Technical Review of Sea Port Oil Terminal (SPOT) Terminal Services LLC request to use the AERCOARE meteorological data preprocessor program in conjunction with AERMOD in support of their Prevention of Significant Deterioration (PSD) Permit Application

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1. Background and Project Overview

Sea Port Terminal (SPOT) Terminal Services LLC, a subsidiary of Enterprise Products Partners L.P. is proposing to construct a deepwater port (DWP) in the Gulf of New Mexico to provide the United States with crude oil loading services on very large crude carriers (VLCCs) and other crude oil carriers for export to the global market. The SPOT DWP will consist of: (1) crude oil export pipelines; (2) a platform, including the crude oil loading pipelines and vapor recovery pipelines with associated pipeline end manifolds (PLEMs), and the vapor combustion units; (3) single point mooring (SPM) buoys and interconnections; (4) service vessel moorings; and (5) anchorage areas and navigation. The proposed facility requires a PSD construction permit.

SPOT Terminal Services has submitted their PSD permit application, including the required air quality analysis, to EPA Region 6. The applicant has requested the use of an alternative model to conduct their PSD air quality modeling analysis. Specifically, SPOT Terminal Services has requested the use of the Coupled Ocean-Atmosphere Response Experiment (COARE) bulk flux algorithm, as implemented in the AERCOARE meteorological data preprocessor program to prepare meteorological data for use in the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) dispersion program in order to assess ambient impacts in a marine environment. SPOT Terminal Services submitted their initial request to initiate the alternative model approval process on September 14, 2018. Based on subsequent discussions between SPOT Terminal Services, EPA Region 6 and OAQPS regarding the proposed project and the associated modeling approach, the applicant provided a revised alternative model request on October 1, 2019 (Appendix A).

In their October 1, 2019 request, SPOT Terminal Services indicated their preference to utilize the AERCOARE/AERMOD alternative modeling approach over the EPA's preferred model, the Offshore and Coastal Dispersion (OCD) model. SPOT's October 1, 2019 request presented seven technical reasons, options, and/or features available in the alternative model to support their request. Several of the presented criteria are relevant to their project, as listed below:

1. The Plume Rise Model Enhancements (PRIME) downwash algorithm available in AERCOARE/AERMOD can be used to assess impacts in the cavity and wake regions of structures, whereas, the OCD model provides downwash for platforms only. The alternative model's downwash algorithm allows for assessing impacts of downwash from solid structures not provided for in OCD along with providing conservative treatment of downwash from the platform by treating it as a solid structure.

2. The dispersion algorithm used in the AERMOD portion of AERMOD-COARE is considered state-of-art by USEPA. OCD is over 30 years old and the dispersion algorithms have not been updated to account for current advancements in dispersion theory.

3. The alternative model allows for the estimation of ambient concentrations resulting from point, area, and volume sources. The OCD model can model point, line, and area sources but cannot model volume sources. SPOT proposes to include both point and volumes sources to represent emission sources in their modeling analysis.

4. Calm wind conditions can be processed by the alternative model. The OCD model does not contain routines for processing either missing data or hours of calm winds – such processing requires custom post-processing. SPOT indicated that the meteorological data to be included in their modeling analysis had approximately 200 calm hours.

5. The alternative model provides that output can be generated in the statistical form that is needed to assess compliance with the newer statistically based National Ambient Air Quality Standards (NAAQS), such as 1-hour NO_2. The OCD model does not contain this option. (Similarly, the AERMOD portion of the alternative model contains the option to employ the ARM2 Tier 2 screening technique, whereas OCD requires additional post-processing to apply NO2 screening technique.)

While not directly relevant to the SPOT DWP project, SPOT did highlight in their alternative model request the following additional features available in the alternative model, which are not provided for within the preferred OCD model:

1. The Tier 3 Plume Volume Molar Ratio Method (PVRMR) and Ozone Limiting Method (OLM) screening techniques can be used to estimate the conversion of oxides of nitrogen (NO_x) to nitrogen dioxide (NO_2) within AERMOD.

2. Predicted meteorology from the Weather Research Forecasting (WRF) model can be used with AERCOARE. This capability eliminates the common difficulties associated with overwater buoy data collection and assimilation, such as hourly data recovery that does not meet minimum modeling requirements and the necessity to patch together data from multiple buoys and fill in missing values to meet minimum requirements. The Mesoscale Model Interface (MMIF) program can be used to read WRF data to generate the meteorology necessary for input to AERCOARE.

As discussed in this technical document, EPA Region 6 has reviewed the applicant's alternative model request and determined that the use of the proposed alternative model is acceptable. As such, EPA Region 6 currently intends to approve the use of AERCOARE in conjunction with AERMOD for the proposed SPOT DWP facility.

2. Modeling Approach

The PSD application, dated January 29, 2019, submitted by SPOT Terminal Services contains detailed descriptions of the modeling approach using AERCOARE/AERMOD. This document is available upon request. A summary of the modeling approach is provided in this section.

SPOT Terminal Services used AERMOD Version 18081, AERCOARE Version D13108 to conduct the dispersion modeling analyses necessary to demonstrate compliance with the NAAQS, PSD Increments, Effects Screening Levels, and State Property Line Standards. Modeled receptors were placed in all areas considered as ambient air out to 20 km from the "property line." The property line was defined based on the Coast Guard safety zone, which serves as the ambient air boundary. Overwater meteorological data for 2012 through 2017 were obtained from the National Oceanic and Atmospheric Administration (NOAA) National Buoy Data Center for use in the air dispersion modeling analysis. Specifically, the 2012, 2013, 2015, 2016, 2017 meteorological data from Buoy 42035, located approximately 37 km northeast of the proposed SPOT DWP, was used in the air dispersion modeling. 2014 data was excluded due to large period of missing data. Any missing data for the 2012, 2013, 2015, 2016, 2017 calendar years was filled using data from similar time periods from Buoy 42035 and data from a nearby buoy (Buoy 42019), as necessary.

For the NAAQS and PSD increment modeling analyses, SPOT Terminal Services initially conducted a significant impact analysis (SIA) to determine if modeled impacts exceeded the significance levels (SILs). For those pollutants and averaging periods that exceeded the SILs, a cumulative impact analysis was conducted to demonstrate compliance with the associated NAAQS and/or PSD Increments. For the State Health Effects and State Property Line Standards analyses, the modeled impacts of the pollutants emitted from the facility having an associated standard were compared with that standard to demonstrate acceptable impact levels.

3. Alternative Model Approval Approach

a. Regulatory Analysis and Background

40 CFR Part 51.166(l) states that all applications of air quality modeling shall be based on the applicable models specified in Appendix W of Part 51 (Guideline on Air Quality Models). However, 51.166(l) also provides that on a case-by-case basis, a modification or substitution of an air quality model may be used following written approval. In addition, the use of a modified or substituted model is subject to notice and opportunity for public comment. The approval of an alternative model is outlined in 40 CFR Part 51 Appendix W, Section 3.2. Section 3.2.2(a) specifies that the determination of acceptability of an alternative model is a Regional Office responsibility in consultation with the Model Clearinghouse (MCH) and that an alternative model may be used subject to Regional Office approval based on the Section 3.2.2 requirements. Section 3.2.2(b) states the alternative model shall be evaluated from both a theoretical and performance perspective before regulatory use and outlines the three separate conditions where an alternative model may be approved. Condition 3 under Section 3.2.2(b), where there is no preferred model for the specific project, applies to this case where SPOT Terminal Services has requested the use of the AERCOARE/AERMOD.

Appendix W specifies the preferred model for overwater sources is the OCD model. OCD is a straight-line Gaussian model developed to determine the impacts of offshore emissions from

point, area or line sources on the air quality of coastal regions. Some of the key features of OCD potentially applicable to offshore sources are the inclusion of platform building downwash and continuous shoreline fumigation. However, as discussed in Section I of this document, OCD does have limitations, as described by SPOT Terminal Services in their request to use an alternative model for their air quality modeling analyses. The following limitations are of particular importance to the SPOT DWP project: (1) OCD does not provide for the multi-tiered screening approach for NO_2 modeling (specifically the Tier 2 or Tier 3 screening approaches); (2) OCD does not contain options to generate outputs in the statistical forms consistent with current NAAQS; (3) OCD does not account for calm wind conditions when calculating predicted pollutant concentrations ; (4) OCD cannot be used to model volume sources; and (5) OCD does not account for current advancements in dispersion theory. In addition, the key features of OCD not provided in AERCOARE/AERMOD are either not applicable to the SPOT DWP project, or AERCOARE/AERMOD provides a more appropriate and conservative approach. Based on the proposed location of the SPOT DWP being approximately 50 km off shore and the fact that the controlling concentrations will occur close to the facility at overwater receptors, OCD's feature regarding shoreline fumigation is not of concern. Additionally, the shoreline distance from the proposed facility of 50 km occurs at the upper distance limit of a near-field model, such as OCD. Therefore, the applicant has stated that the use of the OCD model to accurately simulate conditions at the shoreline is questionable. Regarding downwash features, while OCD accounts for platform downwash, SPOT Terminal Services' proposed use of AERCOARE/AERMOD as an alternative model will utilize the PRIME downwash algorithm, which will provide conservative results by treating the proposed platform structure as a solid structure that extends downward to the sea surface. In addition, the PRIME downwash algorithm allows for the more appropriate treatment of downwash from other solid portions of the platform that cannot be accounted for in OCD. For these reasons, SPOT Terminal Services has requested the use of an alternative model (AERCOARE/AERMOD) via Condition 3 under Section 3.2.2(b) and provided justification for the alternative model consistent with the requirements listed in Section 3.2.2(e).

Section 3.2.2(e) sets forth the five conditions that must be satisfied for alternative model approval under Condition 3 of Section 3.2.2(b):

I. The model or technique has received a scientific peer review.
II. The model or technique can be demonstrated to be applicable to the problem on a theoretical basis.
III. The databases which are necessary to perform the analysis are available and adequate.
IV. Appropriate performance evaluations of the model or technique have shown that the model or technique is not inappropriately biased for regulatory application.
V. A protocol on methods and procedures to be followed has been established.

The following section of this technical review document provides an examination of SPOT Terminal Services' justification for the approval of AERCOARE/AERMOD for their overwater source with respect to the requirements of Section 3.2.2(e).

b. Evaluation of Approach under Section 3.2.2(e)

In their alternative model request, SPOT Terminal Services referenced the April 2011 EPA Region 10 approval and EPA MCH concurrence with the use of AERMOD-COARE for an Artic marine ice-free environment on the basis that the alternative model satisfied the five criteria

contained in Section 3.2.2(e) of Appendix W.[1] The April 2011 EPA MCH concurrence memorandum clearly states that the Region 10 approval did not constitute a generic approval of AERMOD-COARE for other applications. However, the memorandum did state that the April 2011 Region 10 approval concurrence request did provide "a good basis for consideration of AERMOD-COARE for other applications, subject to Regional Office approval based on an assessment of the appropriateness of the performance evaluations (element 4) and the availability of the necessary data bases (element 3) on a case-by-case basis". Therefore, the justification for the use of AERCOARE/AERMOD for the SPOT DWP modeling analysis addressed each of the five elements in Section 3.2.2(e), with emphasis on elements 3 and 4, as discussed below.

I. The model or technique has received a scientific peer review.

As detailed in the April 2011 Region 10 approval, the science behind the COARE algorithm, which has been incorporated into AERCOARE has been published in scientific peer review journals. Information pertaining to the scientific peer review can be found at: http://www.coaps.fsu.edu/COARE/.

II. The model or technique can be demonstrated to be applicable to the problem on a theoretical basis.

In the April 2011 Region 10 alternative model approval, EPA deemed AERMOD-COARE to be appropriate for use in the Artic marine ice-free environment. That approval also documents that COARE algorithm is applicable on a theoretical basis and included the following excerpts from the Region 10 project documentation:

> "Version 3.0 of the COARE algorithm with journal references and a User's Manual can be accessed at:
>
> ftp://ftp.etl.noaa.gov/users/cfairall/wcrp_wgsf/computer_programs/cor3_0/
>
> and
>
> http://www.coaps.fsu.edu/COARE/flux_algor/
>
> These references provided copies of the code, descriptions of the scientific basis for the code, and detailed descriptions on how to use the COARE program. However, Shell acknowledges that COARE was not specifically designed to provide an input file for AERMOD, and there are certain steps that must be taken to produce the input files for AERMOD."
>
> "Communication with Ken Richmond of ENVIRON and marine boundary layer experts Dr. Andrey Grachev and Dr. Chris Fairall from the National Oceanic and Atmospheric Administration (NOAA) provided the following insight:

[1] The Model Clearinghouse Information Storage and Retrieval System (MCHISRS) Record for the April 2011 Region 10 Approval and Model Clearinghouse Concurrence memorandums available at: https://cfpub.epa.gov/oarweb/MCHISRS/index.cfm?fuseaction=main.resultdetails&recnum=11-X-01

From Dr. Chris Fairall:

'The original COARE version (2.5) (and the 2003 version (3.0)) was set up so that it could handle water and air temperatures from the tropics to the Arctic. Parameters such as the kinematic viscosity of air have T dependencies. I have listed below a few references to Arctic applications I dug up.'"

"Minimum meteorological variables needed to run the COARE algorithm are the wind speed, the sea surface temperature, the air temperature, and some form of humidity measurement (e.g. relative humidity, absolute humidity, dew point, and wet bulb temperature). Barometric pressure, precipitation, and a typical mixed layer height are also input variables that can be provided or assigned by COARE default parameters. If options are selected for warm-layer heating and/or cool-skin effects, then solar radiation and downward longwave radiation are needed. Shell is not planning to invoke these options but has tested and provided a framework for the provision of these variables using measured solar radiation, cloud cover and ceiling height. COARE also contains several options for the surface roughness length based on wave period and wave height. Shell plans to use the default option that does not need these variables."

The current AERCOARE User Manual also states:

"AERCOARE uses Version 3.0 of the COARE algorithm that has been updated several times since the initial international TOGA-COARE field program in the western Pacific Ocean from November 1992 to February 1993. The basic algorithm uses air-sea temperature difference, overwater humidity, and wind speed measurements to estimate the sensible heat, latent heat, and momentum fluxes. The original algorithm was based on measurements in the tropics with winds generally less than 10 m/s, but has since been modified and extensively evaluated against measurements in high latitudes with winds up to 20 m/s. Based on these studies, AERCOARE is expected to be appropriate for marine conditions found at all latitudes including."

III. The databases which are necessary to perform the analysis are available and adequate.

The previous evaluation conducted in support of the March 2011 Region 10 alternative model approval of AERMOD-COARE utilized tracer gas experiments from Cameron, Louisiana, and Carpinteria and Pismo Beach, California. As stated in the Region 10 approval, these tracer study databases were previously used in the performance evaluation of the OCD and CALPUFF models.

Like in the Region 10 approval, EPA Region 6 finds that the databases associated with these three experiments are representative of the atmospheric conditions in the Gulf of Mexico. In fact, we find that the availability of the Cameron, Louisiana tracer experiment dataset, in particular, is even more representative of the atmospheric conditions occuring in the Gulf where the SPOT DWP is proposed to be located compared to the Artic

environment in the Region 10 approval. Figure 1 shows the location of the Cameron, Louisiana tracer gas experiment and its proximity to the proposed SPOT DWP project location.

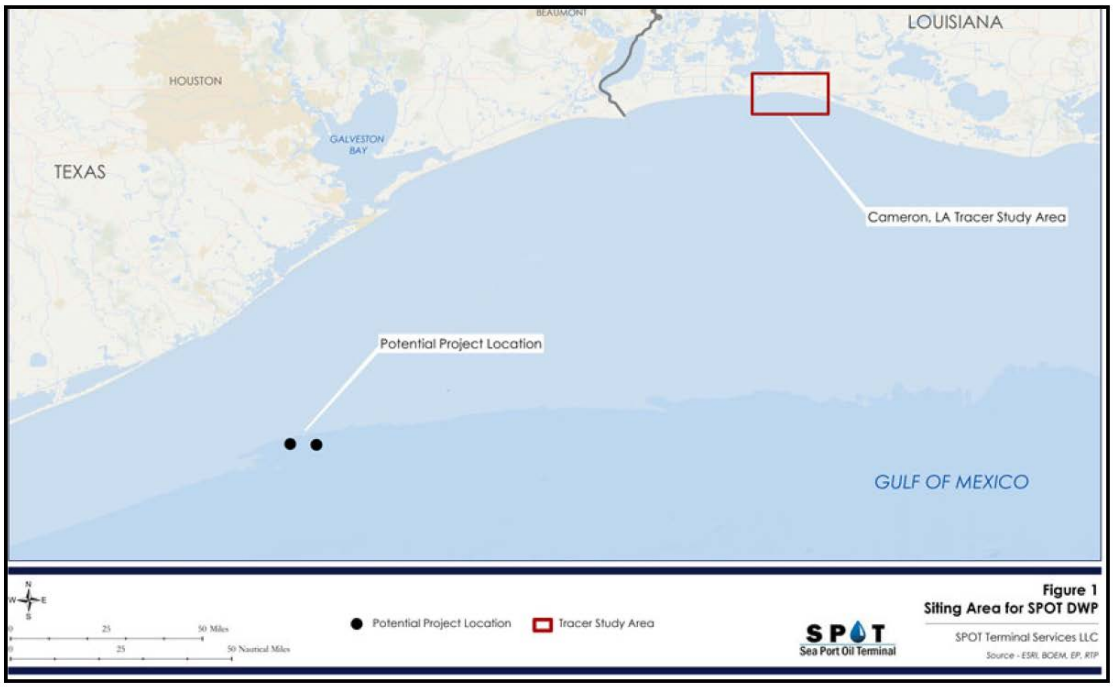

Figure 1. Location of Proposed SPOT DWP relative to Cameron, Louisiana tracer study location.
(Image taken from SPOT Terminal Services' September ##, 2019 revised alternative model approval request.)

The tracer gas experiment in Cameron, Louisiana included tracer releases from both a boat and a low profile platform. The study's receptors were located in flat terrain near the shoreline. The dataset contains both very stable and fairly unstable conditions. The terrain and offshore conditions are expected to mimic those found at the proposed DWP location since both are located in the Western Gulf of Mexico.

IV. *Appropriate performance evaluations of the model or technique have shown that the model or technique is not inappropriately biased for regulatory application.*

The April 2011 Region 10 approval included a performance evaluation of AERMOD-COARE using data from the previously mentioned tracer gas experiments. The results of that evaluation demonstrated that the model is not biased toward underestimates. A brief overview of the Region 10 evaluation is provided below, with special emphasis on the results for the Cameron, Louisiana dataset. Additional details regarding the 2011 evaluation are available in the April 2011 Region 10 alternative model approval.

In the Region 10 evaluation, AERMOD-COARE predictions from five cases using various combinations of meteorological data assembly were obtained for each of the tracer study datasets, including the Cameron, Louisiana dataset. Statistical procedures were applied to evaluate whether the COARE-AERMOD alternative modeling approach

was biased towards underpredictions. For the Cameron dataset, AERMOD was applied using default dispersion options for rural flat terrain.

Quantile-quantile (Q-Q) plots were prepared to test the ability of the model predictions to represent the frequency distribution of the observations. Q-Q plots can be inspected to examine whether a model is biased towards underestimates at the important upper-end of the frequency distribution. The Q-Q plot for the Cameron, Louisiana dataset is provided below in Figure 2.

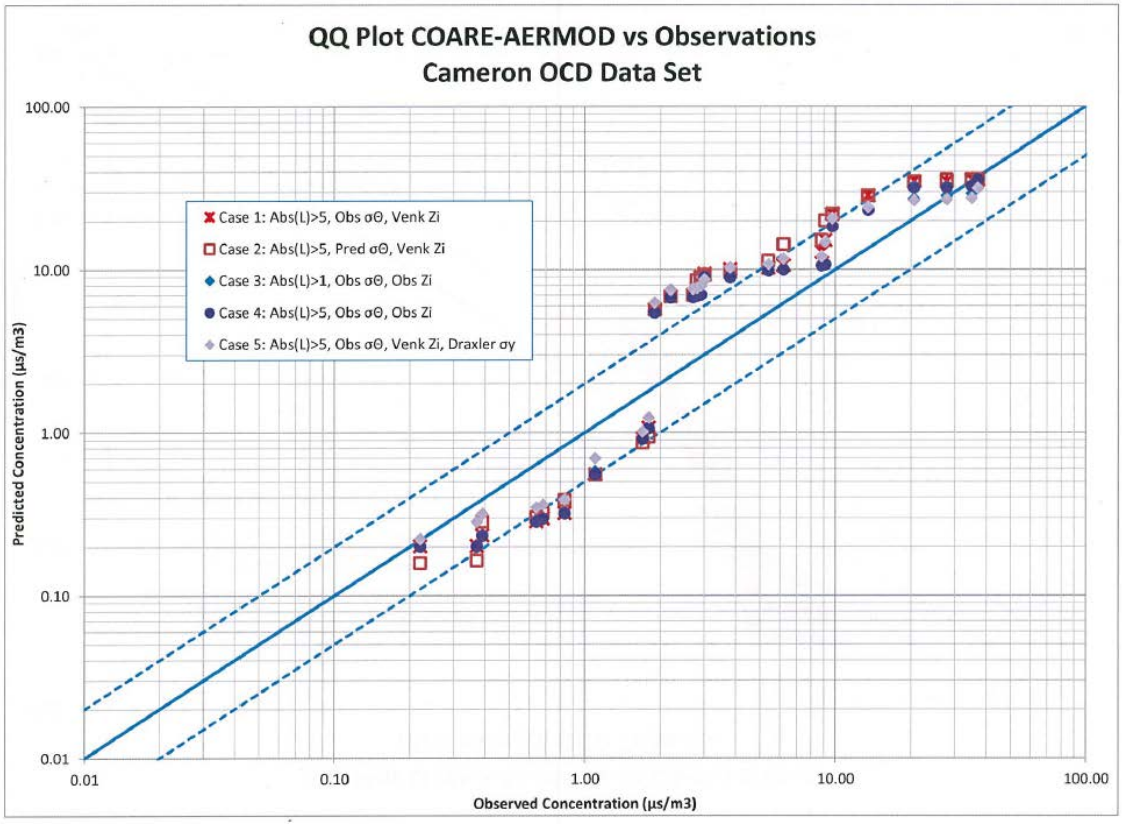

Figure 2. Cameron, Louisiana Q-Q Plot.
(Image taken from Region 10's April 2011 alternative model approval.)

As shown in this figure, the modeled concentrations generally are within the factor of 2 bounds of the plot. Predictions using the AERCOARE-prepared meteorological data tend to be biased towards overprediction for the highest concentrations with no apparent difference in model performance between the five cases.

Sigma plots were also prepared from the BOOT program output in the Region 10 evaluation to show the over/under prediction tendencies of the model for each of the five cases, along with showing the associated scatter in the predicted concentrations. The Cameron, Louisiana sigma plot is provided below in Figure 3.

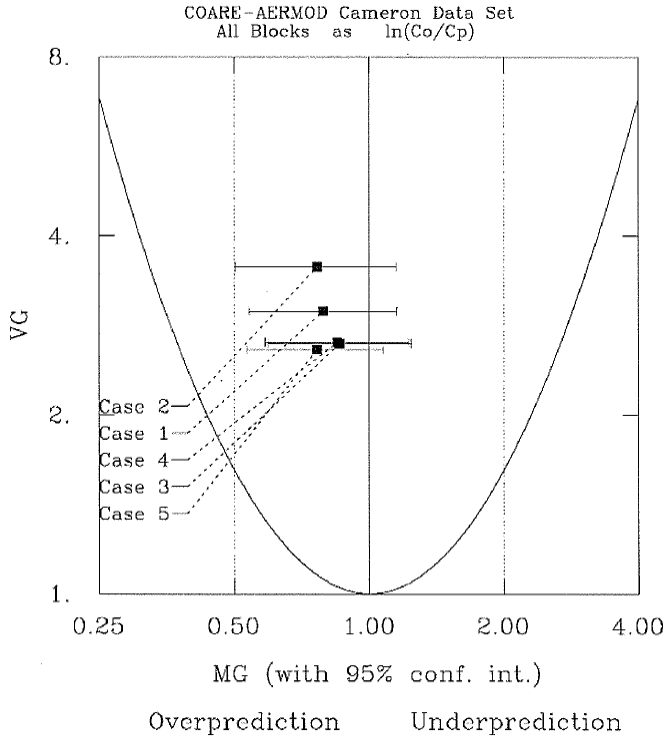

Figure 3. Cameron, Louisiana Sigma Plot.
(Image taken from Region 10's April 2011 alternative model approval.)

The sigma plot shows that Case 2 has the most scatter, and that all cases are biased towards over-prediction.

Similar to the determination in the evaluation conducted as part of the Region 10 alternative model approval for the combined dataset from all three tracer studies, specific examination of the Cameron, Louisiana results again demonstrates that the model is not biased toward underestimates.

It is important to note that in the model evaluation that was conducted in support of the April 2011 Region 10 alternative model approval, the COARE algorithm output was assembled along with other meteorological variables in a spreadsheet to prepare the AERMOD overwater meteorological input files. Therefore, the April 2011 approval was the approval of the spreadsheet version of the COARE algorithm and not the current version of the AERCOARE meteorological preprocessor program that is proposed for use by SPOT Terminal Services. Since the April 2011 Region 10 approval, additional studies related to COARE-AERMOD have taken place, including a study that incorporated the COARE air-sea flux procedure into the AERCOARE program. The results of this study are provided in an October 2012 EPA report titled Evaluation of the Combined AERCOARE/AERMOD Modeling Approach for Offshore Sources (EPA 910-R-12-007). The 2012 study include the same tracer studies that were utilized in the April 2011 model evaluation supporting the Region 10 alternative model approval with the addition of one other tracer dataset – Ventura, California. The 2012 study found that the

AERCOARE/AERMOD modeling approach was not biased towards underestimates at the high-end of the concentration frequency distribution for the four tracer field studies included in the model evaluation. The results of the 2012 study also demonstrated that the results from the AERCOARE programmed version of the COARE algorithm were consistent with the results from the spreadsheet version of COARE relied upon in the Region 10 approval. Therefore, Region 6 believes that the model performance evaluation based on the spreadsheet version of COARE that is referenced in the Region 10 approval is applicable to and supports our intended approval of AERCOARE/AERMOD for the SPOT DWP project.

In addition, as previously mentioned, Region 6 believes that the databases relied upon in the model evaluation that was part of the Region 10 approval are even more appropriate and representative of the atmospheric conditions for a project located in the Gulf of Mexico as compared to the Artic marine environment, which was the location of the Region 10 approval.

V. A protocol on methods and procedures to be followed has been established.

SPOT Terminal Services submitted a modeling protocol to EPA on October 5, 2018. The modeling protocol outlined the modeling techniques employed in the air modeling analyses conducted in support of the SPOT DWP project. This modeling protocol supplemented the applicant's demonstration of AERCOARE/AERMOD as an alternative model contained in their initial September 14, 2018 request to initiate the alternative model approval process.

c. Additional Justification of Alternative Model Approach

While EPA Region 6 finds that the requested alternative model approach is approvable under Condition 3 of Section 3.2.2(b) by meeting the required elements of Section 3.2.2(e) of Appendix W, we also find additional justification for the approval of AERCOARE/AERMOD for the proposed SPOT DWP based on the result of the 2016 model performance study published in the Journal of the Air & Waste Management Association. [2] In this study, the same tracer studies that had been used to examine individual model performance were used to directly compare the performance of the AERCOARE/AERMOD modeling approach to OCD using statistical procedures and measures. The study concluded that the model performance for AERCOARE/AERMOD modeling approach was comparable to OCD for the overwater field tracer studies, including the Cameron, Louisiana dataset. While the level of evaluation and comparison presented in this study does not the meet the definition or intention of a full equivalency demonstration under Condition 1 of Section 3.2.2(b), Region 6 does find that the results of the 2016 study further support our finding that the use of AERCOARE/AERMOD for the proposed SPOT DWP is appropriate and approvable.

[2] June 2016 Article from Journal of the Air & Waste Management Association, *AERCOARE: An overwater meteorological preprocessor for AERMOD*. Herman Wong, Rob Elleman, Eric Wolvovsky, Ken Richmond & James Paumier (2016) AERCOARE: An overwater meteorological preprocessor for AERMOD, Journal of the Air & Waste Management Association, 66:11, 1121-1140, DOI: 10.1080/10962247.2016.1202156.

4. Conclusions and Conditions for Use

EPA Region 6 has reviewed the alternative model request submittal provided by SPOT Terminal Services and has determined that the proposed AERCOARE/AERMOD modeling approach is acceptable as an alternative model for the air quality modeling analysis submitted in support of their PSD permit application. Based on our review, we find that the proposed approach addresses the five elements contained in Section 3.2.2(e) of Appendix W. As such, pursuant to Sections 3.0(b) and 3.2.2(a), Region 6 currently intends to approve the use of AERCOARE/AERMOD as an acceptable alternative model for the SPOT DWP project.

As with the April 2011 Region 10 alternative model approval of AERMOD-COARE, approval to use this alternative model is made on a case-by-case basis. Should a project desire to use AERCOARE/AERMOD in an overwater modeling analysis for a different facility and/or location, a request for alternative approval must be made to the appropriate EPA Regional Office containing the appropriate technical justifications/demonstrations consistent with Appendix W.

Appendix A - Sea Port Terminal (SPOT) Terminal Services LLC' s Alternative Model Request dated October 1, 2019

S P T
Sea Port Oil Terminal

P.O. Box 4324; Houston, TX 77210-4324 phone (713) 381-6500 www.enterpriseproducts.com

October 1, 2019

7019 0140 0000 4303 8606
Return Receipt Requested

Ms. Ashley Mohr
Environmental Scientist
U.S. Environmental Protection Agency
Air Permits Section (6PD-R), Region 6 Main Office
1445 Ross Avenue
Dallas, TX 75202

Subject: **Request for Approval for Use of COARE Bulk Flux Algorithm to Generate Hourly Meteorological Data for use with AERMOD**

Dear Ms. Mohr,

SPOT Terminal Services LLC, a subsidiary of Enterprise Products Partners L.P. is proposing to construct, own, and operate the Sea Port Oil Terminal (SPOT, also the Project) in the Gulf of Mexico. SPOT will allow for the loading of crude oil on Very Large Crude Carriers (VLCCs) for export to the global market. SPOT deepwater port (DWP) would be located in federal waters within the Outer Continental Shelf (OCS), approximately 25 to 30 nautical miles (28.8 to 34.5 statute miles, or 46.3 to 55.6 kilometers) off the coast of Brazoria County, Texas. The DWP would be capable of loading crude oil at a rate of 85,000 barrels per hour (bbls/hr) to VLCCs. SPOT has filed an application for a license to construct, own, and operate the DWP pursuant to the Deepwater Port Act of 1974, as amended (DWPA), and in accordance with the U.S. Coast Guard's (USCG's) and the Maritime Administration's (MARAD's) implementing regulations.

The Project is subject to Prevention of Significant Deterioration (PSD) preconstruction permitting and the associated source impact analysis requirements of 40 Code of Federal Regulations [CFR] 52.21(k). The primary pollutant to be emitted would be volatile organic compounds (VOCs) from crude oil loading to the VLCCs. The primary sources of emissions are expected to be devices used to control VOCs from crude oil loading to the VLCCs. Platform-based minor sources would include a diesel engine for power generation, intermittent sources, such as a firewater pump diesel engine, an emergency electrical generator diesel engine, and a diesel engine stationary crane on the platform. Mobile sources for National Environmental Policy Act (NEPA) evaluation would include VLCC engine and support vessels.

SPOT is seeking approval for the proposed Project to use the Coupled Ocean-Atmosphere Response Experiment (COARE) bulk flux algorithm, as implemented in the meteorological data processor program AERCOARE, to prepare meteorological data for use in the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD). AERCOARE, in conjunction with AERMOD (referred to as AERMOD-COARE in this request) is an alternative refined model for assessing compliance with air quality standards when emission sources and dispersion occur over water. The Offshore and Coastal Dispersion (OCD) model is currently listed as a preferred model for over-water dispersion in USEPA's Guideline on Air Quality Models (see Section 4.2.2.3 of Appendix W).

AERMOD-COARE is preferred by the Project over OCD because of the following technical reasons, options, and features available in the model:

1. The Plume Rise Model Enhancements (PRIME) downwash algorithm can be used to assess impacts in the cavity and wake regions of structures. While the OCD model does incorporate platform downwash, SPOT has proposed use of PRIME considering the platform as a solid structure which will result in conservative, overprediction of concentrations;

2. While not proposed for use in the SPOT project, the Plume Volume Molar Ratio Method (PVRMR) and Ozone Limiting Method (OLM) can be used to estimate the conversion of oxides of nitrogen (NOx) to nitrogen dioxide (NO_2). The Ambient Ratio Method (ARM2) screening technique however was used and was applied within the model;

3. Output can be generated in the statistical form that is needed to assess compliance with the newer statistically based National Ambient Air Quality Standards (NAAQS), such as 1-hour NO_2;

4. While SPOT has not proposed to model any area sources, concentrations can be estimated for dispersion resulting from point, area, and volume sources;

5. Calm wind conditions can be processed by the model;

6. The dispersion algorithm used in the AERMOD portion of AERMOD-COARE is considered state-of-art by USEPA. OCD is over 30 years old and the dispersion algorithms have not been updated to account for current advancements in dispersion theory. In addition, the OCD model is only applicable for evaluating dispersion of emissions from offshore sources that are located within 27 nautical miles (50 kilometers) of the shoreline. OCD requires input coordinates that define the shoreline and terrain elevation of the shoreline. OCD contains specific air pollutant calculation procedures to determine pollutant concentrations at these shoreline receptors that account for the change in the atmospheric boundary layer, hence dispersion characteristics, at the water/land transition at the shoreline. OCD's dispersion science becomes questionable near the 27-nautical-mile (50–kilometer) limit of the model and not applicable at and beyond 27 nautical miles (50 kilometers). Application of OCD for the SPOT Project is questionable at best because the shoreline is close to or beyond the 27-nautical-mile (50-kilometer) limit of the model, depending on the final location selected for the Project; and

7. While not proposed for use in the SPOT project, predicted meteorology from the Weather Research Forecasting (WRF) model can be used with AERCOARE. This capability eliminates the common difficulties associated with overwater buoy data collection and assimilation, such as hourly data recovery that does not meet minimum modeling requirements and the necessity to patch together data from multiple buoys and fill in missing values to meet minimum requirements. The Mesoscale Model Interface (MMIF) program can be used to read WRF data to generate the meteorology necessary for input to AERCOARE.

Pursuant to Section 3.0 and 3.2.2.a of 40 CFR 51, Appendix W (Guideline on Air Quality Models[1]), approval of an alternative refined model is the responsibility of the Regional Administrator—in this case, USEPA Region 6. There are three separate conditions outlined in Section 3.2.2.b of Appendix W under which an alternate model may be approved by the Regional Administrator for regulatory use. The first two conditions involve demonstrating that the alternative refined model produces concentrations equivalent to the preferred model or demonstrating that the alternative model performs better than the

preferred model based upon measured air quality data. The Project is requesting approval for use of the AERMOD-COARE modeling system under Condition 3 which states that there is no preferred model. Even though OCD is listed as a preferred model in Appendix W, this request is made because the preferred model is less appropriate (i.e., old science) for its application to the Project. In addition, model performance of the AERMOD-COARE modeling approach has been found to be comparable to OCD using the tracer studies from overwater field studies.[2] In this study, the authors conclude that AERMOD-COARE could be applied as an alternative to OCD for many regulatory applications.

It should be noted that while the AERMOD-COARE model is technically superior to the OCD model, OCD currently has capabilities that AERMOD-COARE does not. Namely, OCD has algorithms to estimate the effects of both platform downwash as well as shoreline fumigation. The SPOT facility will employ a platform, so consideration of platform downwash effects is relevant. However, shoreline fumigation is of less concern given the distance of the proposed facility from the shoreline and considering that controlling concentrations will occur close to the facility overwater. In addition, SPOT has proposed to treat the platform as a solid structure without airflow under the platform. This procedure will result in an overestimate of downwash effects and lead to conservative, overprediction of concentrations.

Under Condition 3, there are five elements that must be addressed (see Section 3.2.2.e):

1. The model has received scientific peer review;

2. The model can be demonstrated to be applicable to the problem on a theoretical basis;

3. The databases that are necessary to perform the analysis are available and adequate;

4. Appropriate performance evaluations of the model have shown that the model is not biased toward underestimates; and

5. A protocol on methods and procedures to be followed has been established.

In April of 2011, the U.S. Environmental Protection Agency (USEPA) Region 10 (R10) granted approval pursuant to Section 3.0 and 3.2.2.a for the use of output from the COARE algorithm coupled with AERMOD to estimate ambient air pollutant concentrations in an ice-free marine environment. [3,4] The COARE algorithm output was assembled with other meteorological variables in a spreadsheet to form the AERMOD overwater meteorological input files. The Applicant's request for the use of the COARE algorithm was modeled after R10's April 2011 approval. The 2011 approval was based upon the spreadsheet version of the COARE algorithm, not the current version of the COARE algorithm which is now included in the AERCOARE program. The Applicant has proposed to use the AERCOARE program, which includes the programmed version of COARE algorithm.

After USEPA's 2011 approval of the use of the COARE algorithm in spreadsheet form, R10 initiated additional studies in late 2011. One of the studies was designed to code the COARE air-sea flux procedure into the AERCOARE program, thereby eliminating the need to process the data in a spreadsheet. The AERCOARE program also provides support for missing data, adds options for the treatment of overwater mixing heights, and can consider many different data input formats. The results of this study are documented in an October 2012 USEPA report, Evaluation of the Combined AERCOARE/AERMOD Modeling Approach for Offshore Sources (EPA 910-R-12-007). The 2012 study employed the same four tracer studies that were employed in the initial study supporting the April 2011

approval of the spreadsheet version of the COARE output. The 2012 report demonstrates that the programmed AERCOARE version of the COARE results are similar to those made by the spreadsheet version of the COARE results. Comparison of the Q/Q and Sigma Plots from the 2011 and 2012 reports for each of the four tracer studies are nearly identical indicating similar model performance. The previous R10 approval of the COARE algorithms in spreadsheet form should therefore apply to the current COARE algorithms as included in AERCOARE.

As documented in the April 1, 2011, USEPA Region 10 memorandum, the AERMOD-COARE model was approved for use in an Artic marine ice-free environment because it satisfied the five criteria contained in Section 3.2.2.e of Appendix W. In its May 2011 concurrence memorandum, USEPA's Model Clearinghouse stated that its concurrence with USEPA Region 10's approval did not constitute a generic approval of AERMOD-COARE for other applications. However, USEPA's Model Clearinghouse stated:

> *"the scope of the assessment submitted with the R10 Model Clearinghouse request provides a good basis for consideration of AERMOD-COARE for other applications, subject to Regional Office approval based on an assessment of the appropriateness of the performance evaluations (element 4) and the availability of the necessary data bases (element 3) on a case-by-case basis".*

1. Therefore, the Project provides the following justification for each of the five elements contained in Section 3.2.2.e, with emphasis on elements 3 and 4. It should be noted that Region 10 approved of the use AERMOD-COARE based upon tracer studies conducted offshore California and Louisiana, areas far removed from an artic environment. As noted below, the Cameron, LA tracer study was conducted less than 250km from the proposed Project location. These data are more representative of the SPOT Project location than any data from the tracer studies used in Region 10's approval.**The model has received scientific peer review.**

The science behind COARE has been published in scientific peer review journals. The following information is provided as justification that the model has received scientific peer review. Information pertaining to scientific peer review can be found at the following site:

> http://www.coaps.fsu.edu/COARE/.

In addition, a more thorough AERMOD-COARE evaluation study has been performed since the first case-by-case approval by USEPA Region 10 and the Model Clearinghouse of the alternative model. This study was conducted by ENVIRON under contract with USEPA (Contract No. EP-D-07-102, completed in October 2012)[5].

The following is an excerpt from Shell's February 18, 2011, response to the USEPA Region 10 Technical Staff AERMOD-COARE Information and Data Request, dated February 14, 2011, as presented in the April 1, 2011, USEPA Region 10 memorandum:

> *"As reflected in the report provided to EPA in December, Shell believes that COARE reflects the most up-to-date science for marine boundary layer conditions. The Coupled Ocean Atmosphere Response Experiment (COARE) began with research in the late 1970s that culminated in the release of the first COARE code in 1993. It has been updated and improved several time since 1993, the current version of the code was released in 2003. It has world-wide acceptance by organizations such as NOAA, the Institute of Atmospheric Physics, CSIRO in Australia, Woods Hole Oceanographic Institute, the French Centre d'Etude des Environments Terrestre et Planetaires and many others. In the ENVIRON report on the evaluation of the COARE-AERMOD method provided to EPA on December 16, 2010, a*

number of links were provided to reference papers on the topic. For example, one link leads to the following paper:

Brunke, Michael A., Chris W. Fairall, Xubin Zeng, Laurence Eymard, and Judith A. Curry, "Which Bulk Aerodynamic Algorithms are Least Problematic in Computing Ocean Surface Turbulent Fluxes", Journal of Climate, 15 February 2003, pp. 619-635.

This study reports that the COARE algorithm is a preferred method for estimating air mixing in a marine environment. There are many other papers referenced or linked to in the December ENVIRON report that provide a sound scientific basis for the COARE algorithm. We are not stating that it is the only method that could be used, but we have clearly made the required showing that, '[t]he technique has received scientific peer review."

2. The model can be demonstrated to be applicable to the problem on a theoretical basis.

The COARE Bulk Air-Sea Flux algorithm has been well vetted in the regulatory modeling community and has been shown to be applicable on a theoretical basis. USEPA has previously deemed the model appropriate for use in an Arctic marine ice-free environment.

As presented in the April 1, 2011, USEPA Region 10 memorandum:

Version 3.0 of the COARE algorithm with journal references and a User's Manual can be accessed at:

ftp://ftp.etl.noaa.gov/users/cfairall/wcrp_wgsf/computer_programs/cor3_0/

and

http://www.coaps.fsu.edu/COARE/flux_algor/

These references provided copies of the code, descriptions of the scientific basis for the code, and detailed descriptions on how to use the COARE program. However, Shell acknowledges that COARE was not specifically designed to provide an input file for AERMOD, and there are certain steps that must be taken to produce the input files for AERMOD.

Communication with Ken Richmond of ENVIRON and marine boundary layer experts Dr. Andrey Grachev and Dr. Chris Fairall from the National Oceanic and Atmospheric Administration (NOAA) provided the following insight:

From Dr. Chris Fairall:

"*The original COARE version (2.5) (and the 2003 version (3.0)) was set up so that it could handle water and air temperatures from the tropics to the Arctic. Parameters such as the kinematic viscosity of air have T dependencies. I have listed below a few references to Arctic applications I dug up.*

Minimum meteorological variables needed to run the COARE algorithm are the wind speed, the sea surface temperature, the air temperature, and some form of humidity measurement (e.g. relative humidity, absolute humidity, dew point, and wet bulb temperature). Barometric pressure, precipitation, and a typical mixed layer height are also input variables that can be provided or assigned by COARE default parameters. If options are selected for warm-layer heating and/or cool-

skin effects then solar radiation and downward longwave radiation are needed. Shell is not planning to invoke these options but has tested and provided a framework for the provision of these variables using measured solar radiation, cloud cover and ceiling height. COARE also contains several options for the surface roughness length based on wave period and wave height. Shell plans to use the default option that does not need these variables."

As stated in the AERCOARE User Manual:

"AERCOARE uses Version 3.0 of the COARE algorithm that has been updated several times since the initial international TOGA-COARE field program in the western Pacific Ocean from November 1992 to February 1993. The basic algorithm uses air-sea temperature difference, overwater humidity, and wind speed measurements to estimate the sensible heat, latent heat, and momentum fluxes. The original algorithm was based on measurements in the tropics with winds generally less than 10 m/s, but has since been modified and extensively evaluated against measurements in high latitudes with winds up to 20 m/s. Based on these studies, AERCOARE is expected to be appropriate for marine conditions found at all latitudes including. The current version considers both warm-layer diurnal heating and cool-skin effects and allows alternative parameterizations of the surface roughness when wave measurements are available."

The COARE algorithms have been evaluated based upon data collected in field studies conducted in the Gulf. Based on this, and other studies, EPA has determined that the model is applicable to dispersion applications over a marine, ice free environment similar to the Gulf.

3. The databases that are necessary to perform the analysis are available and adequate.

The model evaluation datasets used in the AERCOARE validation studies were obtained from the archives supporting development of the Minerals Management Service (MMS) version of CALPUFF and OCD Version 4. Three datasets were evaluated: Carpinteria, and Pismo Beach, California, as well as Cameron, Louisiana. These studies occurred under a wide range of overwater atmospheric stabilities that might be expected in coastal waters regardless of the latitude. A key positive consideration in approving AERMOD-COARE for use by the Project is the availability of a validation study in the same Gulf of Mexico region as the Project location.

The pollutant dispersion tracer gas measurement study in Cameron, Louisiana, occurred in level terrain near the shoreline downwind of offshore tracer gas releases. The terrain and offshore conditions of this study mimic those found in the Project location since both are offshore in the western Gulf of Mexico. The Cameron, Louisiana, study, in conjunction with the Pismo Beach, California, study, provide two tests of overwater dispersion without the complications introduced due to air modification over the land or complex terrain[4]. The location of the Cameron, Louisiana, tracer gas experiment in the Gulf of Mexico in proximity to the proposed SPOT Project location is shown on Figure 1. The Cameron, Louisiana, evaluation database is, therefore, representative of the atmospheric conditions in the Gulf of Mexico in the vicinity of the Project.

Figure 2 shows the land use, release points, receptors, and meteorological stations for the Cameron, Louisiana, evaluation dataset. Twenty-six (26) tracer gas samples from the field studies in July 1981 and February 1982 were used in the evaluation. Tracer gas was released from both a boat and a low-profile platform at a height of 42.7 feet (13 meters) above the water surface. The receptors were located in flat terrain near the shoreline, with transport distances ranging from 2.5 to 6.2 statute miles (4 to 10 kilometers).

The Cameron, Louisiana, meteorological data used in the AERCOARE evaluation were based on the OCD and CALPUFF model evaluation dataset. The dataset contains both very stable and fairly unstable conditions. There are several hours of stable lapse rates accompanied by unstable air-sea temperature differences, thus providing a range of dispersion conditions.

Furthermore, the meteorological inputs needed to populate AERCOARE are available and adequate.

4. Appropriate performance evaluations of the model have shown that the model is not biased toward underestimates.

The April 1, 2011, memorandum from USEPA Region 10, in conjunction with the USEPA/ENVIRON October 2012 Model Evaluation Study, present the detailed results of the model evaluation studies. These studies demonstrate that the model is not biased toward underestimates.

As documented in the October 2012 Model Evaluation Study, AERCOARE Version 1.0 (12275) was applied to prepare the overwater meteorological data for the Cameron, Louisiana, offshore dataset. AERCOARE simulations were conducted using five different methods for the preparation of the meteorological data, including the estimation of mixing heights, the use of horizontal wind direction (sigma theta data), and limitations on other variables provided to AERMOD to calculate concentrations from the field studies.

AERMOD was run using default dispersion options for rural flat terrain for the Cameron, Louisiana, simulations. Peak calculated concentrations were compared to peak observed concentrations (from tracer gas in-field concentration measurements), resulting in a total of 101 paired samples for statistical analysis. Quantile-quantile (Q-Q) plots were prepared, among other statistical analyses, to test the ability of the model predictions to represent the frequency distribution of the observations. Q-Q plots are ranked pairings of predicted and observed concentrations. The rank of the predicted concentration is plotted against the same ranking of the observed concentration. The Q-Q plots were evaluated to determine whether the models are biased toward underestimates at the important upper end of the frequency distribution.

The Q-Q plot for the Cameron, Louisiana, dataset is presented as Figure 3. As shown, the model concentrations generally are within the factor of 2 bounds of the plot. In addition, no apparent difference in the model performance under the five different AERCOARE meteorological data preparation cases were observed. The AERMOD predictions using AERCOARE-prepared meteorological data tend to be biased toward over-prediction for the highest concentrations, with less than a factor of 2 under-prediction at the lower concentrations. Importantly, COARE-AERMOD does not appear to be biased toward underestimates for the higher end of the frequency distribution, regardless of the five different meteorological preparation options examined in this study.

5. A protocol on methods and procedures to be followed has been established.

SPOT has developed and submitted a modeling protocol document for USEPA Region 6 review and approval. The modeling protocol outlines the modeling techniques that were employed by the SPOT Project, and it conforms with the modeling procedures outlined in the Guideline on Air Quality Models (Appendix W of 40 CFR 51), associated USEPA modeling policy and guidance, as well as Texas Commission on Environmental Quality (TCEQ) Air Quality Modeling Guidelines.

Summary

Based on the information and reasoning provided in this document, along with supporting references and data, SPOT believes that the proposed AERMOD-COARE modeling approach is justified as a more suitable method for estimating dispersion in the OCS of the Gulf of Mexico than OCD. The surface fluxes calculated by the COARE algorithm in conjunction with the overwater meteorological data are preferred to the conventional application of AERMET, which is only applicable over land surfaces. In addition, AERMOD is preferred over OCD because of the PRIME downwash algorithm, the ability to simulate volume sources, the ability to incorporate NOx to NO_2 conversion using ARM2, AERMOD's ability to generate the concentrations in the statistical form of the new NAAQS, and the distance of the proposed source location from the shoreline.

If you have any questions or require additional information, please contact Mr. David Keen (919) 845-1422 Ext. 41, Mr. Bruce Wattle (716) 651-3610, or the undersigned.

Sincerely,
SPOT Terminal Services LLC

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Senior Manager, Environmental

Rodney M. Sartor
Senior Director, Environmental

/bjm
cc: Rodney Sartor, SPOT Terminal Services LLC
David Keen, RTP Environmental Associates, Inc.
Antonino Riccobono, Ecology and Environment, Inc.
Bruce Wattle, Ecology and Environment, Inc.

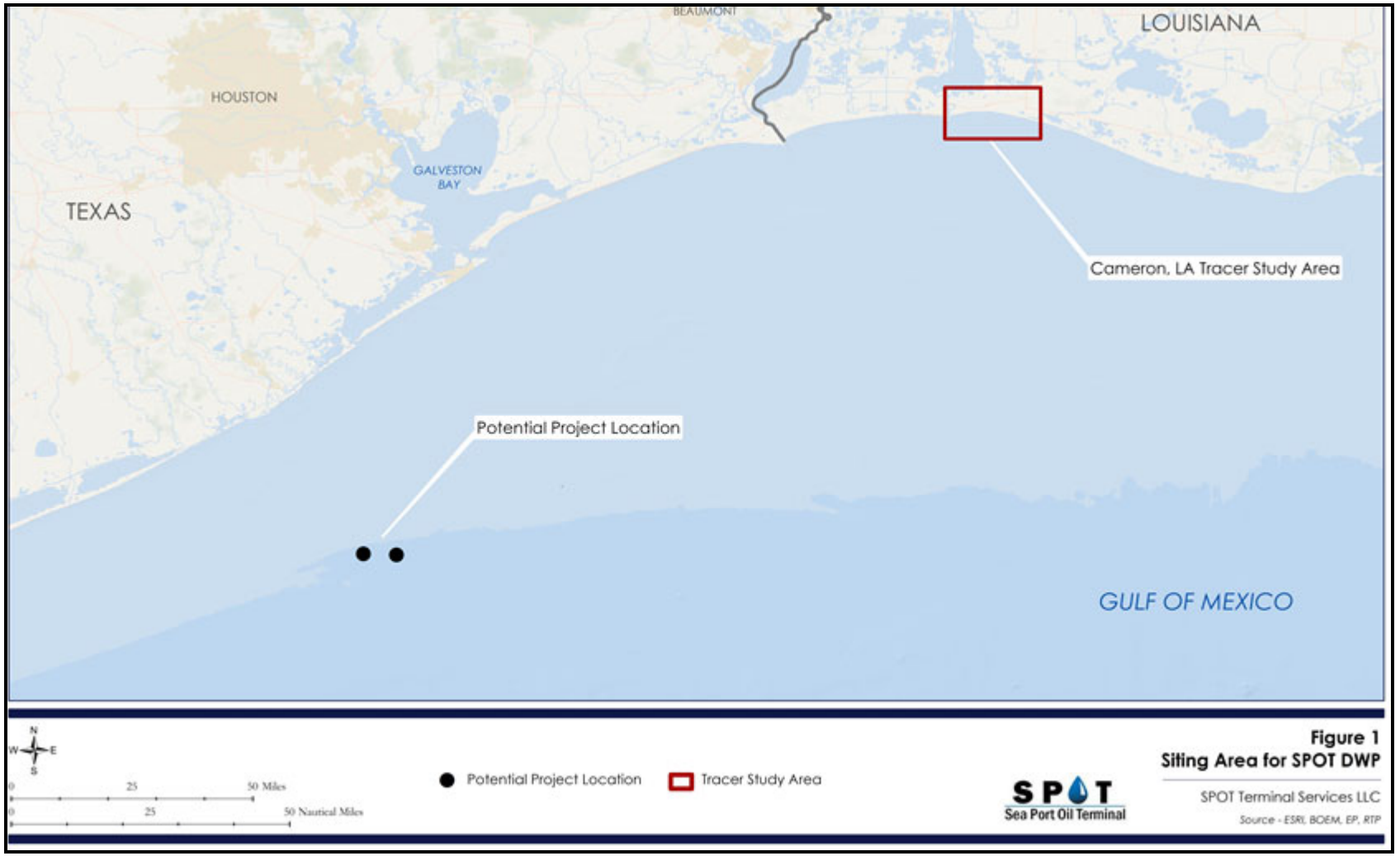

Figure 1. Siting Area for SPOT DWP

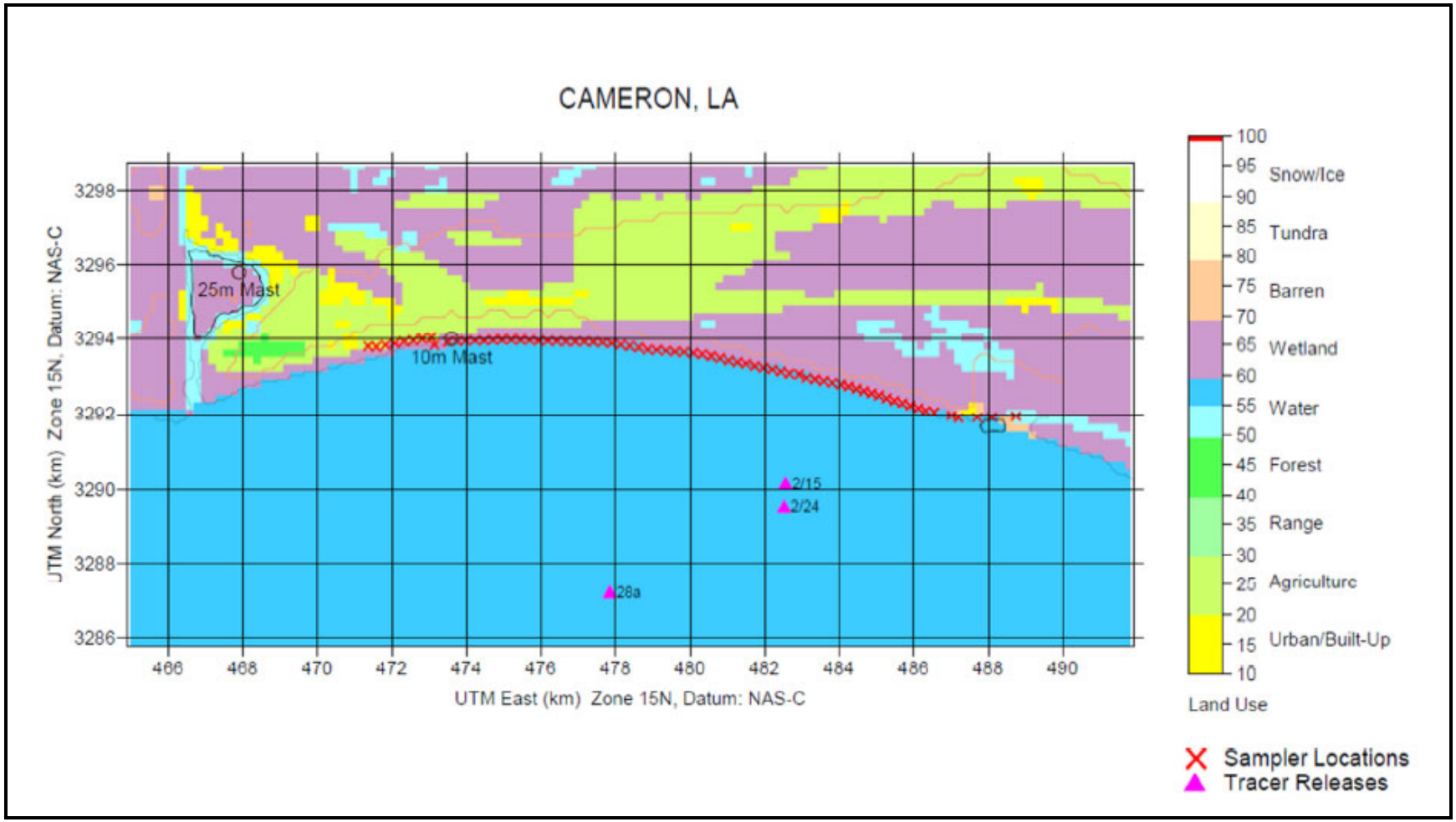

Figure 2. Cameron, Louisiana, Tracer Study Location Relative to the Contemplated Locations of the SPOT Loading Project

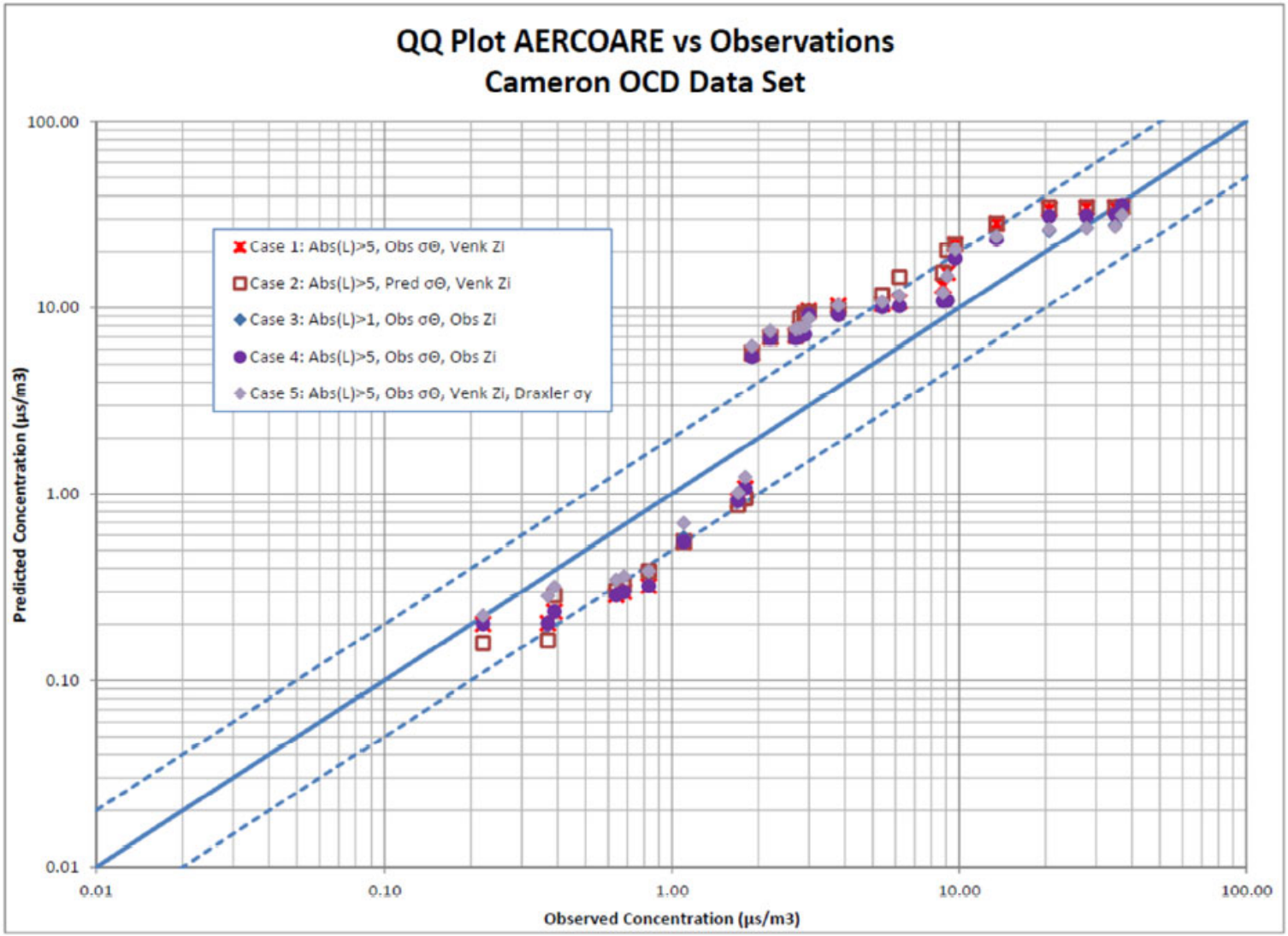

Figure 3. QQ Plot of AERCOARE vs Cameron, Louisiana, Tracer Study Results

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1. Guidelines on Air Quality Models, Appendix W of 40 CFR Part 51, January 17, 2017.

2 AERCOARE: An Overwater Meteorological Preprocessor for AERMOD, Wong, Herman, et. al, Journal of the Air & Waste Management Association, 2016, Vol 66, No 11, 1121-1140.

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4. Model Clearinghouse Review of AERMOD-COARE as an Alternative Model for Application in an Arctic Marine Ice-Free Environment, George Bridgers, USEPA to Herman Wong, USEPA, May 6, 2011.

5. Evaluation of the Combined AERCOARE/AERMOD Modeling Approach for Offshore Sources, USEPA Contract No. EP-D-07-102, EPA 910-R-12-007, October 2012.