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August 30, 2022

Mr. Tim Allen
Branch of Air & Water Resources
United States Fish and Wildlife Service
7333 W. Jefferson, Suite 375
Lakewood CO 80235

Subject: Coastal Virginia Offshore Wind Commercial Project - Modeling Protocol Supplement CALPUFF Modeling for Class I Area AQRVs Assessment

Dear Mr. Allen,

The Virginia Electric and Power Company, doing business as Dominion Energy Virginia (hereafter referred to as Dominion Energy), is proposing to construct, own, and operate the Coastal Virginia Offshore Wind Commercial (CVOW) Commercial Project (herein referred to as the Project). The Project will be located in the Commercial Lease of Submerged Lands for Renewable Energy Development on the Outer Continental Shelf (OCS) Offshore Virginia (Lease No. OCS-A 0483) (Lease Area). On July 18, 2022, Dominion Energy provided the U.S. Environmental Protection Agency (EPA) Region 3 with an updated proposed modeling protocol (Protocol) for the Project to address the near-field air quality dispersion modeling analysis in support of the Outer Continental Shelf (OCS) permitting. In accordance with federal Prevention of Significant Deterioration (PSD) regulations, additional impacts must be addressed for projects subject to PSD review. This letter is a supplement to the Protocol to address CALPUFF modeling to assess Class I area Air Quality Related Values (AQRVs). An AQRV is defined as "… a resource, identified by the Federal Land Manager (FLM) for one or more Federal areas that may be adversely affected by a change in air quality. The resource may include visibility or a specific scenic, cultural, physical, biological, ecological, or recreational resource identified by the FLM for a particular area"[1].

As discussed on August 15, 2022, this Protocol Supplement is being submitted to the U.S. Fish and Wildlife Service (USFWS) for review and approval of the CALPUFF modeling procedures and data that are proposed for use in the Class I AQRVs assessment.

Project Description

The purpose of this Project is to provide between 2,500 and 3,000 megawatts (MW) of clean, reliable offshore wind energy; to increase the amount and availability of renewable energy to Virginia and North Carolina consumers; to create the opportunity to displace electricity generated by fossil fuel-powered plants, and to offer substantial economic and environmental benefits to the Commonwealth of Virginia.

[1] Federal Land Managers' Air Quality Related Values Work Group (FLAG). Phase 1 Report – Revised (2010). Natural Resource Report NPS/NRPC/NRR – 2010/232

This Project represents a viable and needed opportunity for Virginia to obtain clean renewable energy and realize its economic and environmental goals. The Lease Area covers approximately 112,799 acres (ac; 45,658 hectares [ha]) and is approximately 27 statute miles (mi; 23.75 nautical miles [nm], 43.99 kilometers [km]) off the Virginia Beach coastline (**Figure 1**).

Air emissions from the proposed Project primarily consist of products of combustion from the vessels associated with the construction and operation of the Project. The Project is subject to PSD major source preconstruction permitting requirements.

PSD Additional Impact Assessments

In accordance with federal PSD regulations, additional impacts must be addressed for projects subject to PSD review. The additional PSD impact analyses for Class I areas are discussed below.

The nearest Class I area to the Project is the Swanquarter Wilderness area in North Carolina, located 179 km south-southeast of the Lease Area boundary. The only other Class I area within 300 km of the Lease Area boundary is the Shenandoah National Park in Virginia located (295 km northwest). The next closest, beyond 300 km, are E.B. Forsythe (Brigantine) National Wilderness Area in New Jersey (304 km north-northeast) and the James River Face Wilderness in Virginia (334 km northwest). All other Class I areas are over 400 km away (**Figure 2**). Swanquarter and Brigantine are managed by the USFWS. Shenandoah is managed by the National Park Service (NPS). James River Face is managed by the US Forest Service (USFS).

Due to proximity and the expected emissions, the USFWS requires an AQRV assessment for Swanquarter. The AQRVs assessed will be Sulfur (S) and Nitrogen (N) deposition and visibility impairment. A decision by the National Park Service for the requirement of an AQRV assessment for Shenandoah is still pending.

CALPUFF Class I Modeling Assessments

Model Selection

CALPUFF is a Lagrangian modeling system recommended for Class I area air quality impact assessments by the FLM Workgroup. From April 2003 until January 2017, CALPUFF was the EPA's preferred model for assessing NAAQS and/or PSD increments in situations of long-range transport (at distances greater than 31 mi [50 km]) of emissions. With the 2017 revisions to the *Guideline on Air Quality Models* (Appendix W to 40 CFR Part 51), CALPUFF was delisted as an EPA-preferred model, yet retained as a screening technique for long-range transport assessments for NAAQS and PSD increments. Nevertheless, the CALPUFF modeling system has remained the FLM's preferred model for assessing AQRVs at Class I areas and is proposed for use in this AQRV assessment.

CALPUFF is a multi-layer, multi-species non-steady-state puff model that simulates the effects of time- and space-varying meteorological conditions on pollution transport, transformation, dispersion and removal through the treatment of air pollutant emissions from sources released as a series of discrete puffs. Each puff is tracked individually by the model until it leaves the modeling domain, and the contribution of each puff to receptor concentrations (or deposition fluxes) is calculated separately and can be used to create individual source impacts, or summed to create total impacts over source groups based on the user's selections. CALPUFF can use three-dimensional meteorological fields developed by the CALMET model based on prognostic meteorological model output (e.g., Weather Research and Forecasting model, or WRF), station meteorological data (surface observations and upper air soundings), or a combination of both (hybrid mode). CALPUFF can also accept prognostic meteorological data that is processed through the EPA Mesoscale Model Interface Program (MMIF). CALPUFF can be applied on scales of tens to hundreds of kilometers. It includes algorithms for sub-grid scale effects (such as terrain impingement), as well as longer range effects (such as pollutant removal due to wet scavenging and dry deposition, chemical transformation, and visibility effects of particulate matter concentrations). CALPUFF is well suited for situations involving complex flows including spatial changes in meteorological fields due to factors such as the presence of complex terrain or the influence of water bodies. CALPUFF can assess plume fumigation (coastal fumigation or inversion break-up conditions), light wind speed or calm wind impacts, or other factors for which a steady-state straight-line modeling approach is not appropriate. CALPUFF can account for the cumulative impact of multiple spatially distributed sources with temporally varying emissions within a large region. CALPUFF can properly model the emissions associated with the construction of an offshore wind farm which vary in space and time.

CALPUFF View

CALPUFF View is a CALPUFF model graphical user interface (GUI) developed and maintained by Lakes Environmental (Ontario, Canada). The software amalgamates the various CALPUFF pre- and post-processing programs, providing a user-friendly model setup wizard interface and other tools and creates a graphical display of the various model inputs and outputs for visualization and quality assurance / quality control (QA/QC). CALPUFF View has been specifically developed to facilitate long-range visibility and deposition assessments for Class I areas as described in FLAG 2010, containing a database of the various parameters for each specific Class I area as defined in Tables 5 through 10 of FLAG 2010. The CALPUFF View software is proposed to be used to facilitate the modeling assessment.

Source Data

During construction, primary Project emissions sources include marine vessel engines. As required by EPA and Virginia regulations, air permit applications for new major facilities must include a BACT review in accordance with 40 CFR 52.21 and 9VAC5-80-1705 (for criteria pollutants where the Project area is designated as an attainment area). Virginia regulations also require a BACT review for minor new source review pollutants in accordance with 9VAC5-80-1180. Table 1 lists the preliminarily proposed BACT control options for diesel engines located on any marine vessel used during construction, commissioning, operation, and maintenance of the Project, when that marine vessel qualifies as an "OCS source," as defined in 40 CFR § 55.2.

Table 1 Preliminarily Proposed Project BACT Summary

Pollutant	Control Technology or Limitation
Marine Vessels When Operating as OCS Sources	
NO_X VOC CO $PM/PM_{10}/PM_{2.5}$ GHG	• Use of the highest-tier engines available to the Project at the time of vessel deployment; and • Good combustion practices
$PM/PM_{10}/PM_{2.5}$, SO_2	• Use of ULSD for all vessels that are fueled exclusively at U.S.-based terminals; and • At a minimum, use of LSMGO containing no more than 0.1 percent sulfur by weight for any vessels that are fueled at marine terminals located outside the United States
Permanent Backup Generator Engines	
NO_X VOC CO $PM/PM_{10}/PM_{2.5}$	• Use of engines that comply with the applicable New Source Performance Standards for non-emergency engines in 40 CFR 60 Subpart IIII; • Good combustion practices (for emissions of all pollutants; and • Use of ULSD fuel oil
GHG SO_2	• Good combustion practices (for emissions of all pollutants); and • Use of ULSD fuel oil
Gas-Insulated Switchgear	
GHG	• For the individual wind turbine generators, use of SF_6-free switchgear; and • For the offshore substations, use of enclosed pressurized circuit breakers with low pressure alarms for leak detection, to achieve an SF_6 leakage rate of no more than 0.5 percent by weight per year of the total stored SF_6 quantity

An emissions inventory for the construction phase, including underlying assumptions for engine type and rating, engine use (hours), number of trips, and emission factors, was developed. This inventory is being used in the AERCOARE/AERMOD modeling analysis, incorporating an actual proposed construction schedule and will be used for the Class I AQRV modeling of annual totals of deposition. For the Class I AQRV visibility impairment modeling, the FLMs request that maximum 24-hour emission scenarios be evaluated.

For the AQRV visibility scenario, the worst-case 24-hour period of simultaneous activities at the nearest wind turbines to the Class I areas (Swanquarter, Shenandoah if required) will be evaluated for all hours of a 3-year meteorological period. This is a highly conservative approach because in reality, these emission sources will be at that particular location for a short period of time (less than one week) and then will move to other locations resulting in spatially and temporally distributed emissions throughout the construction period. Additional refinement of this approach may be necessary to successfully complete the AQRV assessment.

Model Domain

The proposed modeling domain was defined by a 31 mi (50 km) buffer area beyond the closest Class I areas (to allow for modeling of potential contaminant re-circulation), 335 mi x 283 mi (540 km x 456 km), centered at approximately 37.020°N, 76.622°W. Because the modeling domain covers such a large region, to account for the curvature of the earth, Lambert Conformal Conic projection coordinates will be used to define the meteorological grid points and source and receptor locations in the domain. This domain is shown in **Figure 3**.

Meteorological Data

The preferred meteorological dataset for long range CALPUFF modeling is three-dimensional gridded CALPUFF-ready (3D.dat format) meteorology for the most recently available three-year period prepared using the MMIF Program. MMIF converts prognostic meteorological model output fields to the parameters and formats required for direct input into CALPUFF. It is requested for the USFWS to produce gridded WRF model-derived multi-level meteorological data processed for CALMET over the proposed model domain (335 mi x 283 mi [540 km x 456 km]) at the proposed grid resolution (7 mi [12 km]) and ten vertical layers, consistent with the default layers specified by EPA/FLM guidance (cell face heights of 20, 40, 80, 160, 320, 640, 1200, 2000, 3000 and 4000 meters). The 7 mi (12-km) grid resolution is consistent with the CALMET-WRF simulations and will be maintained for the CALPUFF modeling.

Table 1 lists the LCC Projection information for the proposed CALMET domain to account for rotation of the input prognostic winds.

Table 1. Domain LCC Projection Parametrization for MMIF Extraction

RLAT0	40.574 N
RLON0	97.000 W
XLAT	33.000 N
XLAT2	45.000 N
NX	45
NY	38
NZ	10
DGRIDKM	12
ZFACE	0., 20.00., 40.00, 80.00, 160.00, 320.00, 640.00, 1200.00, 2000.00, 3000.00, 4000.00
XORIGKM (SW Corner)	1515.000
YORIGKM (SW Corner)	-420.000

Class I Receptors

NPS has developed a database of Class I area receptors for use in modeling analyses at the following web site: https://irma.nps.gov/DataStore/Reference/Profile/2249830. The Class I receptor locations are provided in Geographic Coordinates (latitude and longitude) and must be converted to LCC for the modeling. The CALPUFF View software allows for the direct import of specific Class I receptors into the model and automatically conducts the required coordinate conversions (e.g., lat/long to LCC km of the specified domain and the original WRF projection). The receptor elevations provided in the NPS receptor files are maintained.

There are five sections of the Swanquarter Wilderness area with a total of 52 receptors. The receptor placement is shown in LCC projection in Figure 4.

CALPUFF Model Options

The CALPUFF model options corresponding to those specified as defaults in Appendix B of the IWAQM Phase 2[2] document will be selected. The following options corresponding to the regulatory switch in CALPUFF will be employed:

- Gaussian vertical distribution used in the near field
- Partial plume path adjustment
- Transitional plume rise computed
- Model stack tip downwash
- Use MESOPUFF II chemical transformation mechanism
- Model wet removal
- Model dry deposition
- Use Pasquill-Gifford dispersion coefficients for rural areas
- Do not adjust sigma-y and sigma-z for roughness
- Allow partial plume penetration of elevated inversions
- Time-dependent dispersion equations (Heffter) are used to determine sigma-y and sigma-z once the horizontal puff size reaches 550 meters.

Both dry and wet deposition will be modeled. Gaseous phase dry deposition will be modeled for NO_X, HNO_3, and SO_2, while particle deposition will be assumed for NO_3^- and SO_4. Emissions of NH_3 will be assumed to remain in the gaseous phase, while particle deposition will be assumed for H_2SO_4. H_2SO_4 will be treated as primary SO_4 emitted.

Table 1 presents the deposition parameters proposed as input to CALPUFF for each species. Scavenging coefficients will be input to CALPUFF for the wet deposition algorithm. The default values provided in the model will be used for SO_2, SO_4, HNO_3, and NO_3^-. For the frozen coefficient for NH_3, conservatively, the highest scavenging coefficient provided in CALPUFF will be selected. For the liquid scavenging coefficient, the equation which serves as the basis of the default values in CALPUFF will be used and applied for NH_3

Table 1. CALPUFF Input Parameters for Deposition

Dry Deposition of Gases

	SO_2	NO_X	HNO_3	NH_3
Diffusivity (cm^2/s)	0.1509	0.1656	0.1628	0.1628
Alpha Star	1000	1	1	1
Reactivity	8	8	18	18
Mesophyll Resistance (s/cm)	0	5	0	0
Henry's Law Coefficient	0.04	3.5	8.0E-8	8.0E-8

Dry Deposition of Particles

	SO_4	NO_3^-
Geometric Mass Mean Diameter (microns)	0.48	0.48
Geometric Standard Deviation (microns)	2.0	2.0

[2] USEPA 1998. Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report and Recommendations for Modeling Long Range Transport Impacts. EPA-454/R-98-018.

Other Dry Deposition Parameters

Reference cuticle resistance (s/cm)	30
Reference ground resistance (s/cm)	10
Reference pollutant reactivity	8
Number of particle-size intervals	9
Vegetation state in unirrigated areas	Active and unstressed

Scavenging Coefficients used in CALPUFF

Pollutant	Scavenging Coefficient Liquid (1/sec)	Scavenging Coefficient Frozen (1/sec)
SO_2	3.0×10^{-5}	0
SO_4	1.0×10^{-4}	3.0×10^{-5}
NO_X	0	0
HNO_3	6.0×10^{-5}	0
NO_3^-	1.0×10^{-4}	3.0×10^{-5}
NH_3	7.9×10^{-5}	3.0×10^{-5}

Chemical transformations of NO_X to nitrates (NO_3^-) and nitric acid (HNO_3), and SO_2 to sulfate (SO_4) will be evaluated using CALPUFF's MESOPUFF II Chemistry scheme. Chemical transformations will be modeled using the monthly ozone concentrations measured at the Beauford monitor located in the Morehead City, North Carolina (North Carolina Department of Environmental Quality ID#37-031-9991). A CALPUFF monthly ammonia background concentration of 3 ppb will be used. This value is conservative compared to the monthly ammonia values measured at the NC06 monitor, located 31 mi (50 km) south of Swanquarter in an agricultural area south of Pamlico Sound and 14 mi (23 km) from the Atlantic Ocean, where the concentrations over the two-week deployment period (2010-2022) average 1.8 ppb.

Postprocessing

Visibility Impacts

The CALPUFF Modeling System postprocessor, CALPOST, will be used to generate the visibility impacts from the CALPUFF output. CALPOST Version 6.221 which performs the calculations in accordance with the latest EPA/FLM recommendations using the IMPROVE equation for extinction coefficient calculations is proposed for use. The CALPOST parameter MVISBK is set to 8, sub-mode five (M8_MODE = 5), and the background hygroscopic and non-hygroscopic aerosol levels are derived from the annual average natural conditions provided in Table 6 of the FLAG 2010 guidance. When calculating the sulfate and nitrate components of the visibility extinction coefficient, relative humidity adjustment factors will be applied because these aerosols are hygroscopic and the addition of water enhances their scattering efficiencies. The monthly relative humidity adjustment factors from Tables 7-9 in FLAG 2010 for the Swanquarter Class I area will be input to the RHFAC array in CALPOST (which are auto-populated with the values from Tables 7,8 and 9 of FLAG 2010 for specific Class I areas in the CALPUFF View software). The visibility threshold for concern is not exceeded if the 98th percentile change in light extinction is less than 5% for each year modeled, when compared to the annual average natural condition values for the Swanquarter Class I areas respectively (also auto-populated with the values from FLAG 2010 in CALPUFF View). If this analysis indicates the 98th percentile values for change in light extinction are equal to or greater than 5% for any year, then the results will be further scrutinized to determine the frequency of the exceedances and the conditions under which the exceedances are predicted.

Deposition Assessment

Estimates of atmospheric deposition are obtained by selecting the options in CALPUFF to calculate wet and dry fluxes of the pollutants modeled, in units of grams per square meter per second ($g/m^2/s$). Generally, AQRV analyses require values of total deposition (background plus modeled impact) in units of kilograms/hectare/year (kg/ha/yr); therefore, the modeled deposition flux of each oxide of sulfur or nitrogen from CALPUFF must be normalized for the difference in molecular weights using the multipliers as listed in Section 3.3 of the IWAQM Phase 2 Report and summed to yield a total deposition of sulfur and nitrogen. This is accomplished in CALPOST POSTUTIL and converted from the modeled units to assessment units (m^2 to ha and s to yr) using the appropriate scaling factors.

FLAG 2010 states for total sulfur (S) deposition, the wet and dry fluxes of sulfur dioxide and sulfate are calculated, normalized by the molecular weight of S, and expressed as total S. For total nitrogen (N) deposition, IWAQM recommends that the wet and dry fluxes of HNO_3 and NO_3- and the dry flux of NO_X be calculated, normalized by the molecular weight of N, and expressed as total N. In addition, the FLMs agree that wet and dry fluxes of ammonium sulfate ($(NH_4)_2SO_4$) and ammonium nitrate (NH_4NO_3) should be calculated, normalized by the molecular weight of N, and added to the estimate of total N. Therefore, total nitrogen deposition is the sum of N contributed by dry and wet fluxes of HNO_3, NO_3-, $(NH_4)_2SO_4$, and NH_4NO_3 and the dry flux of NO_X.

The NPS and USFWS have introduced and developed the concept of Deposition Analysis Thresholds (DATs) to use as screening level values for the additional modeled amount of sulfur and nitrogen deposition within Class I areas from new or modified PSD sources. A DAT is defined as the additional amount of nitrogen or sulfur deposition within an FLM area, below which estimated impacts from a proposed new or modified source are considered negligible. The DAT established for both nitrogen and sulfur in eastern and western FLM areas and wildernesses is 0.010 and 0.005 kg/ha/yr, respectively.

If you have any questions or require additional information, please contact either Mr. Scott Lawton at (804) 205-6077 or Scott.Lawton@dominionenergy.com, or Mr. T.R. Andrake at (804) 839-2760 or Thomas.R.Andrake@dominionenergy.com.

Sincerely,

Jason P. Ericson
Director Environmental Services

Cc: Tim Leon-Guerrero, EPA Region 3
Nathalie Schils, Tetra Tech

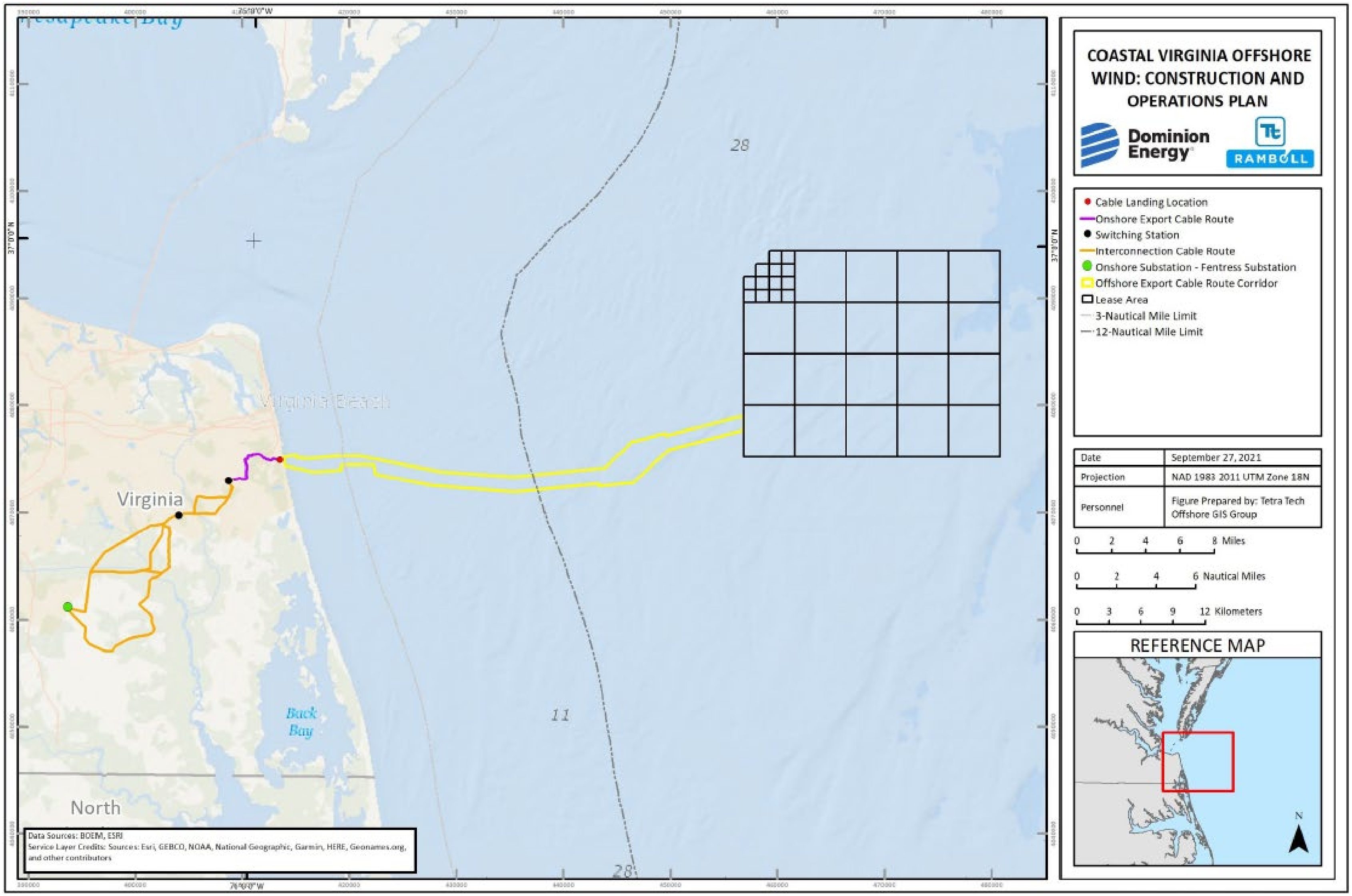

Figure 1. Project Area Overview

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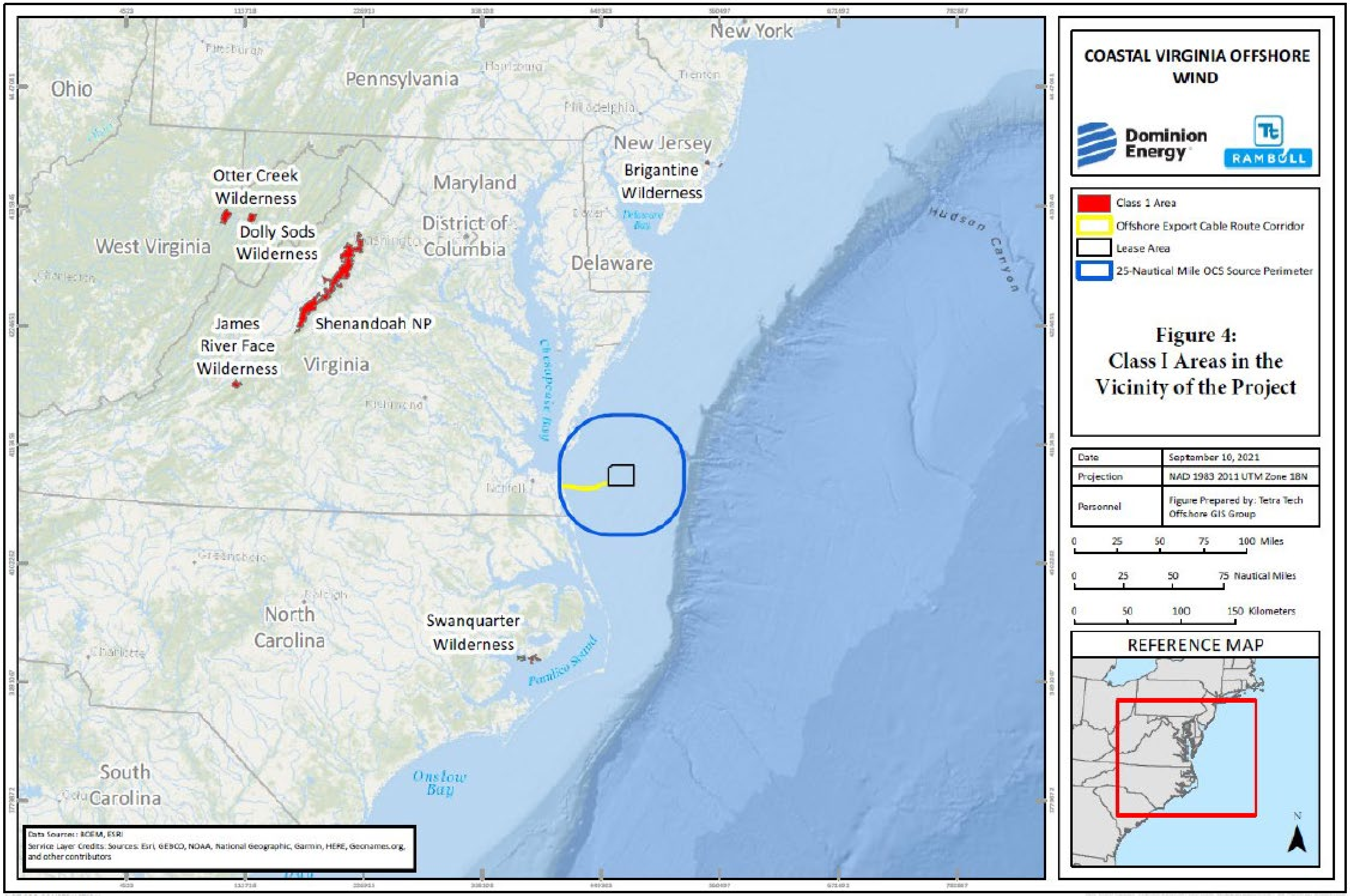
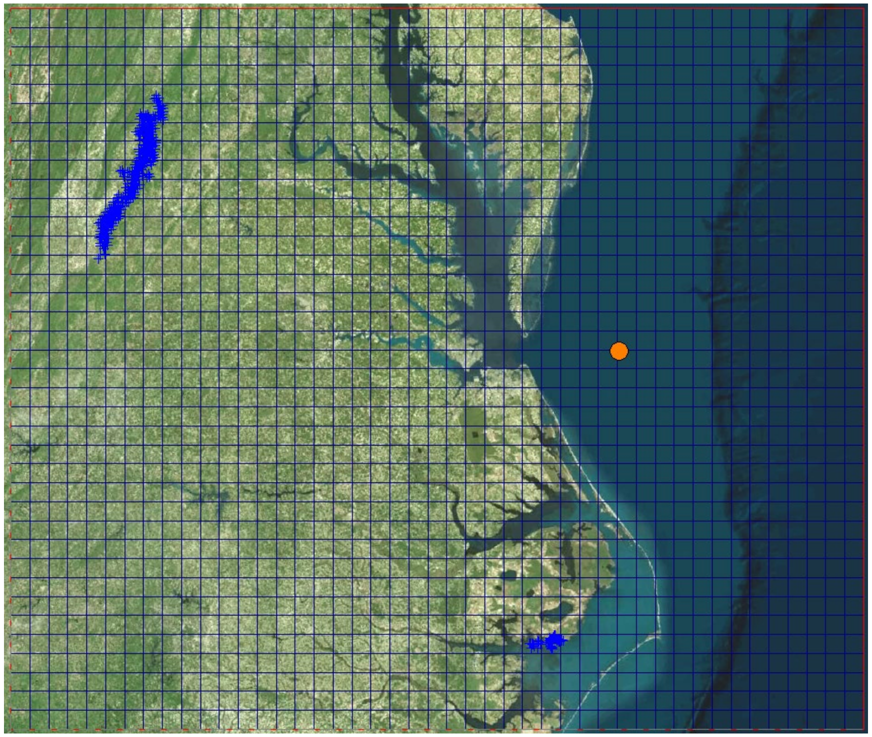


Figure 2. **Nearby Class I Areas**

Dominion Energy



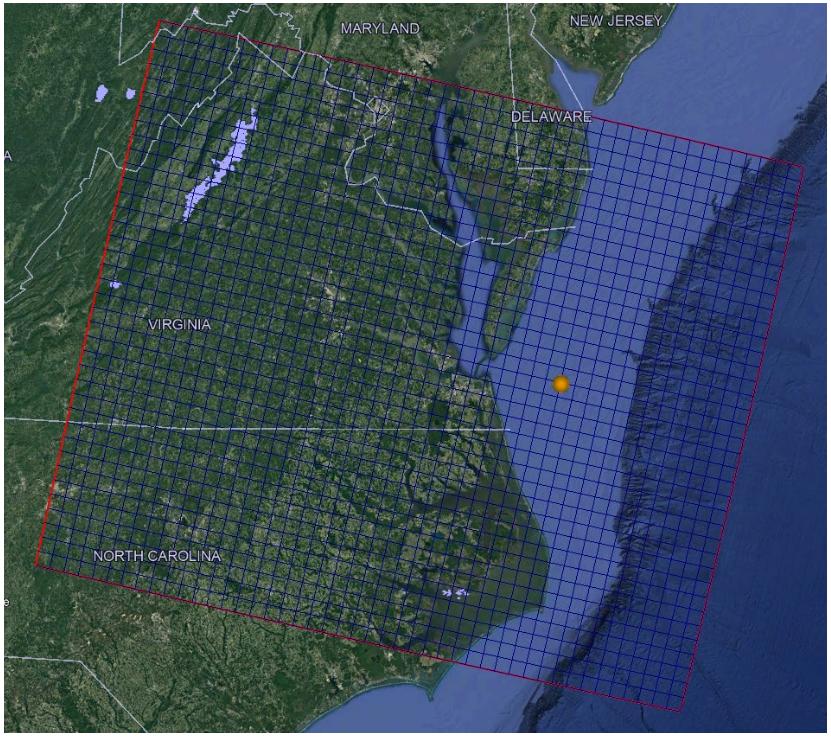


Figure 3. Proposed CALPUFF Modeling Domain (LCC Projection, left; Geographic Coordinates, right)

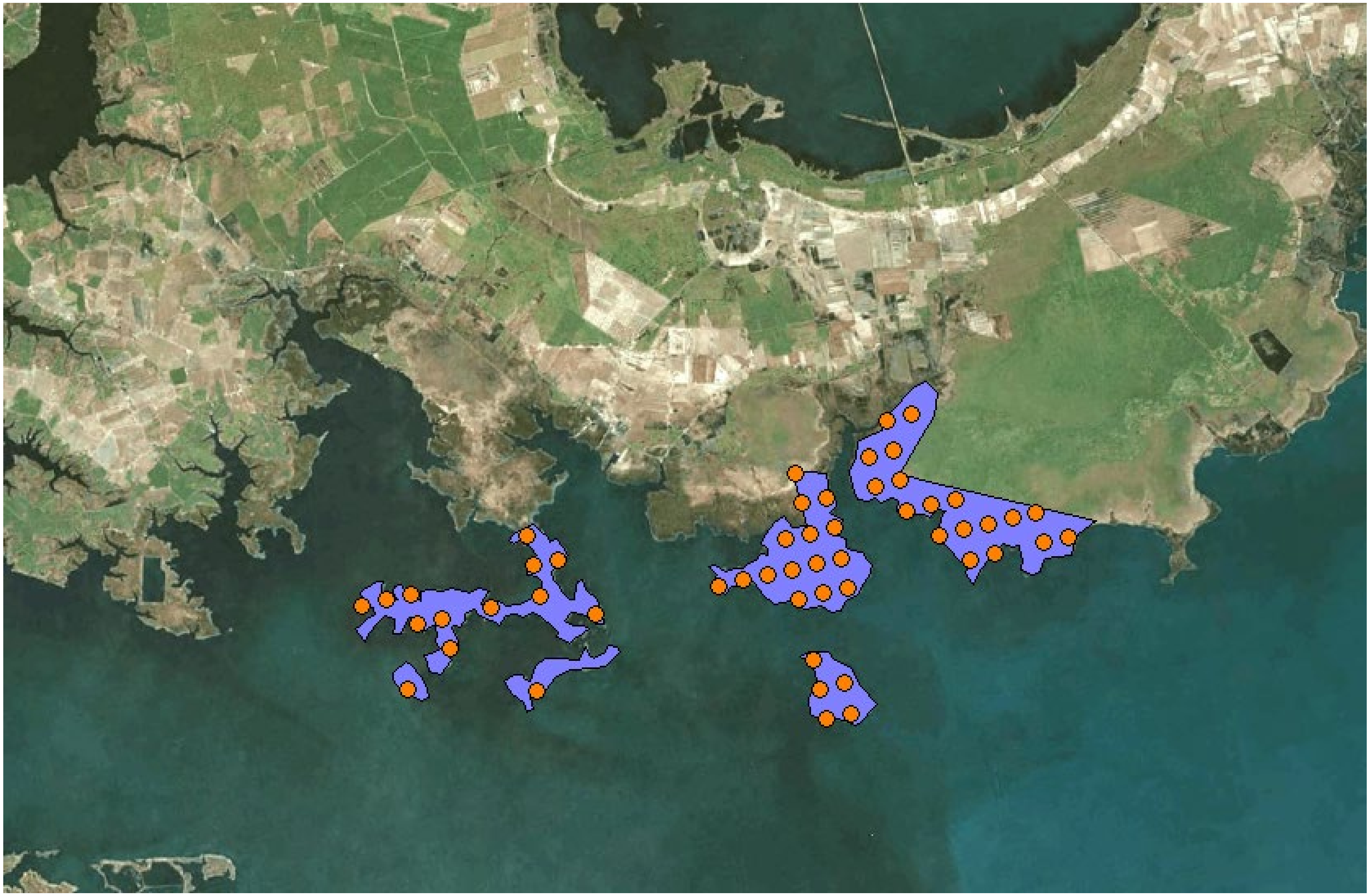


Figure 4. Swanquarter Class I Area Receptors provided by the National Park Service (LCC Projection)