Kitty Hawk Wind

AVANGRID

Construction and Operations Plan

Appendix O - In-Air Acoustic Assessment

September 30, 2022

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AVANGRID

Appendix O – In-Air Acoustic Assessment

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Construction and Operations Plan
Kitty Hawk North Wind Project
Lease Area OCS-A 0508

Appendix O
In-Air Acoustic Assessment

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ACRONYMS AND ABBREVIATIONS

AICUZ	Air Installations Compatible Use Zones
dB	Decibel
dBA	A-weighted decibel
dBL	Linear decibel
DNL	day-night average sound level
electrical service platform (ESP)	Offshore structure that connects the inter-array cables to the offshore export cables
HDD	Horizontal Directional Drilling
HMMH	Harrison, Miller, Miller, and Hanson
Hz	Hertz
IMO	International Maritime Organization
ISO	International Organization for Standards
km	kilometer
landfall	The location where the export cables transition from offshore to onshore
L_{dn}	Day-Night Sound Level
Lease Area	The designated Renewable Energy Lease Area OCS-A 0508
L_{eq}	Equivalent Sound Level
m	meter
NEMA	National Electrical Manufacturers Association
NSA	Noise Sensitive Area
offshore export cables	Cables connecting the ESP to the transition joint bay at the landfall
onshore export cables	Cables connecting the transition joint bay at the landfall to the onshore substation
onshore substation	The landside substation constructed for the Project that contains transformers and other electrical gear
onshore substation site	A site located within the Corporate Landing Business Park in Virginia Beach, Virginia, which will contain the onshore substation, interconnection lines, and switching station
Project	Kitty Hawk North Wind Project
the Company	Kitty Hawk Wind, LLC
Wind Development Area	Approximately 40 percent of the Lease Area in the northwest corner closest to shore (19,441 hectares)
wind turbine generator (WTG)	Wind turbine that will generate electricity

O.1 INTRODUCTION

Kitty Hawk Wind, LLC (the Company), a wholly owned subsidiary of Avangrid Renewables, LLC, proposes to construct, own, and operate the Kitty Hawk North Wind Project (the Project). The Project will be located in the designated Renewable Energy Lease Area OCS-A 0508 (Lease Area). The Commercial Lease of Submerged Lands for Renewable Energy Development on the Outer Continental Shelf was awarded through the Bureau of Ocean Energy Management competitive renewable energy lease auction of the Wind Energy Area offshore of North Carolina. The Lease Area covers 49,536 hectares and is located approximately 44 kilometers (km) offshore of Corolla, North Carolina (Figure O-1).

At this time, the Company proposes to develop approximately 40 percent of the Lease Area in the northwest corner closest to shore (19,441 hectares; the Wind Development Area). The Project will connect from the electrical service platform (ESP) through offshore export cables (within a designated corridor) and onshore export cables to the new onshore substation and switching station in the City of Virginia Beach, Virginia, where the renewable electricity generated will be transmitted to the electric grid.

The offshore components of the Project, including the wind turbine generators (WTGs), ESP, and inter-array cables, will be located in federal waters within the Lease Area, while the offshore export cable corridors will traverse both federal and state territorial waters of Virginia. The onshore components of the Project, including the onshore export cables, the onshore substation, and switching station will be located in the City of Virginia Beach, Virginia.

This In-Air Acoustic Assessment has been completed to demonstrate how the overall Project has been adequately designed to minimize in-air sound impacts to the surrounding community and comply with state and local noise ordinances. A separate Underwater Acoustic Assessment (Appendix P) has been prepared to address the sound impacts associated with the Wind Development Area's underwater environment. The objectives of this In-Air Acoustic Assessment include identifying noise-sensitive land uses in the area that may be affected by the Project, as well as describing the standards by which the Project will be assessed. Existing conditions were documented through a publicly available ambient sound survey and population density, and Project compliance was assessed through the use of predictive acoustic modeling for construction and operations. If needed, practical measures were proposed to minimize adverse effects associated with the construction and operations of the Project. Mitigation measures are presented to show the feasibility of the Project to meet the specific noise requirements. However, final design may incorporate different mitigation measures in order to achieve the same objective, as demonstrated in this analysis.

The construction and operational scenarios relevant to the analysis presented in this In-Air Acoustic Assessment include the following:

- Construction and operations of the onshore substation and switching station;
- Construction of the onshore export cables;
- Specialized construction activities including:
    - Horizontal directional drilling (HDD) associated with installation of the export cables; and
    - Impact pile driving of WTG and ESP foundations;
- Vessel activity, including vessels associated with the installation of the offshore export cables in the nearshore environment as well as operations and maintenance vessels;
- Construction and operations of up to 69 WTGs, one ESP, and the associated inter-array cables; and
- Operation of sound signals (i.e., foghorns).

Additional activities may be identified as the Project is further evaluated and refined. Additional sound modeling may be completed, if needed, once final Project components are selected.

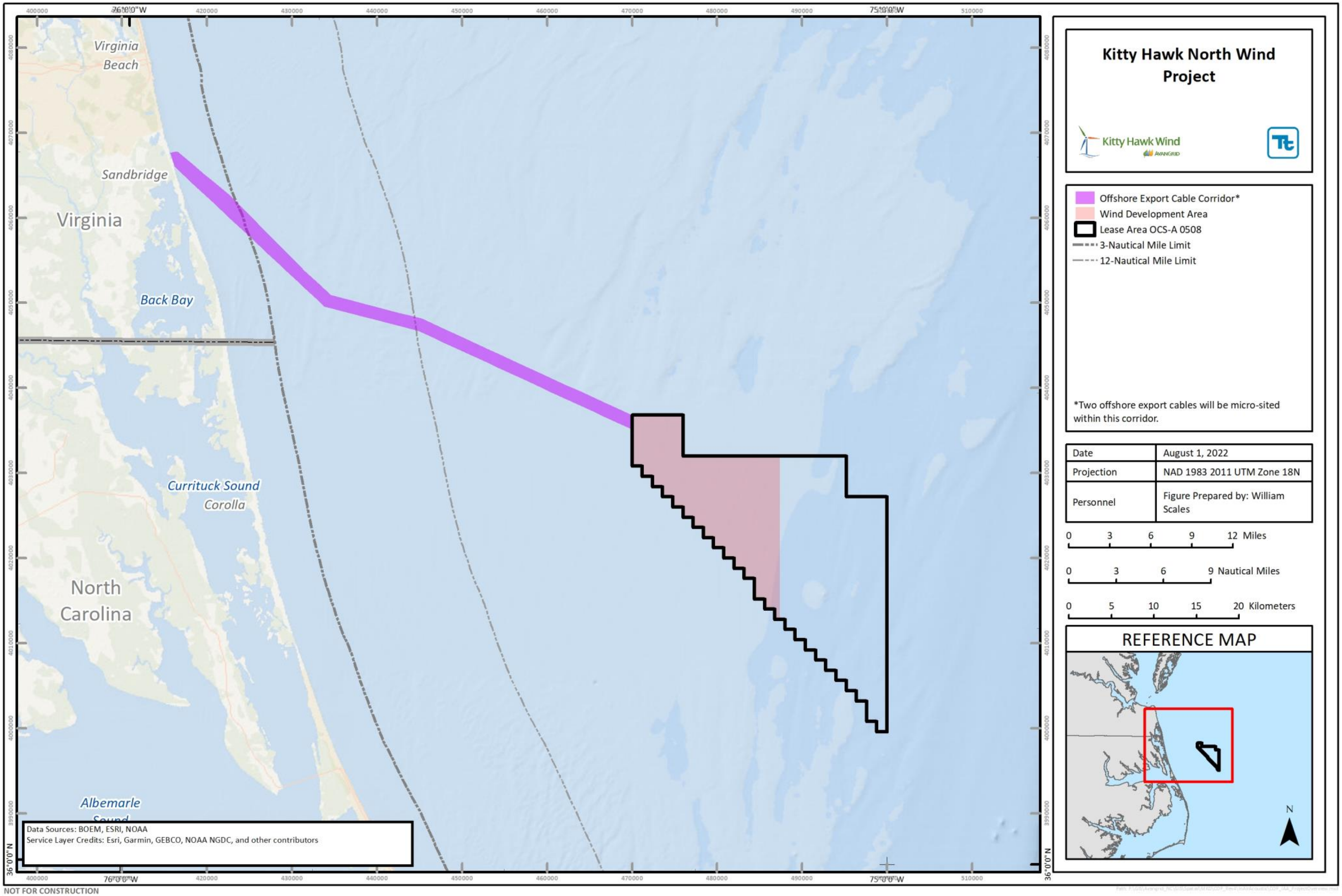

Figure O-1. Offshore Project Overview

O.1.1 Acoustic Concepts and Terminology

This section outlines some of the relevant acoustic concepts to help the non-specialist reader best understand the modeling assessment and results as presented in this report. Airborne sound is described as a rapid fluctuation or oscillation of air pressure above and below atmospheric pressure creating a sound wave. Sound energy is characterized by the properties of sound waves, which include frequency, wavelength, amplitude, and velocity. A sound source is defined by a sound power level (also referred to as L_W), which is independent of any external factors. Sound power is the rate at which acoustical energy is radiated outward and is expressed in units of watts. Sound energy propagates through a medium where it is sensed and then interpreted by a receiver. A sound pressure level (also referred to as L_P) is a measure of this fluctuation at a given receiver location and can be obtained through the use of a microphone or calculated from information about the source sound power level and the surrounding environment. Sound power, however, cannot be measured directly. It is calculated from measurements of sound intensity or sound pressure at a given distance from the source.

While the concept of sound is defined by the laws of physics, the term 'noise' has further qualities of being excessive or loud. The perception of sound as noise is influenced by several technical factors such as loudness, sound quality, tonality, duration, and the existing background levels. Sound levels are presented on a logarithmic scale to account for the large range of acoustic pressures that the human ear is exposed to and is expressed in units of decibels (dB). A decibel is defined as the ratio between a measured value and a reference value usually corresponding to the lower threshold of human hearing defined as 20 micropascals. Conversely, sound power is referenced to 1 picowatt.

Broadband sound includes sound energy summed across the frequency spectrum. In addition to broadband sound pressure levels, analysis of the various frequency components of the sound spectrum is completed to determine tonal characteristics. The unit of frequency is Hertz (Hz), measuring the cycles per second of the sound pressure waves and typically the frequency analysis examines nine octave bands from 32 Hz to 8,000 Hz. Since the human ear does not perceive individual frequencies with equal loudness, spectrally varying sounds are often adjusted with a weighting filter. The A-weighted filter (American National Standards Institute S1.42-2001, ANSI 2016) is applied to compensate for the frequency response of the human auditory system and sound exposure in acoustic assessments is designated in A-weighted decibels (dBA). Unweighted sound levels are referred to as linear. Linear decibels (dBL) are used to determine a sound's tonality and to engineer solutions to reduce or control noise as techniques are different for low and high frequency noise. Typical sound pressure levels associated with various in-air activities and environments are presented in Table O-1.

To take into account sound fluctuations, environmental sound is commonly described in terms of Equivalent Sound Level (L_{eq}). The L_{eq} value is the energy-averaged sound level over a given measurement period. It is further defined as the steady, continuous sound level, over a specified time, which has the same acoustic energy as the actual varying sound levels. Levels of many sounds change from moment to moment. Some sharp impulses last one second or less, while others rise and fall over much longer periods of time. There are various measures of sound pressure designed for different purposes. To describe the background ambient sound level, the L_{90} percentile metric, representing the quietest 10 percent of any time period. Conversely, the L_{10} is the sound level exceeded 10 percent of the time and is a measurement of intrusive noises, such as vehicular traffic or aircraft overflights, while the L_{50} metric is the sound level exceeded 50 percent of the time.

Table O-1. Sound Pressure Levels of Typical In-Air Noise Sources and Acoustic Environments

Noise Source or Activity	Sound Level (dBA)	Subjective Impression
Jet aircraft takeoff from carrier (15 meters [m])	140	Threshold of pain
50-horsepower siren (30 m)	130	

Noise Source or Activity	Sound Level (dBA)	Subjective Impression
Loud rock concert near stage Jet takeoff (61 m)	120	Uncomfortably loud
Float plane takeoff (31 m)	110	Very loud
Jet takeoff (610 m)	100	
Heavy truck or motorcycle (8 m)	90	
Garbage disposal Food blender (1 m) Pneumatic drill (15 m)	80	Loud
Vacuum cleaner (3 m)	70	Moderate
Passenger car at 65 miles per hour (8 m)	65	
Large store air-conditioning unit (6 m)	60	
Light auto traffic (31 m)	50	Quiet
Quiet rural residential area with no activity	45	
Bedroom or quiet living room Bird calls	40	Faint
Typical wilderness area	35	
Quiet library, soft whisper (5 m)	30	Very quiet
Wilderness with no wind or animal activity	25	Extremely quiet
High-quality recording studio	20	
Acoustic test chamber	10	Just audible
	0	Threshold of hearing
Source: Adapted from EPA 1971.		

O.2 REGULATORY CRITERIA

Applicable policies and regulations for the Project include federal, state, and municipal requirements, which help assure that facilities (such as the Project) do not create adverse or nuisance impacts on the community.

O.2.1 Federal Noise Requirements

There are no federal community noise regulations applicable to the Project. The federal government has long recognized the potential hazards caused by noise to the health and safety of humans. Project noise during construction and operations are regulated, in a sense, through portions of the Occupational Health and Safety Act of 1970. This regulation establishes standards for permissible sound exposure in the workplace to guard against the risk of hearing loss with sound exposure level of workers regulated at 90 dBA, over an 8-hour work shift. Project construction contractors will readily provide workers with Occupational Health and Safety Act approved hearing protection devices and identify high noise areas and activities when hearing protection will be required (e.g., areas in close proximity to pile driving operations) and further ensuring that personnel and the general public are adequately protected from potential noise hazards and extended exposure to high noise levels.

O.2.2 State Noise Requirements

The onshore components of the Project will be located in Virginia and a portion of the offshore export cables will be located in Virginia state waters. There are no state noise regulations applicable to the Project.

O.2.3 Local Noise Requirements

The onshore components of the Project will be located in the City of Virginia Beach, Virginia. There are local noise requirements for all proposed onshore locations and those requirements are described below. These restrictions will be followed unless work outside of these timeframes is authorized by the City of Virginia Beach.

O.2.3.1 The City of Virginia Beach

Virginia Beach, Virginia, Municipal Code 23 art. II (City of Virginia Beach 2020) includes provisions regulating sounds considered to be a hazard to public health, welfare, peace and safety, and quality of life, which are applicable to the Project. Virginia Beach, Virginia Municipal Code Section 23-69, Maximum Sound Levels And Residential Dwellings, provides absolute noise limits for both the nighttime and daytime periods. This section also states that construction activities are exempt from daytime provisions:

> *(a) Nighttime. No person shall permit, operate or cause any source of sound to create a sound level that can be heard in another person's residential dwelling during the hours between 10:00 p.m. and 7:00 a.m. in excess of 55 dBA when measured inside the residence at least four (4) feet from the wall nearest the source, with doors and windows to the receiving area closed.*
>
> *(b) Daytime. No person shall permit, operate or cause any source of sound to create a sound level in another person's residential dwelling during the hours between 7:00 a.m. and 10:00 p.m. in excess of 65 dBA when measured inside the residence at least four (4) feet from the wall nearest the source, with doors and windows to the receiving area closed.*
>
> *(d) Exemptions. The following activities or sources of noise shall be exempt from the daytime prohibition set forth in subsection (b) of this section:*
>
> > *(3) Activities related to the construction, repair, maintenance, remodeling or demolition, grading or other improvement of real property.*

Additionally, Virginia Beach, Virginia, Municipal Code Section 23-71, Specific Prohibitions, cites limits to noise activities within proximity to defined noise-sensitive areas (NSAs) and limits construction activities to between 7:00 a.m. and 9:00 p.m. as follows:

> *(e) Noise-sensitive areas. The making of any unreasonably loud and raucous noise within two hundred (200) feet of any school, place of worship, court, hospital, nursing home, or assisted-living facility while the same is being used as such, that substantially interferes with the workings of the institution.*
>
> *(f) Construction equipment. The operation of any bulldozer, crane, backhoe, front loader, pile driver, jackhammer, pneumatic drill, or other construction equipment between the hours of 9:00 p.m. and 7:00 a.m. except as provided in section 23-67 above, or as specifically deemed necessary and authorized by a written document issued by the city manager or his designee.*

O.3 EXISTING AMBIENT CONDITIONS

The affected environment, as described below, is defined as the coastal and onshore areas that have the potential to be directly and/or indirectly affected by the construction, operations, and decommissioning of the Project. This includes the onshore export cables, the onshore substation, switching station, and landfall (Figure O-2).

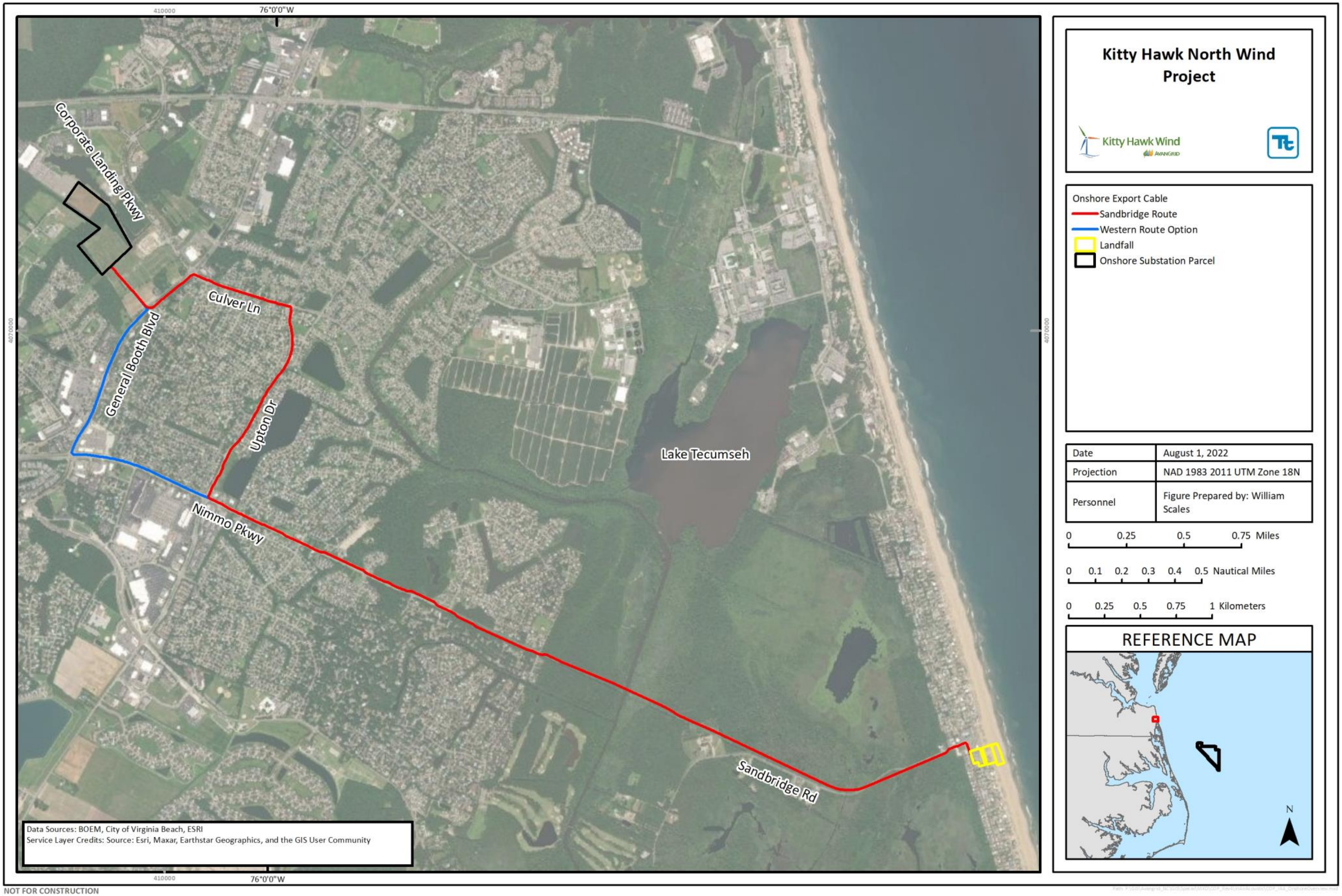

Figure O-2. Onshore Project Overview

Ambient sound levels are characterized by different metrics. To take into account sound fluctuations, environmental sound is commonly described in terms of L_{eq}. Day-Night Sound Level (also referred to as L_{dn}) is also a common metric to describe ambient noise levels over a 24-hour period, which includes a 10 dB penalty during the nighttime period. The ambient acoustic environment within the onshore review area, which encompasses the immediate surroundings of the onshore substation site, onshore export cables, and landfall location, is largely influenced by flyover noise from jets and vehicular traffic. Noise from jets associated with Naval Air Station Oceana, Naval Auxiliary Landing Field Fentress, and Norfolk International Airport, approximately 4 km, 13.4 km, and 26.7 km from the onshore substation site boundary respectively, are also present through the daytime and nighttime at the onshore substation site location.

Since Virginia Beach is home to those naval facilities, it is part of the Department of Defense's Air Installations Compatible Use Zones (AICUZ) Program, which is a program used to balance the need for aircraft operations and community concerns. The goal of the AICUZ Program is to protect the health, safety, and welfare of those living near a military airport while preserving its defense-flying mission. AICUZ guidelines define zones of high noise and accident potential and recommend uses compatible within these zones. The Department of Defense measures noise exposure using the day-night average sound levels (DNL). The DNL noise metric averages noise events that occur over a 24-hour period. Aircraft operations conducted at night (10:00 p.m. to 7:00 a.m.) are weighted because people are more sensitive to noise during normal sleeping hours when ambient noise levels are lower. The DNL contours on the AICUZ maps reflect the noise exposure in the surrounding communities and the fact that noise impacts diminish with distance from the airfield. DNL contours do not reflect the noise of individual aircraft events. DNL contours are used to assess average long-term noise exposure rather than the impact of a single event. As of 2005, around the Naval Air Station Oceana, almost 4,856 hectares are of residential use within noise contours above the 65 dBA DNL and approximately 1,214 hectares acres are in the highest noise zone above 75 dBA DNL. Around the Naval Auxiliary Landing Field Fentress, almost 1,214 hectares are of residential use within noise contours above the 65 dBA DNL and approximately 809 hectares are in the highest noise zone above 75 dBA DNL (Edaw Inc. 2005).

Harrison, Miller, Miller, and Hanson (HMMH) conducted a publicly available study titled "Evaluation of Traffic Noise Abatement Needs for Seven Corridors in the City of Virginia Beach" (HMMH 2018), which reports ambient sound levels within 0.8 km of the onshore substation site. The study shows a 24-hour Day-Night Sound Level of 66 dBA at this location, which would be equivalent to a L_{eq} of approximately 60 dBA. However, the HMMH study removes the contribution of plane noise from this ambient level, and as such, the actual ambient level is expected to be higher.

The HMMH study did not include ambient measurements within proximity to the proposed landfall. To estimate the ambient levels at this location, the population density method used by the Federal Transit Administration (FTA 2018) was used. According to the U.S Census Bureau records (2010), the City of Virginia Beach has approximately 1,759 people per square mile. The Federal Transit Administration methodology for estimating existing sound levels shows that a population density of this size results in sound levels of approximately 54 dBA Day-Night Sound Level, which is equivalent to a L_{eq} of approximately 48 dBA.

O.4 ACOUSTIC MODEL SETUP PARAMETERS

The acoustical modeling for the Project was conducted with the CadnaA® sound model from DataKustik GmbH (version 2020 MR1; DataKustik GmbH 2020). The outdoor sound propagation model is based on the International Organization for Standardization (ISO) 9613, Part 1: "Calculation of the absorption of sound by the atmosphere," (1993) and Part 2: "General method of calculation," (1996). Model predictions are accurate to within 1 dB and/or 1 dBA of calculations based on the ISO 9613 standard, as appropriate.

The ISO 9613 standard was instituted in CadnaA® to calculate propagation and attenuation of sound energy with distance, surface and building reflection, and shielding effects by equipment, buildings, and ground topography. Offsite topography was determined using United States Geological Survey digital elevation data with 30-m interval between height points for the Project Area. The sound model propagation calculation parameters are summarized in Table O-2, below.

CadnaA® allows for three basic types of sound sources to be introduced into the model: point, line, and area sources. Each sound-radiating element was modeled based on its sound emission pattern. Small dimension sources, such as transformer fans, which radiate sound hemispherically, were modeled as point sources. Larger dimensional sources, such as the onshore transformer walls and HDD rigs, were modeled as area sources. Transformers and onsite buildings and barriers were modeled as solid structures because diffracted paths around and over structures tend to reduce sound levels in certain directions.

Ground absorption rates are described by a numerical coefficient. For pavement and water bodies, the absorption coefficient is defined as G = 0 to account for reduced sound attenuation and higher reflectivity. In contrast, ground covered in vegetation, including suburban lawns, are acoustically absorptive and aid in sound attenuation, i.e., G = 1.0.

Table O-2. Acoustic Model Setup Parameters

Model Input	Parameter Value
Standards	ISO 9613-2, Acoustics – Attenuation of sound during propagation outdoors a/
Terrain description	United States Geological Survey topography
Ground absorption	0.0 for water surface, onsite area, reflective ground 0.5 for offsite areas, moderately absorptive ground
Receiver characteristics	1.52 m above ground level
Meteorological factors	Omnidirectional downwind propagation / mild to moderate atmospheric temperature inversion
Temperature	10°C
Relative humidity	70 percent

Note:
a/ Propagation calculations under the ISO 9613 standard incorporate the effects of downwind propagation (from facility to receptor) with wind speeds of 1 to 5 meters per second; 3.6 to 18 kilometers per hour measured at a height of 3 to 11 m above ground level.

O.5 ACOUSTIC MODELING SCENARIOS

The representative acoustic modeling scenarios were derived from descriptions of the expected construction activities and operational conditions through consultations between the Project design and engineering teams. The subsections that follow provide more detailed information about the parameters used to model the sound sources associated with each scenario.

O.5.1 Construction Acoustic Assessment

Two types of pile driving may be required during Project construction, impact and vibratory pile driving. Impact pile driving may be used to install the WTG and ESP foundations. Specialized HDD construction may also be required during landfall of the export cables. Onshore substation, switching station, and onshore export cables installation and construction generally consists of site clearing and grading, excavation (including road excavation for cable work), foundation work, building erection, and finishing work. During construction, there will also be vessels shuttling workers and equipment to the Wind Development Area.

O.5.1.1 Construction of Onshore Project Components

The construction of the onshore substation, onshore switching station, and the onshore export cables will result in a temporary increase in sound levels near the activity. The construction process will require the use of equipment that could be periodically audible from off-site locations at certain times. Onshore substation, switching station, and onshore export cable installation generally consists of site clearing and grading, excavation, foundation work, building erection, and finishing work, which is anticipated to have a total duration of up to 1.5 years.

The noise levels resulting from construction activities vary greatly depending on factors such as the type of equipment, the specific equipment model, the operations being performed, and the overall condition of the equipment. The United States Environmental Protection Agency has published data on the L_{eq} sound levels for typical construction phases (EPA 1971). Following the United States Environmental Protection Agency's method, sound levels were projected from the acoustic center of the construction footprint. This calculation conservatively assumes that all equipment would be operating concurrently onsite for the specified construction phase and that there would be no sound attenuation for ground absorption or onsite shielding by the existing buildings or structures.

The results of these calculations are presented in Table O-3 (below) and show estimated construction sound levels in A-weighted decibels will vary depending on construction phase and distance. The highest levels are expected to occur in proximity to the closest neighborhoods during the site grading and compaction phase. Construction noise levels at 152 meters (m) and 305 m are similar to existing daytime sound levels exhibited in the HMMH study. Thus, construction sound would not be expected to create a noise nuisance condition as it will be similar in character to existing daytime sound levels.

Table O-3. General Construction Noise Levels

Phase No.	Construction Phase	Example Construction Equipment	Equipment Noise Level at 15 meters dBA	Operational Usage Factor (%)	Composite Noise Level, dBA			
					15 m	76 m	152 m	305 m
1	Site clearing	Tracked dozer Wheeled tractor Wheeled loader Water truck	88 80 80 80	40 40 40 40	85	71	50	65
2	Site grading and compaction	Scraper Tracked dozer Grader Roller-compactor Wheeled loader Backhoe-loader Water Truck	85 88 82 75 80 80 80	40 40 40 20 40 40 40	88	73	68	62
3	Trenching and foundations	Excavator Backhoe-loader Skid-steer loader Wheeled loader Auger rig Tracked dozer Cement mixer truck Water truck	80 80 70 80 85 88 80 80	40 40 40 40 20 40 40 40	87	73	67	61

Phase No.	Construction Phase	Example Construction Equipment	Equipment Noise Level at 15 meters dBA	Operational Usage Factor (%)	Composite Noise Level, dBA			
					15 m	76 m	152 m	305 m
4	Equipment pads	Wheeled loader Mobile crane Forklift Flatbed truck Dump truck Cement mixer truck Water truck	80 82 80 75 80 80 80	40 16 40 40 40 40 40	83	70	64	58
5	Equipment installation	Compressor Mobile crane Forklift Wheeled loader Dump truck Specialty truck Water truck	81 82 80 80 80 75 80	40 16 40 40 40 40 40	84	70	64	58

While construction is exempt from the City of Virginia Beach noise regulations during the day, the Company will limit onshore construction activities to daytime periods, to the extent practicable, unless a situation arises that would require operations to continue into the night. Where use of equipment is needed, approval from the appropriate regulatory authority will be sought. In addition, the Company proposes to implement the following measures to avoid, minimize, and mitigate impacts:

- Construction will be limited to daytime period, to the extent practicable;
- Construction equipment will be well-maintained and vehicles using internal combustion engines equipped with mufflers will be regularly checked to ensure they are in good working order;
- Quieter-type adjustable backup alarms would be used for vehicles as feasible;
- Construction equipment will be located within the confines of a temporary construction easement;
- If noise issues are identified, the Company will install moveable temporary noise barriers as close to the sound sources as possible. These have been shown to effectively reduce sound levels by 5 to 15 dBA; and
- A Project hotline will be made available to help actively address all Project-related issues in a timely manner.

During the equipment installation phase, a helicopter may be used for overhead transmission line installation activities. The primary sources of wideband acoustic energy from helicopters are the main and tail rotor. Helicopters generally fly at low altitudes; therefore, potential temporary increases to ambient sound levels would occur in the area where helicopters are operating as well as along their flight path. Helicopter operations will only occur in the daytime.

In addition to the above listed construction equipment, pile driving may be needed to install the foundation for the onshore substation and switching station. The pile driving technique, vibratory or impact, has not been selected at this stage of Project design. In the event that vibratory pile driving is selected, noise levels would be expected to be consistent with those reported during the excavation phase of construction. If impact pile driving is required, higher noise levels may be produced for temporary short-term periods.

Due to the character of the impulsive sound they produce, impact pile drivers are not typically analyzed in combination with non-impulsive construction sound sources such as heavy-duty vehicles. Impulsive sounds are typically transient, brief (less than one second), broadband, and consist of high peak sound pressure with rapid rise time and rapid decay. Non-impulsive sound can be broadband, narrowband or tonal, brief or prolonged, continuous or intermittent) and typically do not have a high peak sound pressure with rapid rise/decay time that impulsive sounds do. Noise is generated from pile drivers from both the ram striking the pile as well as the operating steam, air, or diesel exhaust as it is exhausted from the cylinder (this is not present with hydraulic impact hammers). Assuming an approximate impact rate of 1,400 blows per minute, a sound pressure level of 111 dBA at 6 m is estimated. Assuming a load or usage factor of 20 percent, it is expected that sound from pile driving would attenuate to 70 dBA at a distance of approximately 305 m and would attenuate to below 60 dBA within 1.6 linear km of this construction activity, depending on meteorological and topographical effects.

O.5.1.2 HDD Construction at the Export Cable Landfall Work Area

Ocean to land transition of the export cables at the landfall will be completed using HDD techniques. The Company may install one or more scenarios to limit the impact on both the community and the environment. HDD construction was evaluated for up to three scenarios with two HDD sites per scenario. The sequence of activity is yet to be determined. HDD construction would be exempt from the City of Virginia Beach noise regulations during daytime operations (7 a.m. to 9 p.m.). Where practicable, the Company will look to avoid nighttime operations (9 p.m. to 7 a.m.); however, under some circumstances, they may be deemed necessary due to program, safety, or engineering needs. Should it be deemed necessary, the appropriate regulatory will be notified to seek a waiver from any restriction.

HDD construction equipment consists of HDD drill rigs and auxiliary support equipment including electric mud pumps, portable generators, mud mixing and cleaning equipment, forklifts, loaders, cranes, trucks, and portable light plants. Table O-4 presents the HDD components included in the analysis. Once the HDD and pull-back are complete, noise from the export cable landfall will be limited to typical construction activities associated with equipment such as tracked graders, backhoes and pickup trucks. Nighttime work may be required for cable landfall activities.

Table O-4. HDD Equipment Listing

HDD Equipment Component	Sound Level without Acoustical Treatment (dBA)
HDD drill rig and power unit	102
Drilling mud mixer/recycling unit	90
Mud pumping unit	102
Generator set, 100 kilowatts	100
Generator set, 200 kilowatts	102
Vertical sump pump	75

Table O-5 summarizes the predicted sound levels experienced at the closest NSAs for each HDD scenario. Distances are shown for NSAs to the closest operating HDD per scenario. The resulting sound contour isopleths for HDD construction are provided in Figure O-3, Figure O-4, and Figure O-5.

HDD construction activities at the landfall are assumed to occur during daytime unless a situation arises that would require operations to continue into the night. Where use of equipment is needed, approval from the appropriate regulatory authority will be sought.

In the case of nighttime operations at the landfall, only the HDD drill rig, power unit, light banks, and associated equipment needed for their safe operation will be used. Where additional equipment is needed, approval from the appropriate regulatory authority will be sought. If necessary near NSAs, subject to regulatory requirements and stakeholder engagement, the Company will install moveable temporary noise barriers as close to the sound sources as possible. These have been shown to effectively reduce sound levels by 5 to 15 dBA.

Table O-5. Sound Levels during HDD Construction

NSA	Received Sound Level per Scenario					
	Distance (m)	HDD 1 + HDD 2 (dBA)	Distance (m)	HDD 3 + HDD 4 (dBA)	Distance (m)	HDD 5 + HDD 6 (dBA)
NSA L-1	160	60	188	59	204	57
NSA L-2	127	61	157	60	189	58
NSA L-3	78	67	113	64	151	62
NSA L-4	196	57	231	55	267	52
NSA L-5	128	61	102	63	73	64
NSA L-6	146	61	114	62	79	64
NSA L-7	118	63	83	65	33	69
NSA L-8	116	63	82	65	31	70
NSA L-9	114	63	84	65	50	67
NSA L-10	142	61	110	63	68	65

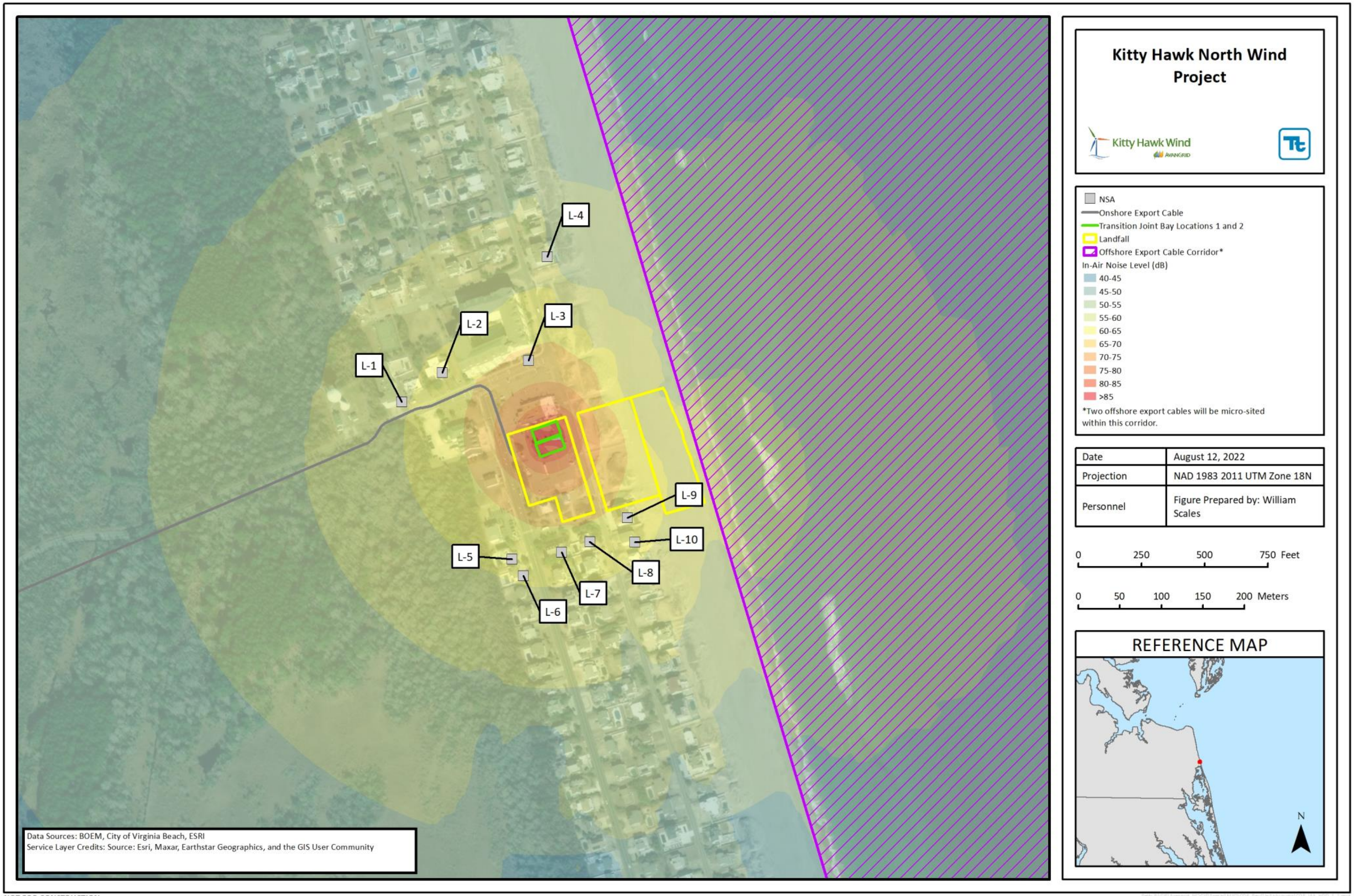

Figure O-3. HDD 1 and HDD 2 Contour Isopleth

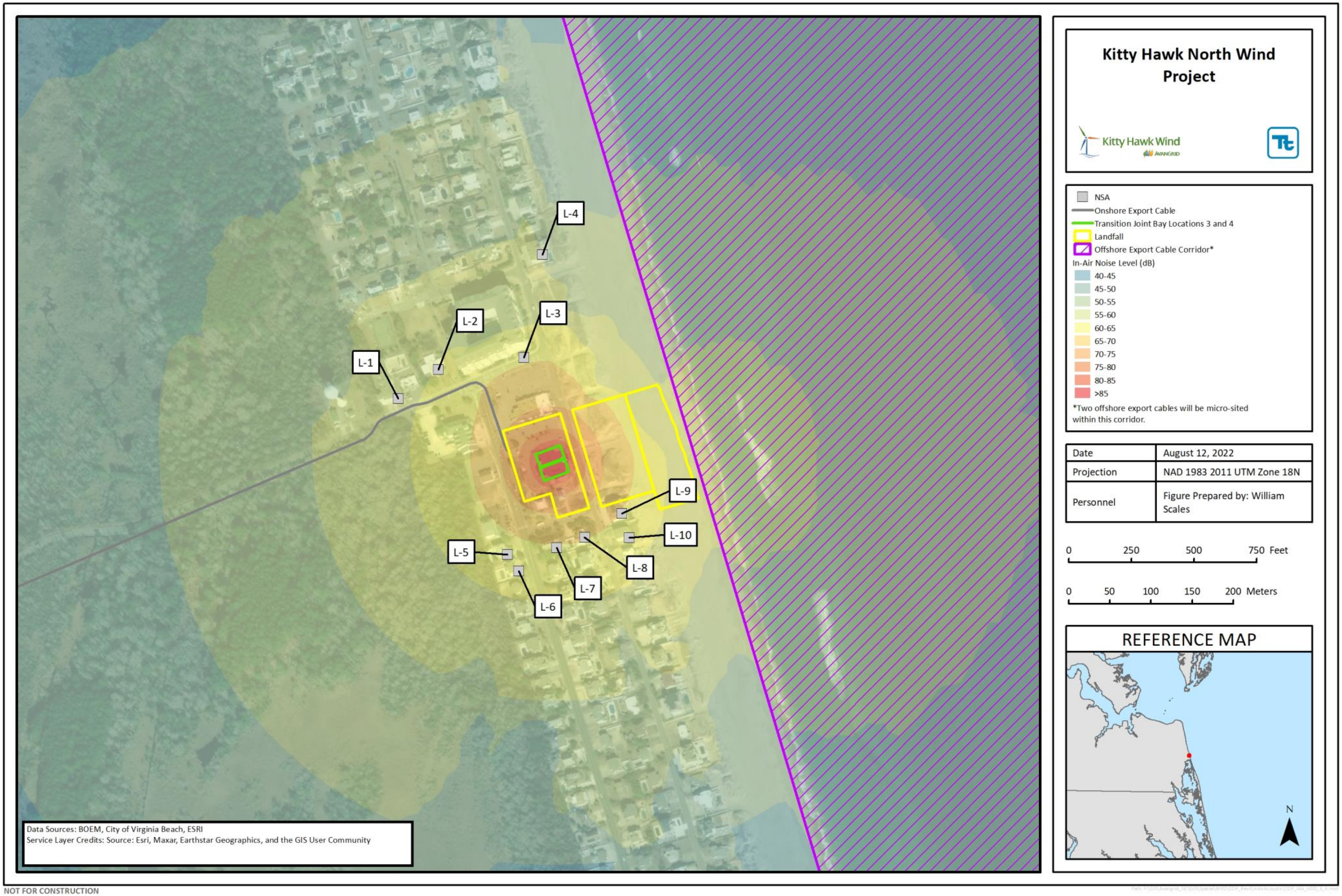

Figure O-4. HDD 3 and HDD 4 Contour Isopleth

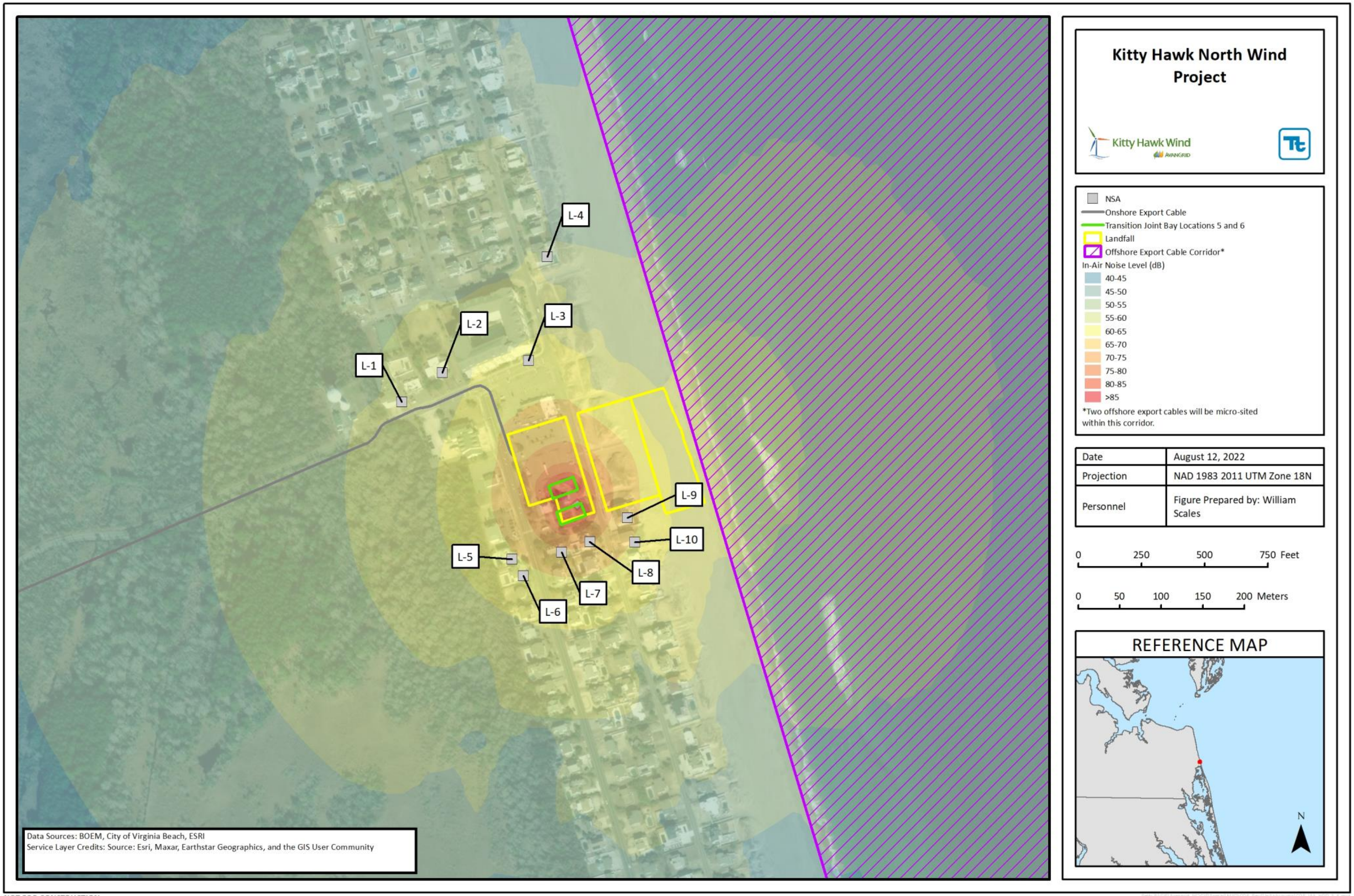

Figure O-5. HDD 5 and HDD 6 Contour Isopleth

O.5.1.3 Impact Pile Driving of WTG and ESP Foundations

Impact pile driving is performed by using hammers that drive a pile into the ground by first inducing downward velocity in a metal ram. Upon impact with the pile accessory, the ram creates a force far larger than its weight, which moves the pile into the ground by increments.

Generating higher sound levels than vibratory pile driving, impact pile installation of the monopile foundation is estimated to produce sound levels of 87 dBA in air at a distance of 122 m with a corresponding sound power level at the source of 137 dBA (USDOT 2012). This is analyzed as a worst-case scenario. Acoustic modeling was conducted for noise produced from impact pile driving of two WTG monopile foundations at the closest and furthest representative location relative to the shoreline, as this is anticipated to represent the maximum design scenario for this activity. Impact pile driving of the monopile, as opposed to the piled jacket design, was analyzed because it is considered the maximum design scenarios for potential onshore noise impacts. The separate Underwater Acoustic Assessment results can be found in Appendix P[1].

Received sound levels generated from impact pile driving during foundation installation are shown in Figure O-6. The highest predicted received sound level at any onshore location during pile driving is less than 30 dBA, which is well below applicable noise regulations. Given the extended distances between the Project and coastal shorelines (approximately 44 and 60 km), no negative impacts are expected from either WTG or ESP foundation installation.

O.5.1.4 Support Vessels

Vessels will transport crews and materials to the offshore Project Area during construction, and to a lesser extent during ongoing operations and maintenance. The installation of the export cables, inter-array cables, and WTG and ESP foundations will require a number of different types of construction vessels, including heavy lift vessels, cable installation, and crew transport vessels. The vessels used nearshore will have sound emissions similar to vessels currently in use in nearby waterways.

The International Maritime Organization (IMO) has established noise limits for vessels as a specialized agency of the United Nations whose primary purpose is to develop and maintain a regulatory framework for shipping including issues pertaining to safety, environmental concerns, legal matters, technical cooperation, maritime security, and the efficiency of shipping. The IMO publishes regulatory guidance documents on these issues (IMO 1981, 1975) and published "Noise Levels on Board Ships," which contains the Code on Noise Levels on Board Ships (resolution A.468(XII)), developed to promote noise control at a national level within the framework of internationally agreed-upon guidelines. In terms of sound generation limits of vessels, IMO resolution A.468 limits received noise levels to 70 dBA at designated listening stations located at the navigation bridge and windows during normal sail and operational conditions. In addition, the IMO further limits noise to 75 dBA at external areas and rescue stations with recommended limits 5 dBA lower. The vessels used for nearshore work and vessels transiting between construction ports and the Wind Development Area are expected to comply with these IMO noise standards.

Nearshore, offshore export cables installation activities move along the cable laterally. Therefore, no shoreline NSAs will be exposed to significant noise levels for an extended period of time. Due to the relatively short duration, it is not anticipated that construction activities associated with the installation of the offshore export cables will cause any significant impact in the communities along the shoreline.

[1] The Company is updating Appendix P Underwater Acoustic Assessment, and it will be provided to BOEM in Q1 2023.

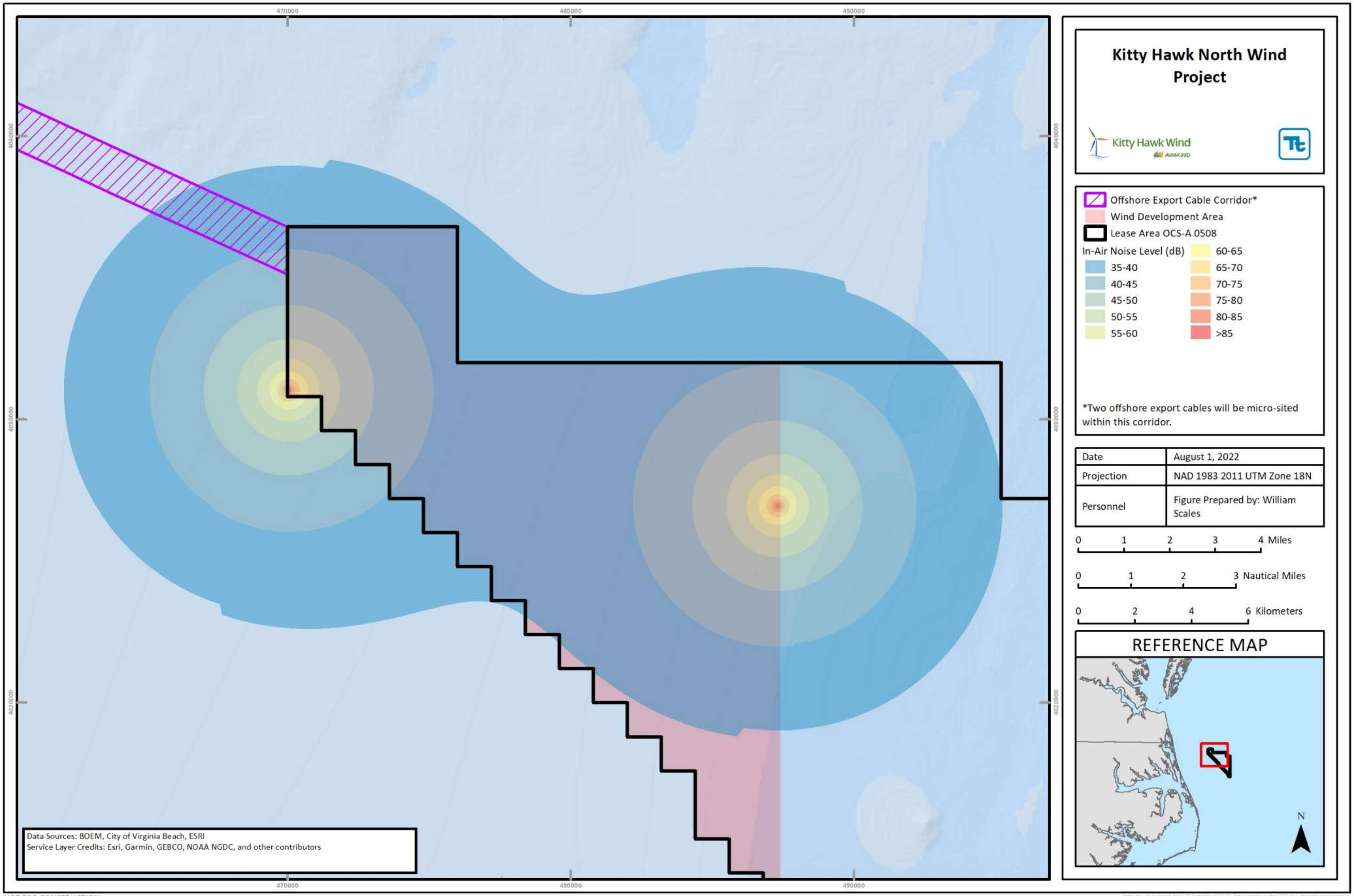

Figure O-6. Impact Pile Driving Received Sound Levels (In-Air)

O.5.2 Operational Acoustic Assessment

The operational component of the Project consists of WTGs, ESP, export cable, the onshore substation, switching station, and sound signals (i.e., foghorns). Of these sources, only the onshore substation and associated transformers and auxiliary equipment are regulated under applicable noise policy.

O.5.2.1 WTGs and ESP

The expected WTG sound level will be below audibility thresholds at all coastal areas. Sound generated by an operating wind turbine is comprised of both aerodynamic and mechanical sound with the dominant sound component from utility scale wind turbines being largely aerodynamic. Aerodynamic sound refers to the sound produced from air flow and the interaction with the wind turbine tower structure and moving rotor blades. Mechanical sound is generated at the gearbox, generator, and cooling fan, and is radiated from the surfaces of the nacelle and machinery enclosure and by openings in the nacelle casing. Due to the improved design of wind turbine mechanical components and the use of improved noise damping materials within the nacelle, including elastomeric elements supporting the generator and gearbox, mechanical sound emissions have been minimized.

Wind facilities, in comparison to conventional energy projects, are somewhat unique in that the sound generated by each individual wind turbine will increase as the wind speed across the site increases. Wind turbine sound is negligible when the rotor is at rest, increases as the rotor tip speed increases, and is generally constant once rated power output and maximum rotational speed are achieved. Under maximum rotational wind speed the assumed maximum sound power level will be reached, generally occurring at approximately 7 to 9 meters per second depending on wind turbine type and according to manufacturer specifications. It is important to recognize, as wind speeds increase, the background ambient sound level will likely increase as well, resulting in acoustic masking effects. The net result is that during periods of elevated wind when higher wind turbine sound emissions occur, the sound produced from a wind turbine operating at maximum rotational speed may well be largely or fully masked by wind generated sounds of foliage or by increased sound related to waves crashing on the shoreline. In practical terms, this means that a nearby receptor may hear these other sound sources (i.e., foliage, ocean waves) rather than the sound of a wind turbine.

Offshore wind facility operations are unique due to reflective nature of sounds surrounded by water and the impact of the shoreline on sound attenuation. As sound waves reach the coastline, a modification of the ground boundary occurs. This sudden change produces a supplementary sound attenuation due to the partial reflection of sound waves. In addition, the wind and temperature gradients are modified as the sea and the land are not always at the same temperature, thus generating friction at the ground surface. These effects result in a variation in the speed and curve of the sound waves. Few studies have been made of the shoreline effect and its effect on acoustical propagation. However, an average attenuation for low frequencies has been documented at 3 dB (Johansson 2003) up to 1,000 m, and then increasing with distance.

In addition, sound propagation from offshore wind turbines is different than propagation from land-based wind turbines. Sound propagation over water at large distances (generally above 2,000-3,000 m) involves a completely reflective surface and is dependent on the distance between the receiver and the sound source. As this distance increases, the effect of water reflection also increases. The influence of the reflecting water on the received sound level may be just as strong as the direct contribution from the sound source. In addition, downwind refractive effects result in a cylindrical wave spreading to form a reflecting layer in the atmosphere at a specified height. Strong reflection may occur during certain periods of the year with higher gradients in wind speed and direction at relatively low heights. Due to this reflecting layer, the sound from a source may be enclosed and form spherical waves that appear at certain distances as a cylindrical wave. This cylindrical spreading of sound energy due to multiple reflections from the sea surface generates a reduced sound at large distances with a slower rate of reduction than sound propagating over land, similar to the effect created by atmospheric temperature and wind gradients. Therefore, sound propagation over water is variable and dependent on a number of factors including:

- The distance over water from the sound source to the receiver;
- The height of the sound source above the completely reflective water surface;
- The height of the atmospheric inversion layer trapping the sound waves below the height of the source, thus creating the cylindrical wave;
- The atmospheric absorption coefficient due to the shoreline effect; and
- The attenuation due to the ground damping and the damping of sound.

As a result, the transmission loss between the received sound pressure at the receiver point and at the sound source may vary considerably due to these noted factors that are unique to offshore sound sources such as offshore WTGs.

Similarly, sound levels from ESP operations will be inaudible at all coastal areas. The ESP will house equipment for high-voltage transmission, including switchgears, transformers, reactors, and control and monitoring equipment. This equipment will not operate at high enough levels to impact any coastal area.

Offshore receptors (boaters) may be subject to higher sound levels resulting from wind turbine operations depending on their distance relative to the wind turbines. However, even within the immediate proximity of the WTGs and ESP, these levels will be well below the relevant Occupational Health and Safety Act health and safety requirements.

O.5.2.2 Onshore Substation and Switching Station

The onshore substation and switching station locations were evaluated at the Corporate Landing parcel. Figure O-7 shows the onshore Project features at the onshore substation site.

Electrical onshore substations, as well as switching stations, have switching, protection and control equipment, as well as one or more transformers that can generate sound, generally described as a 'low humming'. There are three main sound sources associated with a transformer: core sound, load sound, and sound generated by the operation of the cooling equipment. The core is the principal sound source, predominately occurring within the intermediate frequency range between 100 Hz and 600 Hz. The relative magnitudes of the sound at these different frequency levels are dependent on the design of the transformer (i.e., core material, core geometry). However, the sound generated is largely independent of the transformer load. The load sound is primarily caused by the load current in the transformer's conducting coils (or windings), and the main frequency of this sound is equal to twice the supply frequency; 100 Hz for 50 Hz transformers and 120 Hz for 60 Hz transformers. The cooling equipment (fans and pumps) typically dominates when operating in secondary cooling modes.

Transformers are designed and catalogued by either kilovolt ampere or megavolt ampere ratings. Just as horsepower ratings designate the power capacity of an electric motor, a transformer's ampere rating indicates its maximum power output capacity. The transformer industry uses the National Electrical Manufacturers Association (NEMA) published NEMA Standards TR1-1993 (R2000) (NEMA 1993). These standards establish noise ratings to designate the maximum sound emitted from transformers, voltage regulators, and shunt reactors based on the equipment's method of cooling, its dielectric fluid (air-cooled versus oil-cooled) type and its electric power rating. The NEMA methodology for measuring sound involves A-weighted sound measurements using microphones positioned from a tautly drawn string that encircles the device at a height that is one-half the overall height of the device. The equipment sound output is the average of all measurements taken around the perimeter, incorporating contributions from both cooling fans and transformer casing.

Shunt reactors contain components similar to power transformers, but its sound is primarily generated from vibrational forces resulting from magnetic “pull” effects at iron-air interfaces. Also, unlike transformers, the operation of shunt reactors is typically intermittent, occurring only when voltage stabilization is needed during load variation. Both transformers and shunt reactors were included in the acoustic modeling analysis. Circuit-breaker operations may also cause audible sound. Particularly the operation of air-blast breakers, characterized as an impulsive sound event of very short duration. These are expected to occur no more than a few times throughout the year. Because of its short duration and infrequent occurrence, circuit breaker sound was not considered in this sound modeling analysis.

While the onshore substation and switching station engineering design is only at a conceptual level, it is reasonable to expect that any transformer installed as part of the Project will conform to all relevant NEMA standards. However, it is possible that the final warranty sound specifications could vary slightly. Representative octave band center frequencies used in the noise model were derived from standardized engineering technical guidelines and based on measurements from similar equipment types.

The Company has provided the estimated number and sound power levels for the onshore substation and switching station equipment presented below in Table O-6. This is the equipment and associated sound power levels that were used for the modeling of the onshore substation and switching station. All equipment associated with the onshore substation and switching station was modeled to be operating concurrently.

Table O-6. Sound Ratings of Onshore Substation and Switching Station Components

Equipment	Quantity (Onshore Substation)	Quantity (Switching Station)	Sound Power Level (dBA)
275kV, 110-220 MVAR Shunt Reactor	2	0	95
230kV, 100 MVAR Shunt Reactor	2	0	95
275/230 kV, 450 MVA Transformer	2	0	107
Auxiliary Transformer	3	0	70
230 kV DRC Transformer	2	0	95
230 kV Harmonic Filter	2	0	60
Cooler Unit	2	0	85
HPL Compact Breaker	18	12	60
Exhaust Fans	6	0	64
Air Handling Units	6	0	74

The received sound levels were evaluated at the NSAs located closest to the onshore substation site. The resultant sound contour plots display operational sound levels in Figure O-8. As shown in Table O-7, compliance is successfully demonstrated with the applicable 55 dBA nighttime noise limit prescribed by the City of Virginia Beach. However, please note that modeling results represent predicted sound levels at the outside of the NSAs and the City of Virginia Beach 55 dBA nighttime limit is actually applicable as measured inside the residence. Due to sound attenuation provided by the residential structure, received sound levels inside the NSA residences would be even lower than the modeled results given in Table O-7.

Table O-7. Onshore Substation and Switching Station Predicted Nighttime Sound Levels at Nearest NSAs

Location	Distance (m)	Regulatory Limit (dBA L_{eq})	Modeling Results (dBA L_{eq})
NSA-S-1	75	55	53
NSA-S-2	168	55	50
NSA-S-3	290	55	47
NSA-S-4	259	55	45
NSA-S-5	152	55	46
NSA-S-6	152	55	46
NSA-S-7	152	55	46
NSA-S-8	152	55	46
NSA-S-9	152	55	45
NSA-S-10	152	55	45
NSA-S-11	152	55	45
NSA-S-12	152	55	45
NSA-S-13	152	55	45
NSA-S-14	152	55	44
NSA-S-15	152	55	44
NSA-S-16	152	55	44
NSA-S-17	152	55	44
NSA-S-18	183	55	43
NSA-S-19	457	55	38
NSA-S-20	427	55	39
NSA-S-21	351	55	39
NSA-S-22	457	55	39
NSA-S-23	488	55	39
NSA-S-24	549	55	41

Note:
Modeling results represent predicted sound levels at the outside of the NSAs and the City of Virginia Beach 55 dBA nighttime limit is actually applicable as measured inside the residence. Due to sound attenuation provided by the residential structure, received sound levels inside the NSA residences would be even lower than the modeled results given in Table O-7.

O.5.2.3 Sound Signals

Sound signals (i.e., foghorns) may be installed on select WTGs along the outer perimeter of the Wind Development Area. Due to the large amount of distance between the origin of the sound signals to the nearshore environment, the sound level there will be below the threshold of human perception.

Requirements detailed in 33 Code of Federal Regulations § 67 call for a foghorn to be installed at least 10 feet (3 m) but not more than 150 feet (46 m) above mean high water and have a sound signal audible to 0.5 nautical miles (0.9 km). The regulation also requires the foghorn to emit a tone of 119.8 dB at a frequency of 822 Hz occurring for a period of 2 seconds during a 20 second cycle (18 seconds silence). Sound levels were evaluated assuming installation of foghorns on the WTGs closest to the shoreline. Results show that under standard downwind propagation conditions, the received sound levels generated by the foghorn are expected to attenuate to a less than perceivable level onshore.

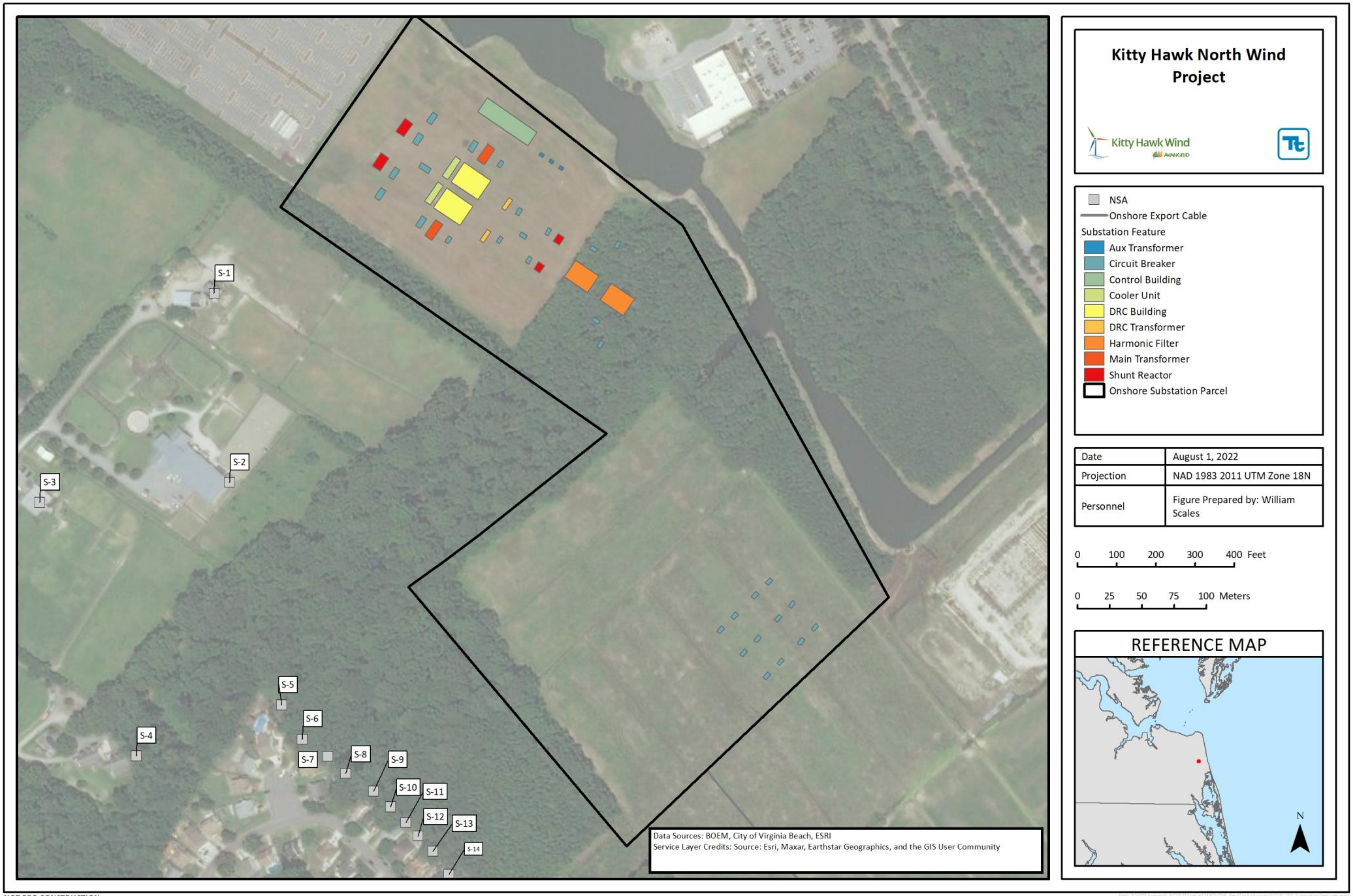

Figure O-7. Onshore Substation Site Features

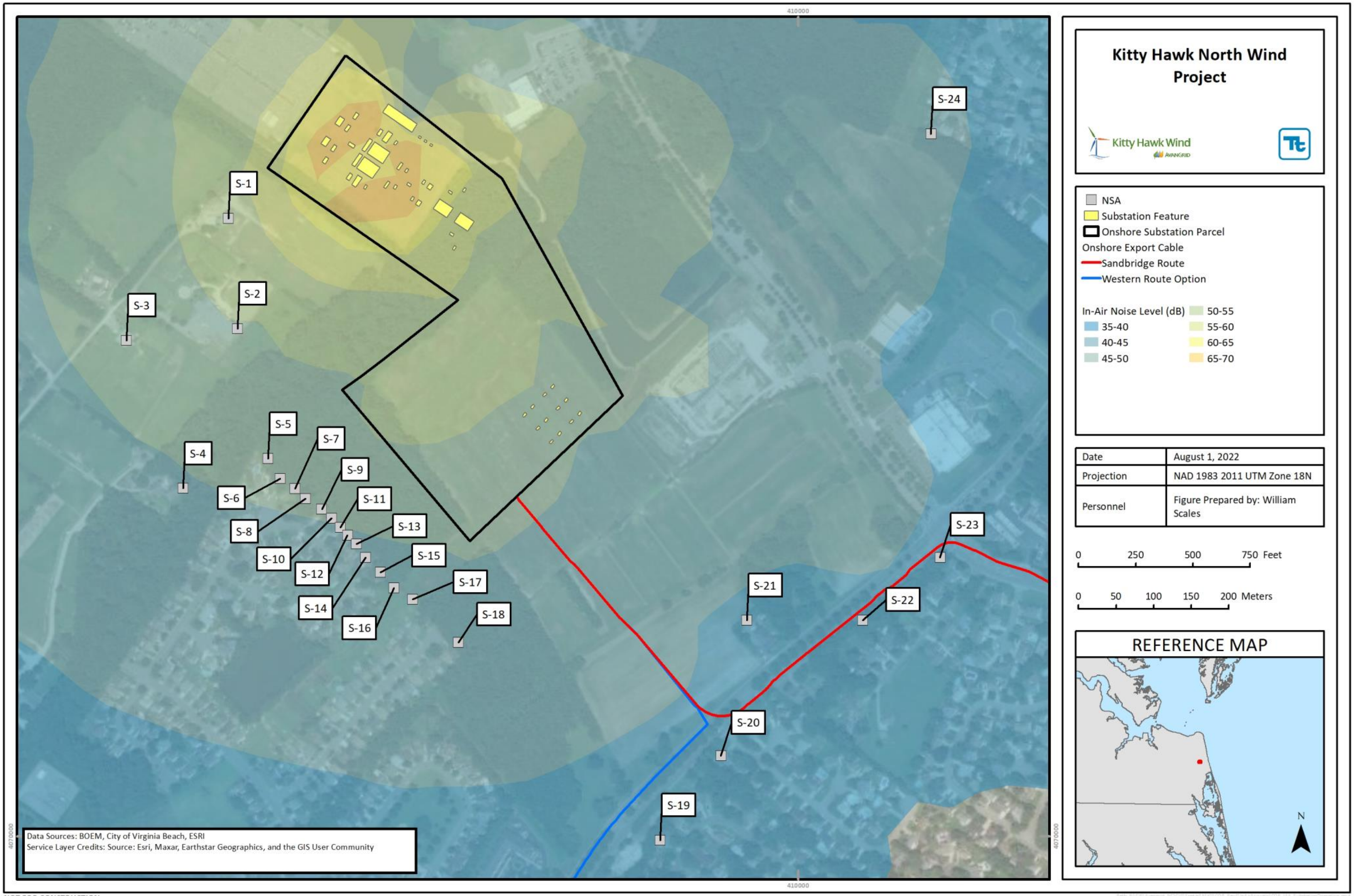

Figure O-8. Onshore Substation Site Operational Sound Levels

O.6 CONCLUSIONS

In-air acoustic modeling was conducted for the Project in order to assess the potential noise impacts associated with construction and operations activities. The modeling analysis was conducted using the parameters and methodology described in Sections O-4 and O-5 of this report. Results are displayed in the form of sound contour plots, with Project-generated sound levels shown as color-coded isopleths in 5 dBA increments. The resultant sound contour plots are independent of the existing acoustic environment (i.e., the plots and tabulated results represent Project-generated sound levels only).

Project construction noise was analyzed at varying distances from typical sources associated with site clearing, site grading and compaction, trenching and foundations, equipment pads, and equipment installation phases for onshore substation, switching station, and onshore export cable construction. Construction levels will primarily be limited to daytime hours. If required, noise mitigation strategies will be used to minimize offsite noise impacts to the extent practicable pending engagement with regulatory agencies and other stakeholders, as applicable.

The export cables will require HDD operations at the landfall. The HDD sound levels could reach 67 dBA during HDD 1 and HDD 2 construction, 65 dBA during HDD 3 and HDD 4 construction, and 70 dBA for HDD 5 and HDD 6 construction. If any noise issues are identified, moveable temporary noise barriers can be erected with placement as close to the sound sources as possible. These barriers have been shown to effectively reduce sound levels by 5 to 15 dBA.

Impact pile driving will occur offshore during the construction phase to install the WTG and ESP foundations. The highest predicted received sound level at any onshore location during pile driving is less than 30 dBA, which is well below all applicable noise regulations. Given the extended distances between the coastal shoreline (approximately 44 km) no onshore impacts are expected.

Onshore substation and switching station operational impacts were evaluated based on onshore substation and switching station equipment and associated sound power levels provided by the Company. Sound levels associated with the onshore substation and switching station will be in compliance with applicable noise regulations, with a maximum impact of 53 dBA at the nearest NSAs, based on the current preliminary design.

Operations associated with WTGs, ESP, and sound signals will not have an impact to the nearshore environment due to the large distance between the source of these sounds and the shoreline.

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