current of 1,200 amps at 230 or 275 kV for several different ROW configurations (e.g., roadway, bike path, existing ROW, etc.). For the 230 kV four-circuit, narrow ROW case, the maximum modeled magnetic field was approximately 17 A/m (212.5 mG). The modeled levels fall to approximately 3 A/m (37.5 mG) at a distance of 16.4 ft (5 m) on either side of the duct bank centerline. For ease of reference, the graphical results from Appendix II-I (Figure 4-104) are provided as Figure 9.3-2. The levels for the 275 kV case are slightly higher (19 A/m). In all cases, the modeled magnetic fields are well below the health-protective magnetic field guidance per ICNIRP of 160 A/m or 2,000 mG.

The HVDC underground onshore interconnection cables were modeled using a current of 2,000 amps at 320 or 525 kV. For the 320 kV HVDC cable circuit, a maximum magnetic field of 47 A/m (587 mG) was modeled. For the 525 kV HVDC cable circuit (monopole mode), a maximum magnetic field of 48 A/m (600 mG) was modeled. For ease of reference, the graphic representation of the modeling is provided as Figures 9.3-3 and 9.3-4, respectively (see Figures 4-114 and 4-132 from Appendix II-I). These modeled results are well below the applicable ICNIRP health protective guideline for static magnetic fields (400 A/m or 5,000 mG).

To analyze a combined HVAC/HVDC onshore interconnection arrangement, a single scenario was modeled with four 275 kV HVAC circuits and one 525 kV HVDC circuit in a single trench. It should be noted that this case was modeled using a range of HVAC and HVDC voltages, and that the data presented for the 275 kV HVAC/525 kV HVDC case are conservatively presented as having the maximum MF level of all configurations considered. Under this scenario, a maximum magnetic field of 78 A/m (975 mG) was modeled. For ease of reference, the graphic representation of the modeling is provided as Figure 9.3-5 (see Figure 4-110 from Appendix II-I). These modeled results are well below the applicable ICNIRP health protective guideline for time-varying magnetic fields (180 A/m or 2,000 mG).

9.3.4 Onshore Substation and/or Converter Station

As described in Section 4.9 of Volume I, the Project includes two onshore substations (one for each POI). At each onshore substation and/or converter station site, the transmission voltage will be stepped up or down, as necessary, in preparation for interconnection with the electric grid at either the existing Cardiff Substation POI or the existing Larrabee Substation POI. At this point in Project development, several onshore substation and/or converter station options are being considered (HVAC with 230 to 275 kV incoming voltage; HVDC with 320 to 525 kV incoming voltage; and air-insulated switchgear or gas-insulated switchgear design). A quantitative assessment of potential onshore substation and/or converter station EMF levels for a conceptual level 230 kV air-insulated switchgear design is provided in Section 4.2.2 of Appendix II-I.

For the purposes of assessing potential risks to human health from the onshore substation and/or converter station, the National Institutes of Environmental Health Sciences (NIESH) has stated:

> *The strength of the EMF from equipment within substations, such as transformers, reactors, and capacitor banks, decreases rapidly with increasing distance. Beyond the substation fence or wall, the EMF produced by the substation equipment is typically indistinguishable from background levels (NIESH 2002).*

Therefore, no risk to human health for the public outside the onshore substation fence is expected.