Outer Continental Shelf
Air Quality Impact Analysis
Volume II

Chukchi Sea

Devil's Paw Prospect

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ConocoPhillips OCS Air Permit Application Air Quality Impact Analysis Alaska Seaward Boundary Point of Compliance

FINAL

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1.0 Introduction

This report documents the procedures and results of an ambient air quality impact analysis supporting a Part 71 air permit application for an exploratory drilling program ConocoPhillips Company is proposing for leases they hold on the Chukchi Sea.

1.1 Project Summary

ConocoPhillips Company (COP) intends to conduct an exploratory drilling program within the Devils Paw Prospect on the Chukchi Sea. As shown in **Figure 1-1**, leases held by COP within the Devils Paw prospect range from 100 to 150 kilometers (km) offshore of the northwest coast of Alaska in waters above the Outer Continental Shelf (OCS). Annually, it is anticipated that exploratory drilling will involve at most three well locations and will only be conducted for a maximum of 100 days during the ice-free period July to November.

The exploratory program will be designed around conducting drilling with a jackup drill rig that will be towed to the project site and supported in place on legs lowered to the sea floor through the rig superstructure. The drill rig will be supported by several mobile support vessels used for spill prevention, resupply, ice management, emergency response, fire response and ongoing biological, climatological and oceanographic monitoring and research.

1.2 Permitting Approach

As shown in **Figure 1-1**, the project area is located beyond the Alaska seaward boundary; therefore, project air emissions are regulated under the OCS Air Regulations (40 CFR Part 55). For the purposes of interpreting the OCS Air Regulations the project is located on waters above the Outer OCS since the Devil's Paw Prospect is located more than 25 miles beyond the Alaska seaward boundary. Because the project is regulated under the OCS Air Regulations, but is within the 200-mile jurisdiction of the United States, these activities will require an air permit issued by the USEPA Region 10.

Based on requested operational assumptions and limitations, project potential emissions will not exceed 250 tons per year for NO_x, SO_2, CO, PM_{10} or $PM_{2.5}$, thus a Prevention of Significant Deterioration (PSD) permit will not be required and COP is requesting a Part 71 permit for this project. COP believes that any ambient air quality impact analysis supporting the Part 71 permit application only needs to demonstrate that impacts from the proposed project, while it is an OCS source, do not cause or contribute to a violation of the National Ambient Air Quality Standards (NAAQS) for NO_2, SO_2, CO, PM_{10}, $PM_{2.5}$, lead and ozone at the point of compliance. This demonstration can be made by showing that project impacts are below the Significant Impact Levels (SILs) or with a cumulative impact analysis showing that project impacts combined with impacts from regional anthropogenic and biogenic sources are below the NAAQS. This ambient air quality impact analysis demonstrates that project impacts are below the SILs and do not cause or contribute to a violation of the NAAQS at the point of compliance making a cumulative impact unnecessary.

1.3 OCS Source Description

The project Potential to Emit (PTE) and ambient air quality impact analysis supporting the air permit application only includes emissions that occur while the drill rig is an "OCS Source". For this application the proposed project becomes an OCS Source when the jackup rig achieves "zero air gap". The drill rig achieves zero air gap after the legs come into contact with the seabed and the rig is jacked to a height at which the drill rig platform clears the water surface.

1.4 Point of Compliance

Any ambient air quality impact analysis must demonstrate that the project does not cause or contribute to a violation of applicable standards at the point of compliance. For this application, the point of compliance for a source proposed to locate in the Outer OCS is the State of Alaska's seaward boundary.

1.5 Technical Approach Overview

The procedures documented herein closely follow those developed in collaboration with USEPA Region 10 and documented in the project modeling protocol (AECOM 2011b) and the supplemental protocol (AECOM 2011a).

As **Figure 1-1** shows, the closest distance from any COP lease block in the Devil's Paw Prospect to the Alaska seaward boundary is approximately 108 km (~67 miles). Considering the OCS source boundary extends 25 miles from this lease block and support vessels can operate anywhere within that boundary, the closest a source will be modeled to the Alaska seaward boundary is 68 km (~42 miles). For conducting an ambient air quality impact analysis based on impacts predicted with a USEPA guideline dispersion model at this distance, a non-steady-state modeling approach that considers spatial and time variations in meteorological conditions is appropriate. Therefore, the CALPUFF modeling system was used for this analysis.

In order to conduct modeling with CALPUFF, three years of mesoscale meteorological wind fields developed with the Weather Research and Forecasting (WRF) model were combined with available observational data and processed with CALMET to create a meteorological input file. A conservative and simplified simulation capturing all potential operating scenarios was developed to represent all COP emissions with CALPUFF. The simulation involved modeling all emissions at two locations. One location was on the edge of the Devil's Paw Prospect representing the drill rig and nearby static vessels and one location on the edge of the OCS source boundary nearest the point of compliance representing the mobile support vessels. Impacts from modeled sources were predicted on the Alaska seaward boundary stretching from Point Hope to Barrow.

This approach to simulating emissions was designed to conservatively represent project ambient air quality impacts on the Alaska seaward boundary while at the same time representing all potential OCS source operating scenarios with a single worst-case simulation. Conservative aspects of this approach involved:

- Collocating the drill rig and nearby static support vessel emissions and modeling them through two worst-case point sources without downwash. This not only maximizes downwind impacts but also ensures the analysis is independent of vessel and drill rig specific configurations and drill rig location on the Devil's Paw Prospect.
- Collocating all mobile vessel emissions and modeling them through a single worst-case volume source at the edge of the OCS source boundary nearest the point of compliance. Again, this not only maximizes downwind impacts but also ensures the analysis is independent of vessel specific configurations and places no limitation on vessel movement.
- Modeling the simultaneous operation of various support vessels and equipment on vessels representing worst-case scenarios that will not occur in reality. For example, among many possible scenarios, the emissions modeled represents resupplying the drill rig during a spill response exercise called in the midst of a major ice incursion which will not occur.

1.6 Summary of the Ambient Air Quality Impact Analysis

Dispersion modeling was conducted to predict project air quality impacts on the Alaska seaward boundary using maximum hourly emissions and worst-case operational scenarios. The analysis shown in **Table 1-1** demonstrates that predicted project impacts are below the SILs at the Alaska seaward boundary. Therefore, the analysis shows that the project will not cause or contribute to a violation of applicable standards at the point of compliance without conducting a cumulative impact analysis.

Figure 1-1 Map of the Chukchi Sea Sales 193 Lease Areas

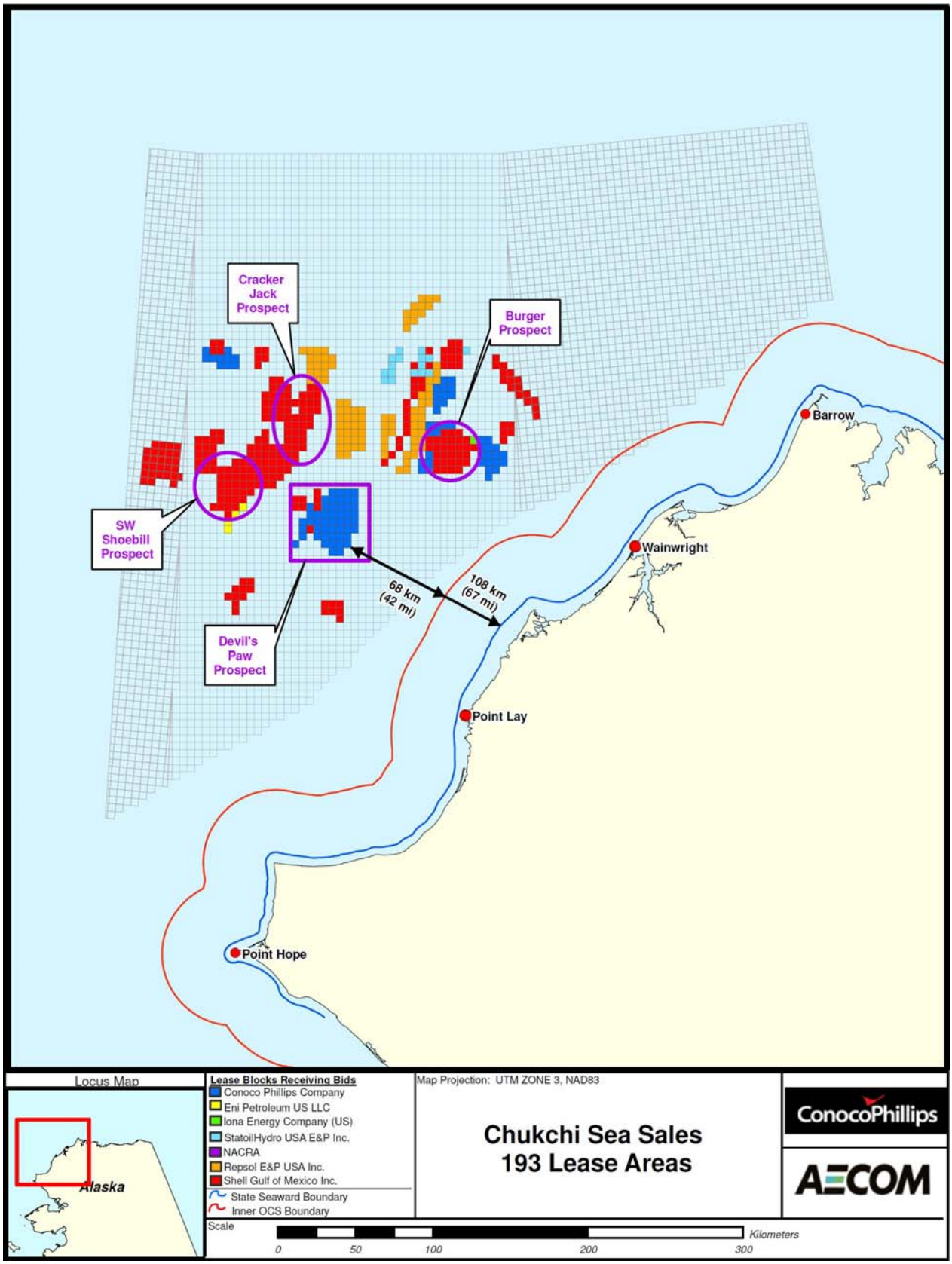


Table 1-1 Model Predicted Project Ambient Air Quality Impacts

Pollutant	Period	Predicted Project Impact [1] ($\mu g/m^3$)	SIL ($\mu g/m^3$)	Percent of SIL
Sulfur Dioxide (SO_2)	1-hour	0.033	7.9	0.4
	3-hour	0.032	25	0.1
	24-hour	0.012	5	0.2
	Annual	0.00008	1	0.01
Nitrogen Dioxide (NO_2) [2]	1-hour	6.2	7.5	83
	Annual	0.023	1	2
Carbon Monoxide (CO)	1-hour	10.3	2,000	0.5
	8-hour	5.7	500	1
PM_{10}	24-hour	0.32	5	6
	Annual	0.003	1	0.3
$PM_{2.5}$ [3]	24-hour	0.32	1.2	26
	Annual	0.003	0.3	0.9
Lead [4]	3-month	0.00002	0.006	0.3
	Quarterly	0.00002	0.06	0.03

[1] Impacts predicted for only the ConocoPhillips OCS Source.

- With the exception of 1-hour SO_2 and NO_2, and 24-hour $PM_{2.5}$ the SIL is compared to the highest predicted concentration for the specific averaging time.
- For 1-hour SO_2 and NO_2, and 24-hour $PM_{2.5}$, the SIL is compared to the highest of the multi-year averages of the maximum modeled 1-hour, or 24-hour concentrations predicted each year at each receptor, based on three years of available site specific meteorological data (USEPA 2011, USEPA 2010b).

[2] As recommended by USEPA for 1-hour NO_2, the 80% ambient ratio method was used to convert NO_x to NO_2 (USEPA 2011). For annual NO_2, the 75% ambient ratio method was used to convert NO_x to NO_2. (40 CFR 51 Appendix W Section 5.2.4c).

[3] Multi-year average of the maximum model predicted impact from modeling conducted using three years of representative meteorological input data. For 24-hour $PM_{2.5}$ this represents a screening level approach and accounts for secondary particulate formation according to the USEPA Office of Air Quality Planning and Standards (USEPA 2010b).

[4] No SIL has been established for lead; therefore, the SIL represents 4% of the respective NAAQS. This value was set following the approach taken by USEPA where the SIL associated with the 1 hour NO_2 NAAQS was set at 4% of the NAAQS following historical precedence (USEPA 2010a).

2.0 Source Inventory

Dispersion modeling that has been conducted to support the air permit application includes emissions from the OCS Source (i.e., the drill rig and vessels physically attached to it), and emissions from vessels that are not part of the OCS Source but support it (i.e., spill response vessels, ice management vessels, supply vessels, etc.) while they are operating within 25 miles of the drill rig. These emissions are only considered in the dispersion modeling while the drill rig is an OCS Source. The drill rig is an OCS Source between the point that the drill rig achieves zero air gap as it is being jacked up and the point that it reaches zero air gap as it is being jacked down.

2.1 Overview of Operations

COP is seeking to permit a maximum 100 day drilling season occurring during the ice free periods between the beginning of July and the end of November. Drilling will be conducted with a jackup rig and COP would like to permit two different options for supplying the drill rig:

- OPTION 1: The drill rig is supplied by an Offshore Supply Vessel (OSV) with backup support provided by a second OSV if the first OSV is unavailable.
- OPTION 2: The drill rig is supplied by a Ware Vessel with backup support provided by either an OSV or an Anchor Handing Tug Supply (AHTS) vessel if the Ware Vessel is unavailable.

The option selected not only has bearing on how the drill rig is supplied, but also how it is towed to the project location as will be described below.

After the jackup rig has been dry towed near the project site, prior to it becoming an OCS Source, the drill rig will be wet towed to the project site (well location) by one AHTS vessel and two OSVs (OPTION 1) or two AHTS vessels and one OSV (OPTION 2).

After the rig is towed to the project site, the three tow vessels will station themselves on each of the three corners of the drill rig and the rig will lower its legs to the sea floor. Once the legs contact the sea floor and the rig is considered stable, the legs are considered pinned and two of the tow vessels will detach from the drill rig and move out approximately 0.5 miles from the drill rig where they will idle or transit the area at low speed. For safety, an AHTS vessel stays connected with a slack line as the drill rig is jacked up to zero air gap.

Once the drill rig achieves zero air gap, the drill rig is considered an OCS Source and emissions associated with all subsequent activities count toward source potential to emit and must be included in the ambient air quality impact analysis. **Figure 2-1** and **Figure 2-2** depict typical vessel configuration at zero air gap for OPTION 1 and OPTION 2, respectively.

At a particular well site, the likelihood the drill rig will achieve zero air gap more than once is small. Extensive studies of the seafloor at the well location will be conducted in advance of the drill rig arriving at the project site to ensure the sea floor will support the drill rig. Therefore, the likelihood that the drill rig will reach zero air gap, need to be jacked down, towed to a slightly different location and jacked back up is small. However, during a single drilling season, there is the possibility that the drill rig will be used at three different well sites. If this occurs, the drill rig will achieve zero air gap at the first well site, a second time at the second well site, and so on.

At zero air gap, jacking up is temporarily halted and the AHTS vessel retrieves its tow line and moves out to approximately 0.5 miles from the drill rig. The three tow vessels then remain approximately 0.5 miles away where they will either idle or transit the area at low speed. Once the three tow vessels are in position, the drill rig continues jacking up to preload height. Then preload occurs, during which the drill rig is filled with seawater to simulate the structural loads of normal operations. The drill rig then continues to jack up to reach its final

operating height. Once the drill rig reaches its final operating height, the drill rig has completed the jacking up process and starts extending the cantilever. At this point:

- Two of the tow vessels cruise outside the 25 mile OCS source boundary. These vessels will reach the OCS source boundary well before the cantilever is fully extended.
- The AHTS vessel anchors near the drill rig for the duration of drilling activities to respond to emergencies.
- The Dedicated Oil Spill Response Vessel (OSRV) moves toward its position approximately 3 miles from the drill rig. The Dedicated OSRV remains near the drill rig either anchored/moored or cruising nearby for spill response, to respond to emergencies and to support boom laying activities during drill rig refueling.

Figure 2-3 and **Figure 2-4** depict the typical vessel configuration just after cantilever extension begins for OPTION 1 and OPTION 2, respectively.

Once the cantilever is extended the drill rig will be ready to take on supplies and begin to prepare for drilling activities. Therefore, as soon as the cantilever is extended, consecutive resupply trips will begin until the drill rig is fully supplied (Initial Resupply). During the Initial Resupply, as many as two trips per day by an OSV (OPTION 1) or a Ware Vessel (OPTION 2) will occur until the drill rig is fully supplied. At this point supply trips will occur less frequently. However, at no time will more than one resupply vessel be within 25 miles of the drill rig. **Figure 2-5** and **Figure 2-6** depict the typical vessel configuration during the Initial Resupply for OPTION 1 and OPTION 2, respectively.

Once the Initial Resupply is complete and normal drilling activities begin, the drill rig is expected to be resupplied approximately every 4 to 6 days depending on if resupply is conducted by an OSV (OPTION 1) or a Ware Vessel (OPTION 2). The majority of the resupply trips simply involve transporting supplies to the drill rig and offloading the supplies while the supply vessel Dynamically Positions (DP) next to the drill rig (Regular Resupply). Then the supply vessel leaves the 25 mile OCS boundary. **Figure 2-7** and **Figure 2-8** depict the typical vessel configuration during a regular resupply trip for OPTION 1 and OPTION 2, respectively.

Approximately every third resupply trip will be to refuel the drill rig (Refueling Resupply). If the drill rig is being supplied with fuel, either the Dedicated OSRV or one of its work boats will move in to lay spill response boom around the refueling activity. Laying boom will not be necessary when supplying the drill rig with supplies other than fuel (i.e., a Regular Resupply). Because the Dedicated OSRV is required to support boom laying activities, refueling will not occur if the Dedicated OSRV is participating in spill response exercises. **Figure 2-9** and **Figure 2-10** depicts the typical vessel configuration during a Refueling Resupply for OPTION 1 and OPTION 2, respectively.

Regardless of the type of resupply trip (i.e., Regular or Refueling), there is the possibility that the resupply vessel could be delayed in approaching the drill rig waiting for bad weather to clear. However, once the resupply vessel arrives at the drill rig and begins transferring supplies, it will only need to remain there approximately 6 hours. As with the Initial Resupply, no more than one resupply vessel will be within 25 miles of the drill rig at the same time.

At any point during normal operations and resupply, the following activities could be occurring within the 25 miles of the drill rig:

- Ice management by ice breakers
- Research vessel activities
- Spill response activities

However, as previously discussed, Refueling Resupply cannot occur while spill response exercises are occurring since both require the presence of the Dedicated OSRV.

The majority of the time during normal operations, the Dedicated OSRV and the AHTS vessel will be the only vessels within 25 miles of the drill rig because resupply trips occur periodically and can be completed in 12 hours or less depending on weather. In addition, the research vessel and ice breakers are intermittent and transient activities. **Figure 2-11** depicts the typical vessel configuration during normal operations.

At the end of the project (i.e., when exploration drilling is completed), removal of the drill rig from the project site requires cantilever retraction and jacking the drill rig down to the water at which point the drill rig ceases being an OCS Source. While the rig is being jacked down, the legs are loosened from the seabed via water jets applied to the seabed through the legs. An AHTS vessel is connected for safety via a slack line to the drill rig, and the other two tow vessels remain approximately 0.5 miles away. This scenario, which takes place just prior to the drill rig jacking down to zero air gap, is depicted in **Figure 2-12** and **Figure 2-13** for OPTION 1 and OPTION 2, respectively. By the time the legs are loosened, the drill rig is no longer an OCS Source and the other two tow vessels connect and the legs are pulled the rest of the way up in preparation for towing. The drill rig ceases to be an OCS Source after the AHTS vessel is connected but before the two tow vessels connect to the drill rig.

In contrast to the typical operational scenarios discussed above, modeling must consider the worst-case potential vessel configurations (i.e., situations that must be considered to avoid permit conditions to protect ambient air quality but that are unlikely to occur in reality). Worst-case potential vessel configurations that were considered in the modeling for the Regular Resupply are depicted in **Figure 2-14** and **Figure 2-15** for OPTION 1 and OPTION 2, respectively and represent resupplying the drill rig during a spill response exercise called in the midst of a major ice incursion which will not occur. These figures can be compared to the typical vessel configurations depicted in **Figure 2-7** and **Figure 2-8**, respectively.

Figure 2-1 Typical Vessel Arrangement at Zero Air Gap While Jacking Up – OPTION 1

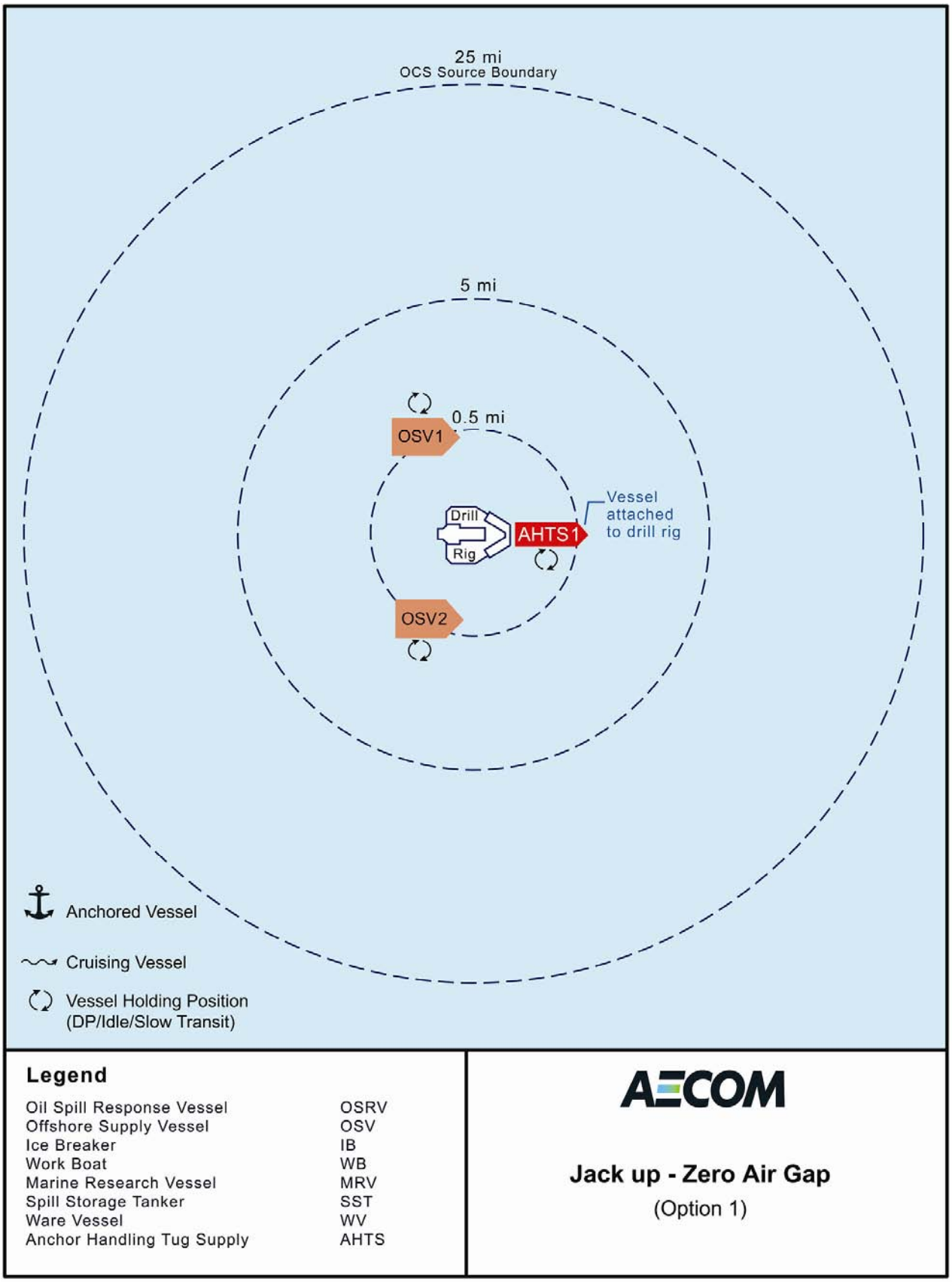
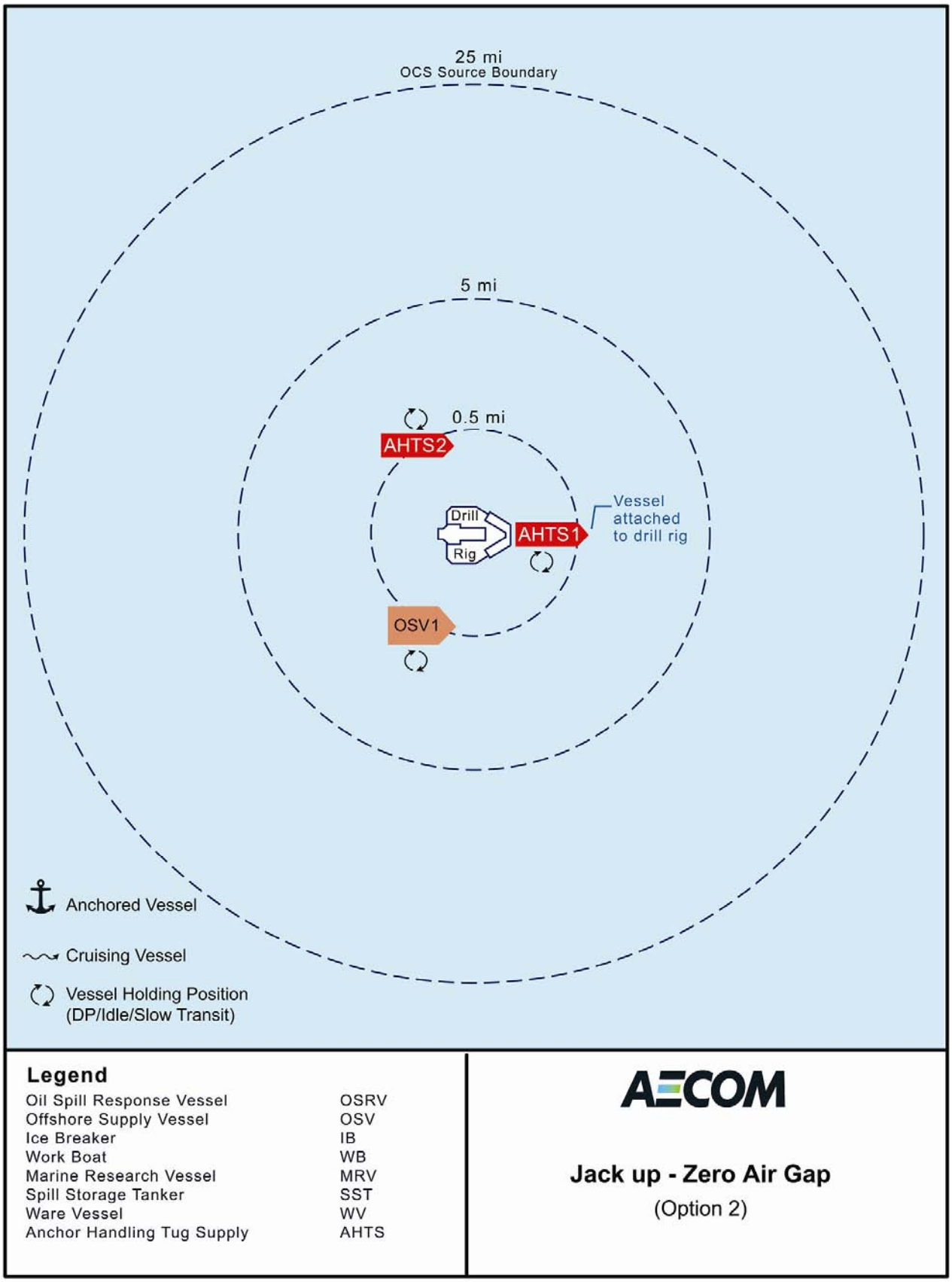


Figure 2-2 Typical Vessel Arrangement at Zero Air Gap While Jacking Up – OPTION 2



Legend

Oil Spill Response Vessel	OSRV
Offshore Supply Vessel	OSV
Ice Breaker	IB
Work Boat	WB
Marine Research Vessel	MRV
Spill Storage Tanker	SST
Ware Vessel	WV
Anchor Handling Tug Supply	AHTS

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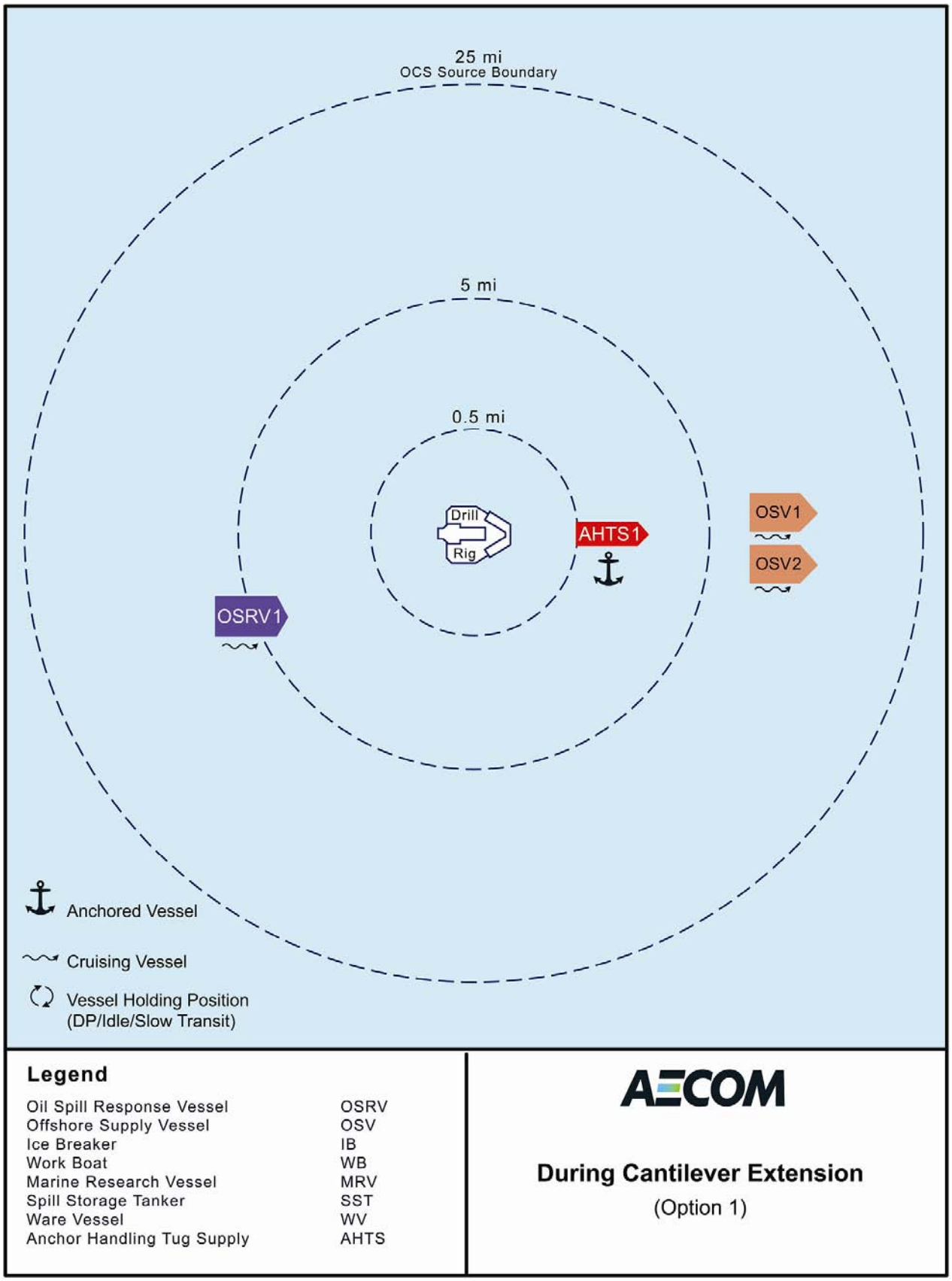
Jack up - Zero Air Gap

(Option 2)

Figure 2-3 Typical Vessel Arrangement During Cantilever Extension – OPTION 1



Legend

Oil Spill Response Vessel	OSRV
Offshore Supply Vessel	OSV
Ice Breaker	IB
Work Boat	WB
Marine Research Vessel	MRV
Spill Storage Tanker	SST
Ware Vessel	WV
Anchor Handling Tug Supply	AHTS

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During Cantilever Extension

(Option 1)

Figure 2-4 Typical Vessel Arrangement During Cantilever Extension – OPTION 2

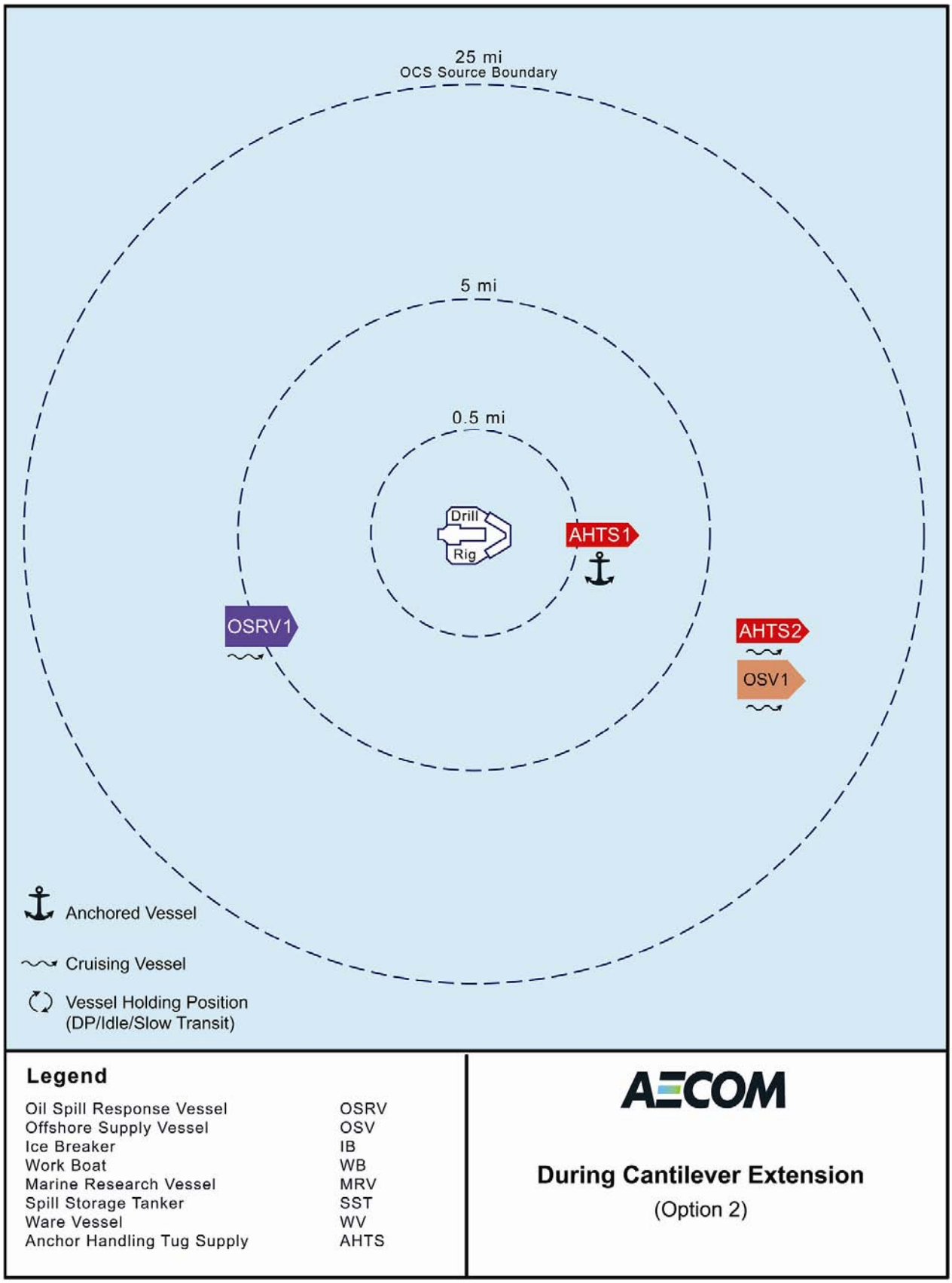


Figure 2-5 Typical Vessel Arrangement During Initial Resupply – OPTION 1

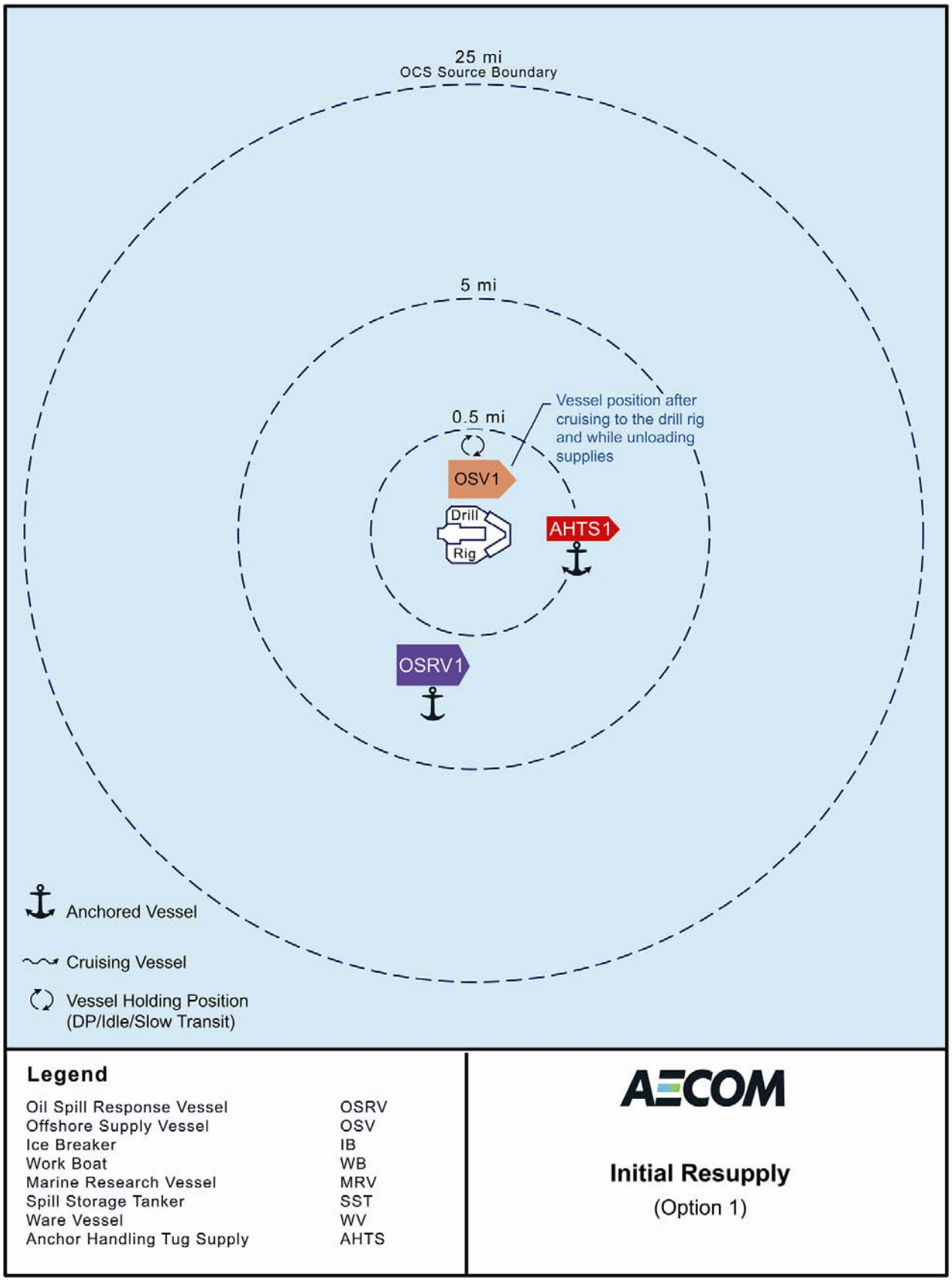


Figure 2-6 Typical Vessel Arrangement During Initial Resupply – OPTION 2

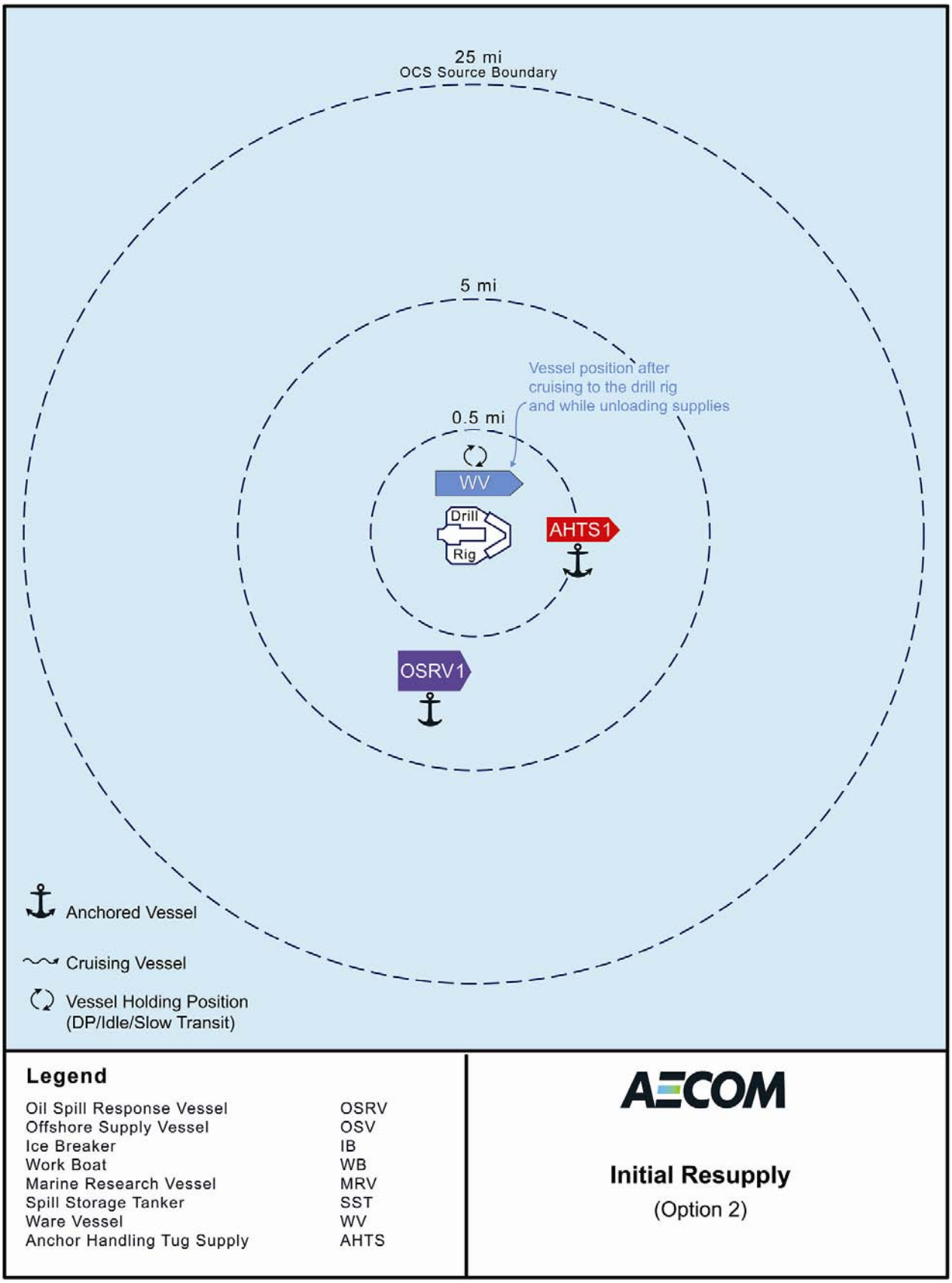
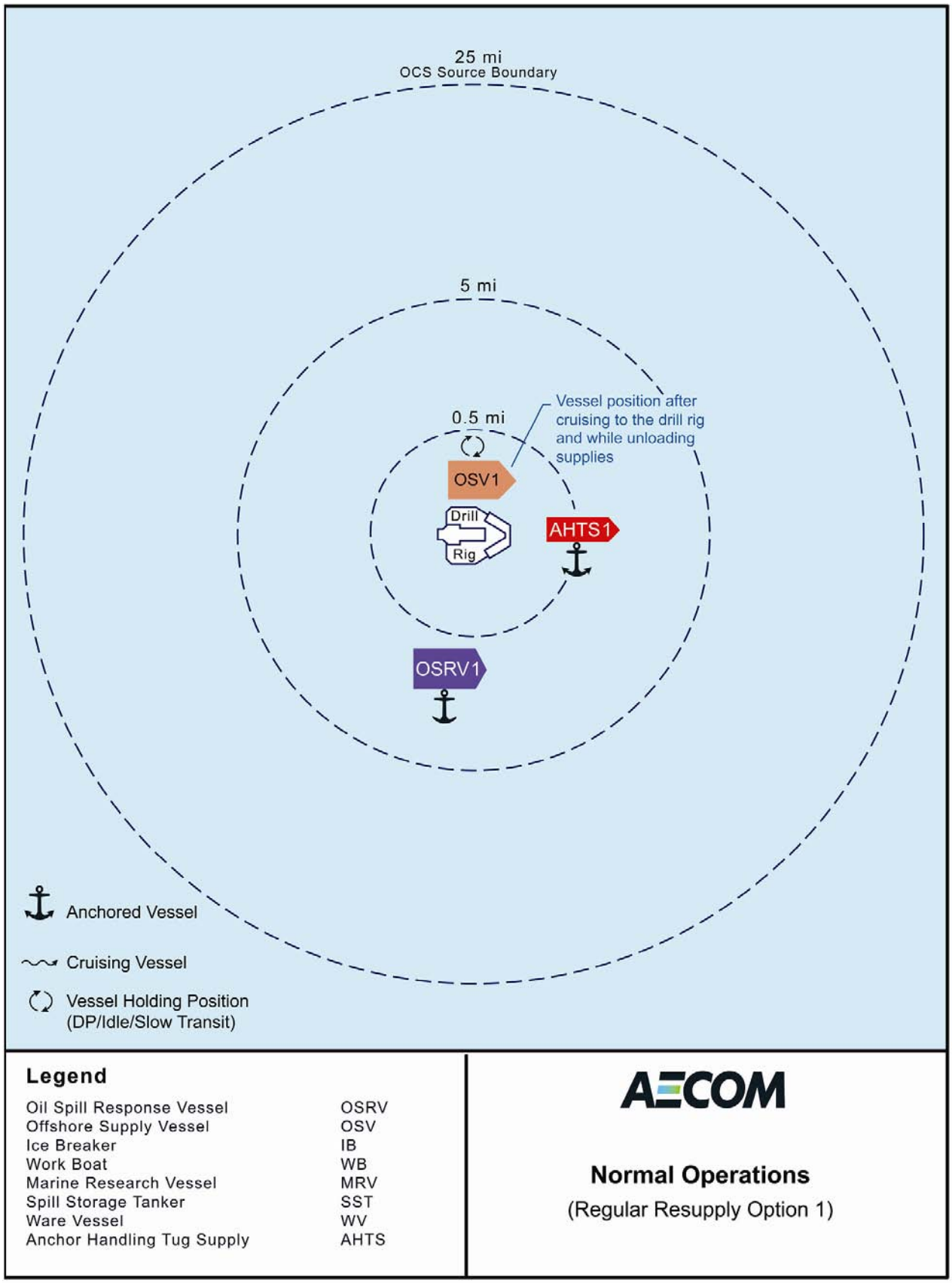


Figure 2-7 Typical Vessel Arrangement During a Regular Resupply – OPTION 1



Legend

Oil Spill Response Vessel	OSRV
Offshore Supply Vessel	OSV
Ice Breaker	IB
Work Boat	WB
Marine Research Vessel	MRV
Spill Storage Tanker	SST
Ware Vessel	WV
Anchor Handling Tug Supply	AHTS

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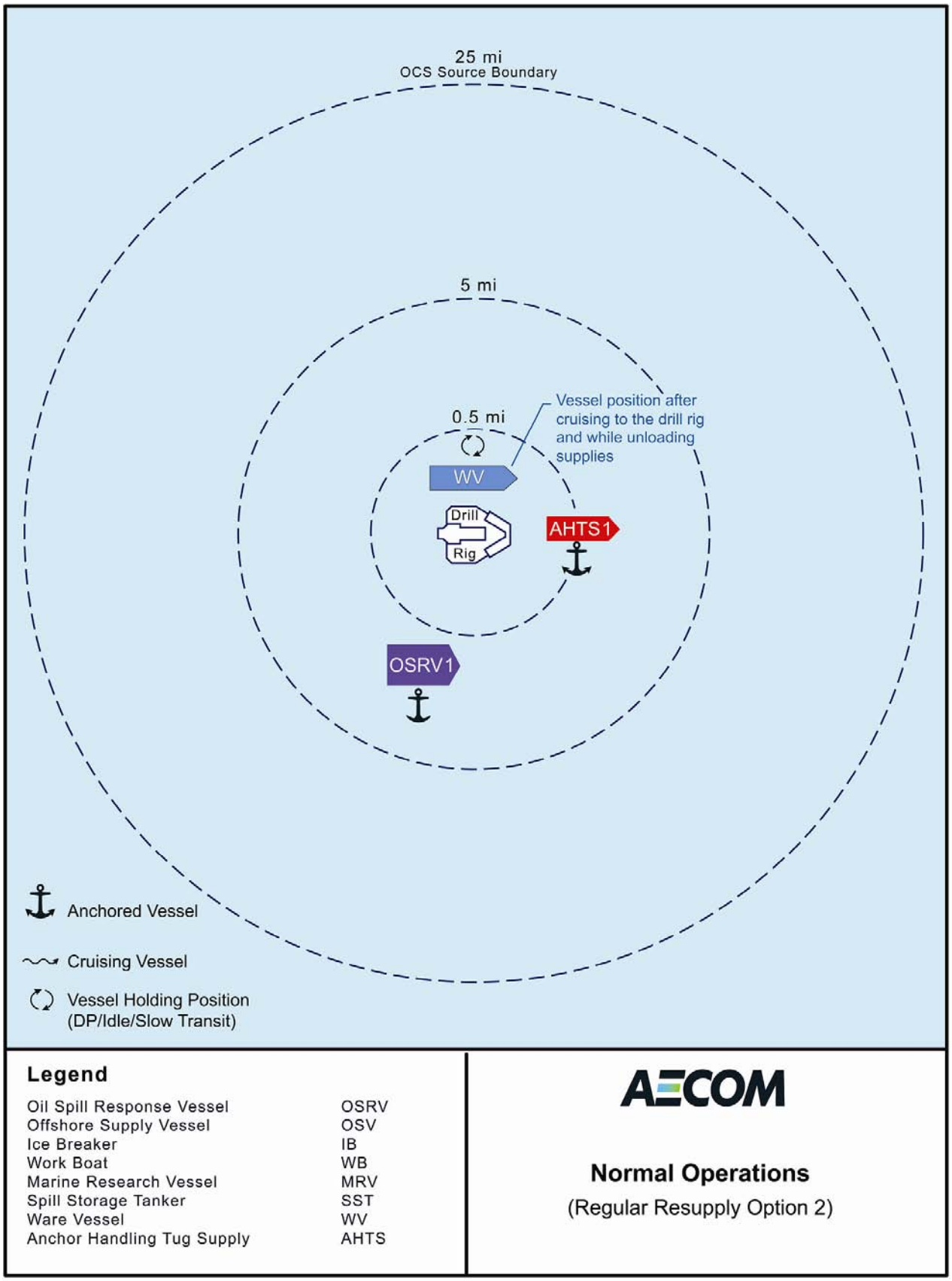
Normal Operations

(Regular Resupply Option 1)

Figure 2-8 Typical Vessel Arrangement During a Regular Resupply – OPTION 2



Legend

Oil Spill Response Vessel	OSRV
Offshore Supply Vessel	OSV
Ice Breaker	IB
Work Boat	WB
Marine Research Vessel	MRV
Spill Storage Tanker	SST
Ware Vessel	WV
Anchor Handling Tug Supply	AHTS

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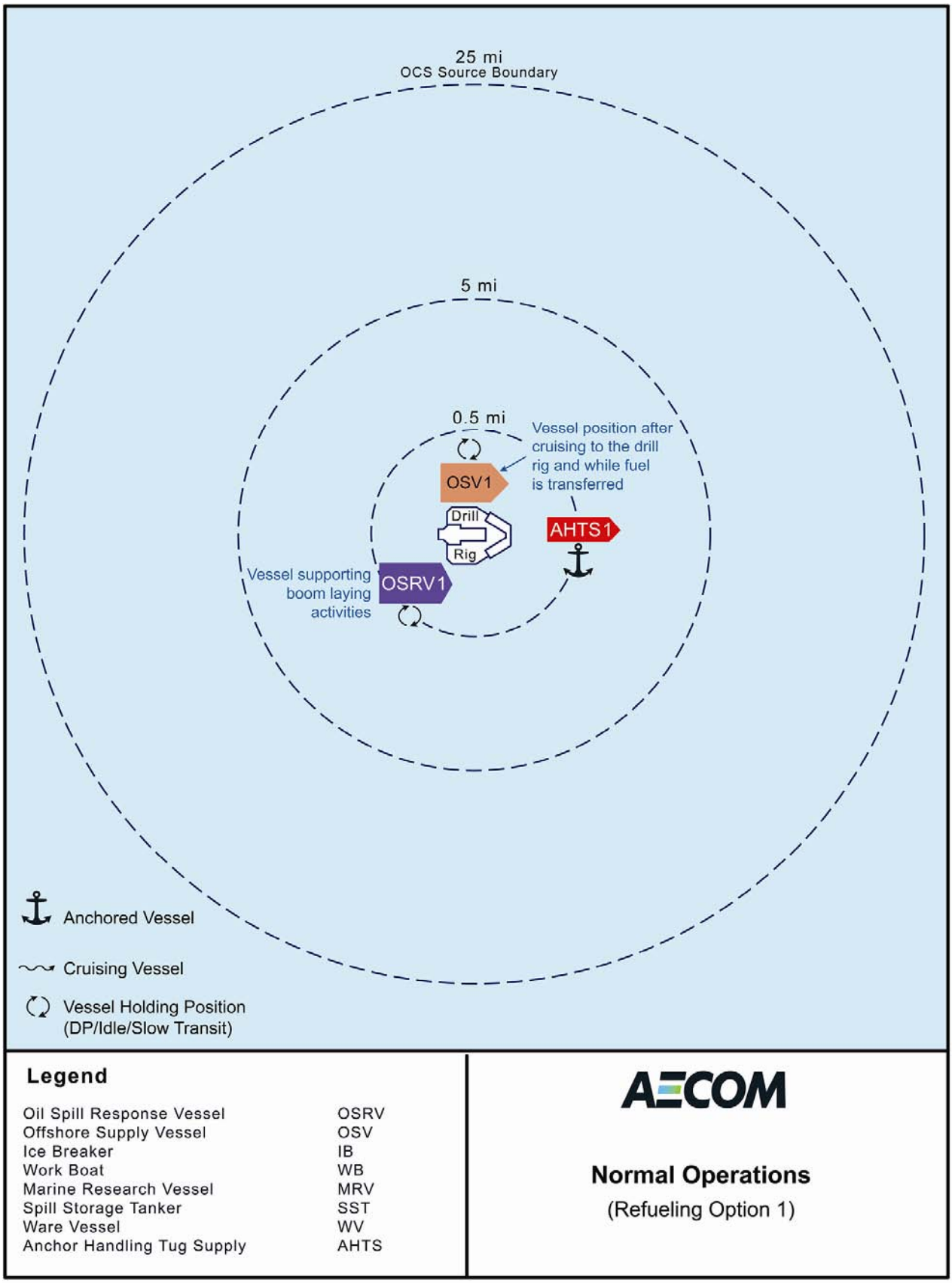
Normal Operations

(Regular Resupply Option 2)

Figure 2-9 Typical Vessel Arrangement During a Refueling Resupply – OPTION 1



Legend

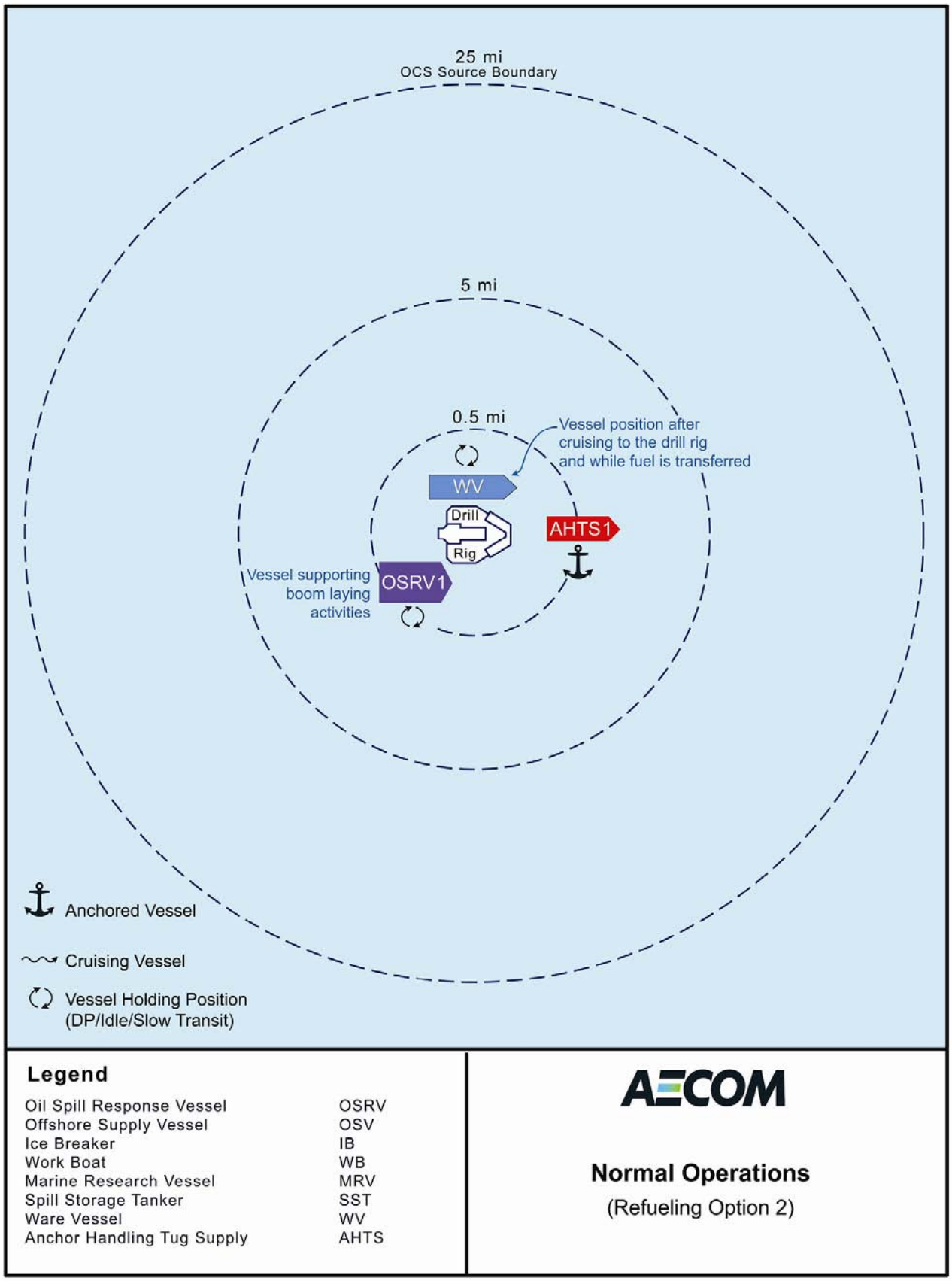
Oil Spill Response Vessel	OSRV
Offshore Supply Vessel	OSV
Ice Breaker	IB
Work Boat	WB
Marine Research Vessel	MRV
Spill Storage Tanker	SST
Ware Vessel	WV
Anchor Handling Tug Supply	AHTS

AECOM

Normal Operations

(Refueling Option 1)

Figure 2-10 Typical Vessel Arrangement During a Refueling Resupply – OPTION 2



Legend

Oil Spill Response Vessel	OSRV
Offshore Supply Vessel	OSV
Ice Breaker	IB
Work Boat	WB
Marine Research Vessel	MRV
Spill Storage Tanker	SST
Ware Vessel	WV
Anchor Handling Tug Supply	AHTS

AECOM

Normal Operations

(Refueling Option 2)

Figure 2-11 Typical Vessel Arrangement During Normal Operations

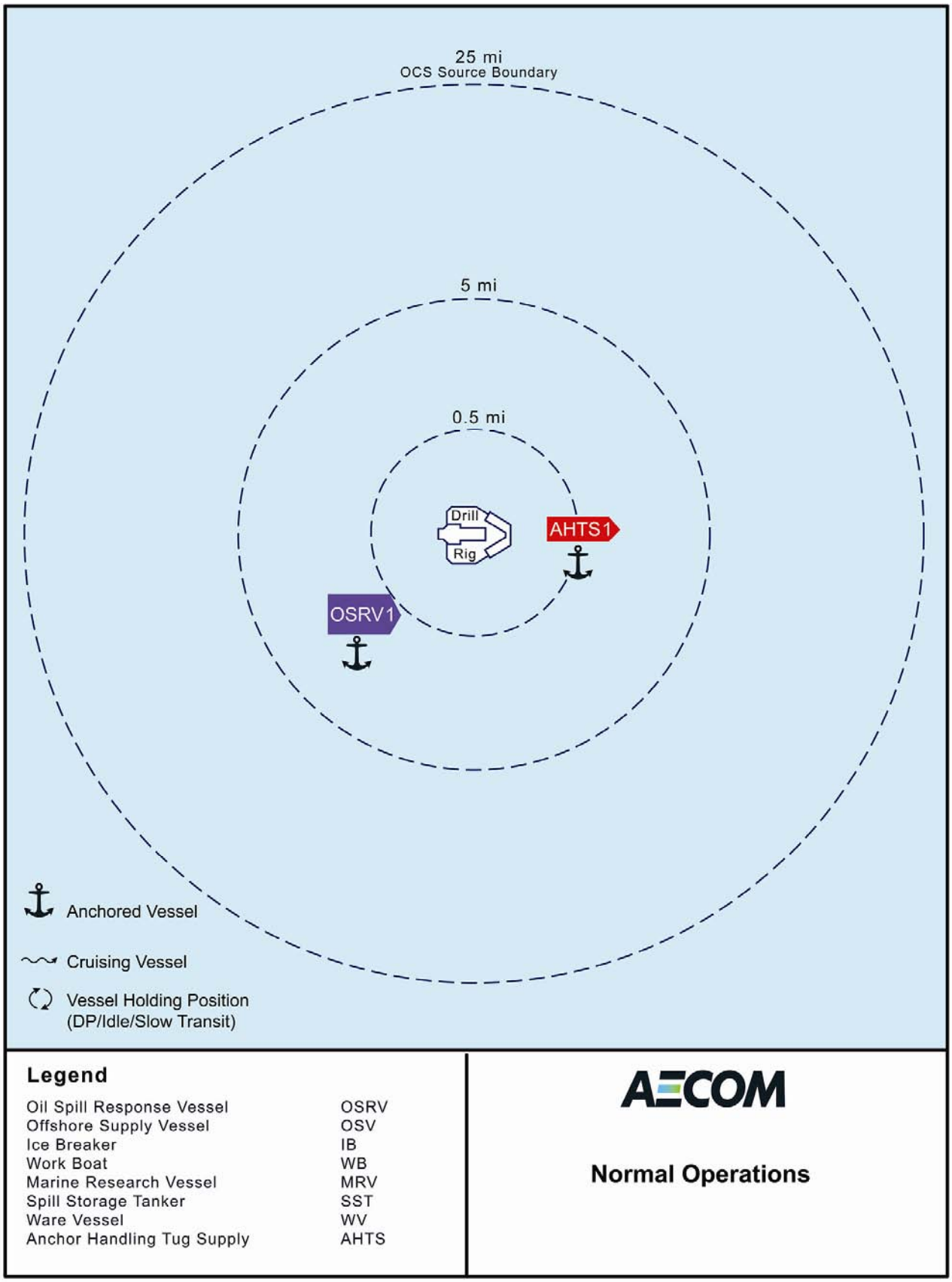


Figure 2-12 Typical Vessel Arrangement at Zero Air Gap While Jacking Down – OPTION 1

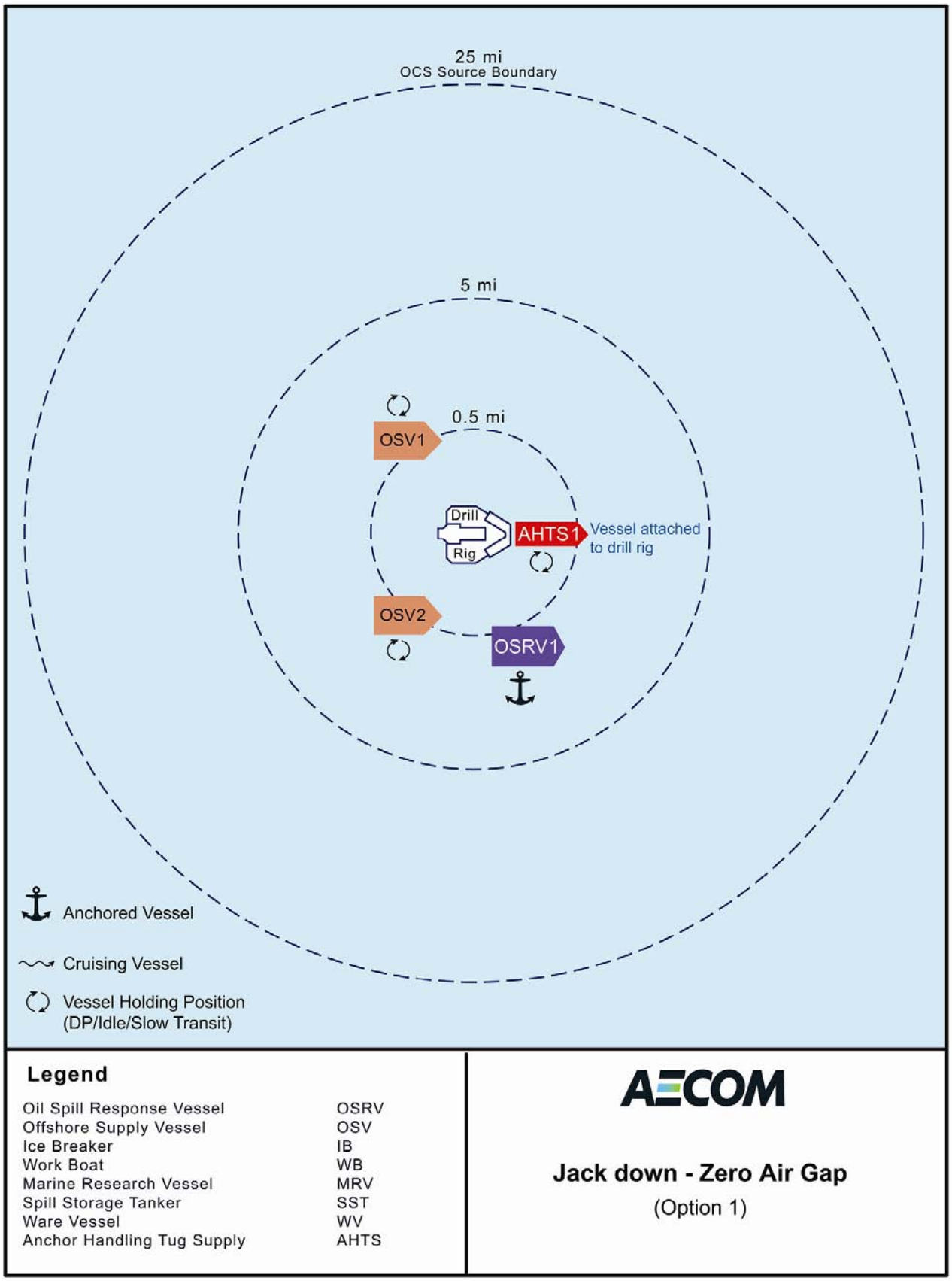


Figure 2-13 Typical Vessel Arrangement at Zero Air Gap While Jacking Down – OPTION 2

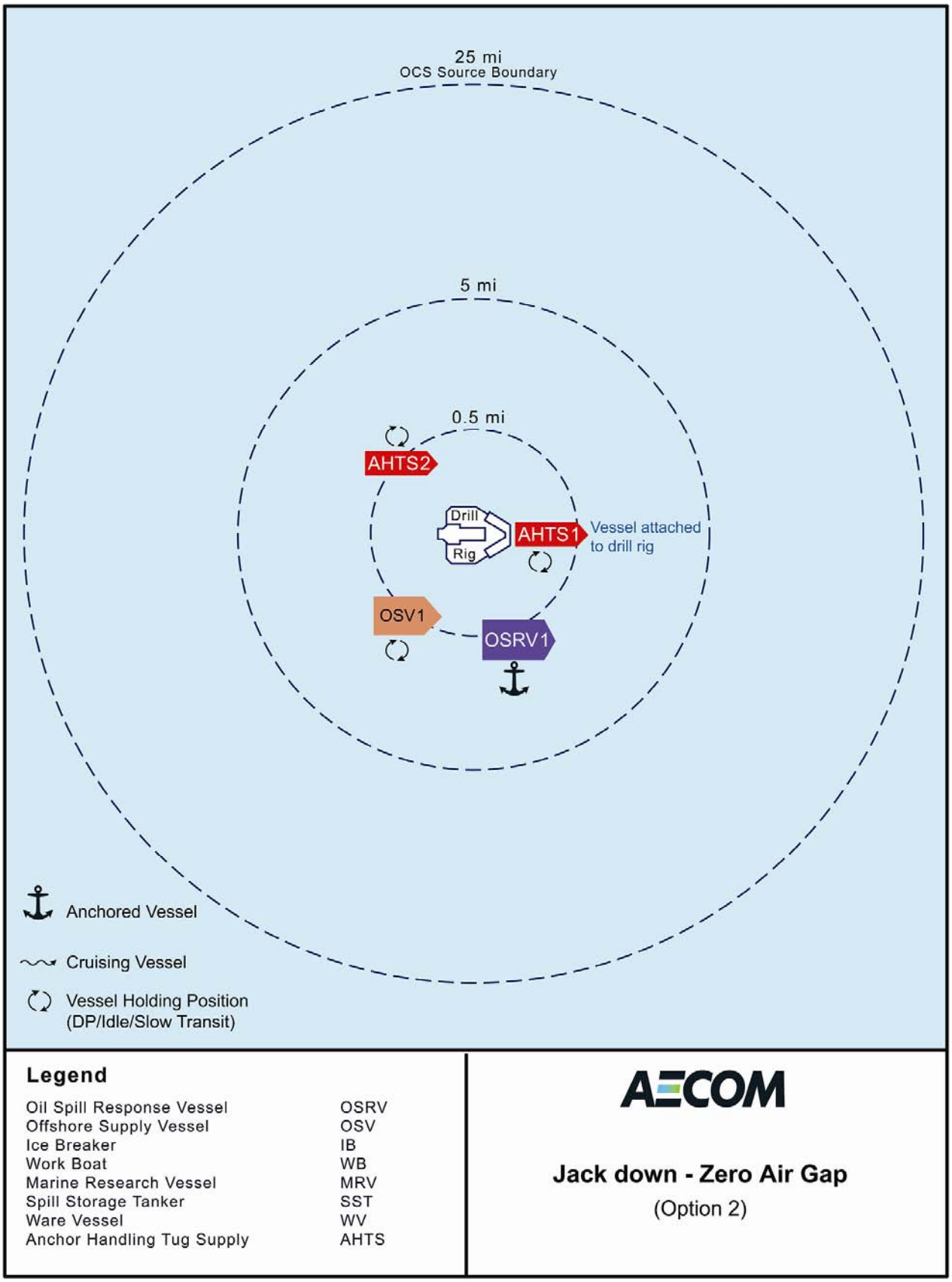


Figure 2-14 Modeled Vessel Arrangement During a Regular Resupply – OPTION 1

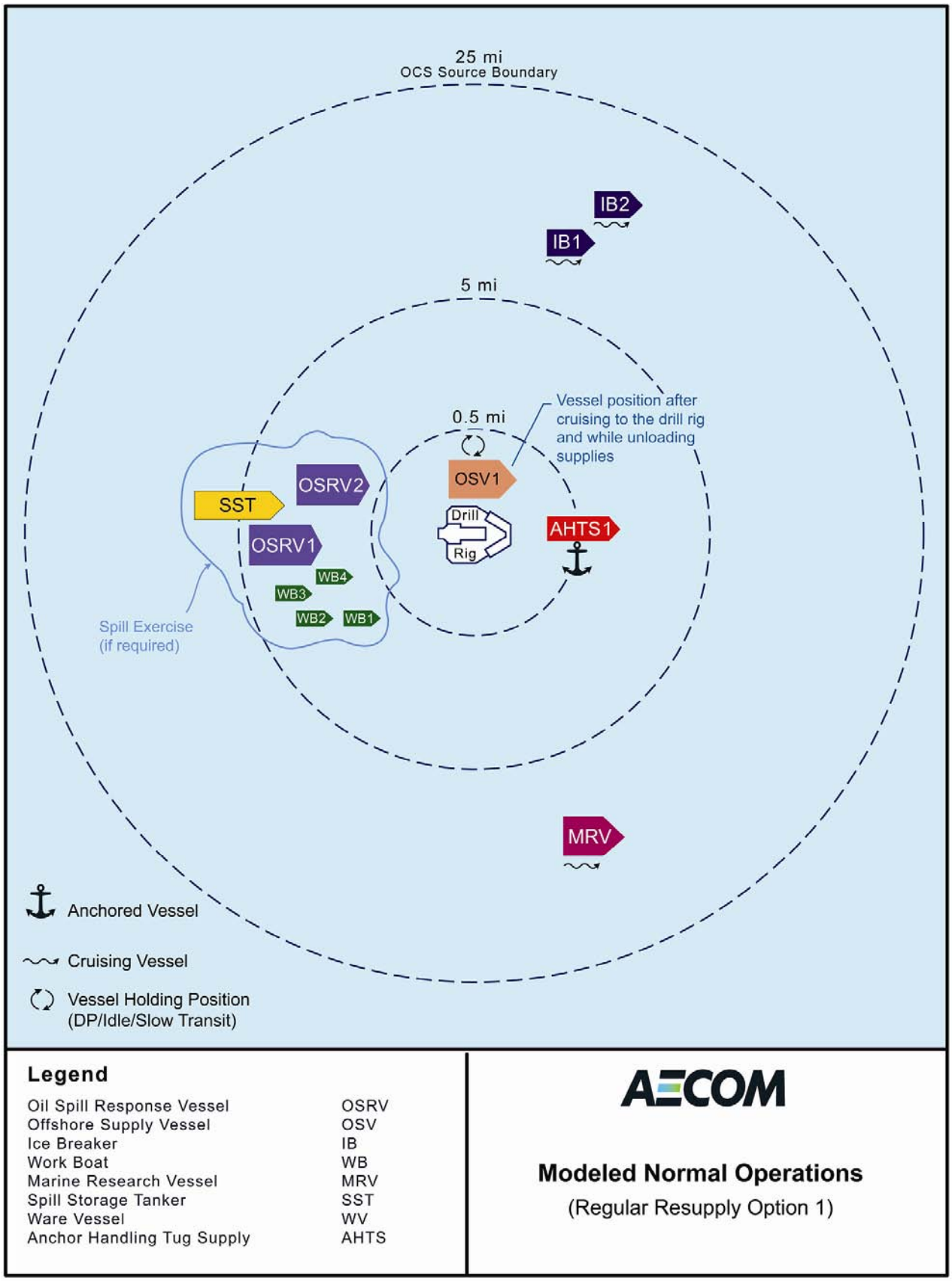
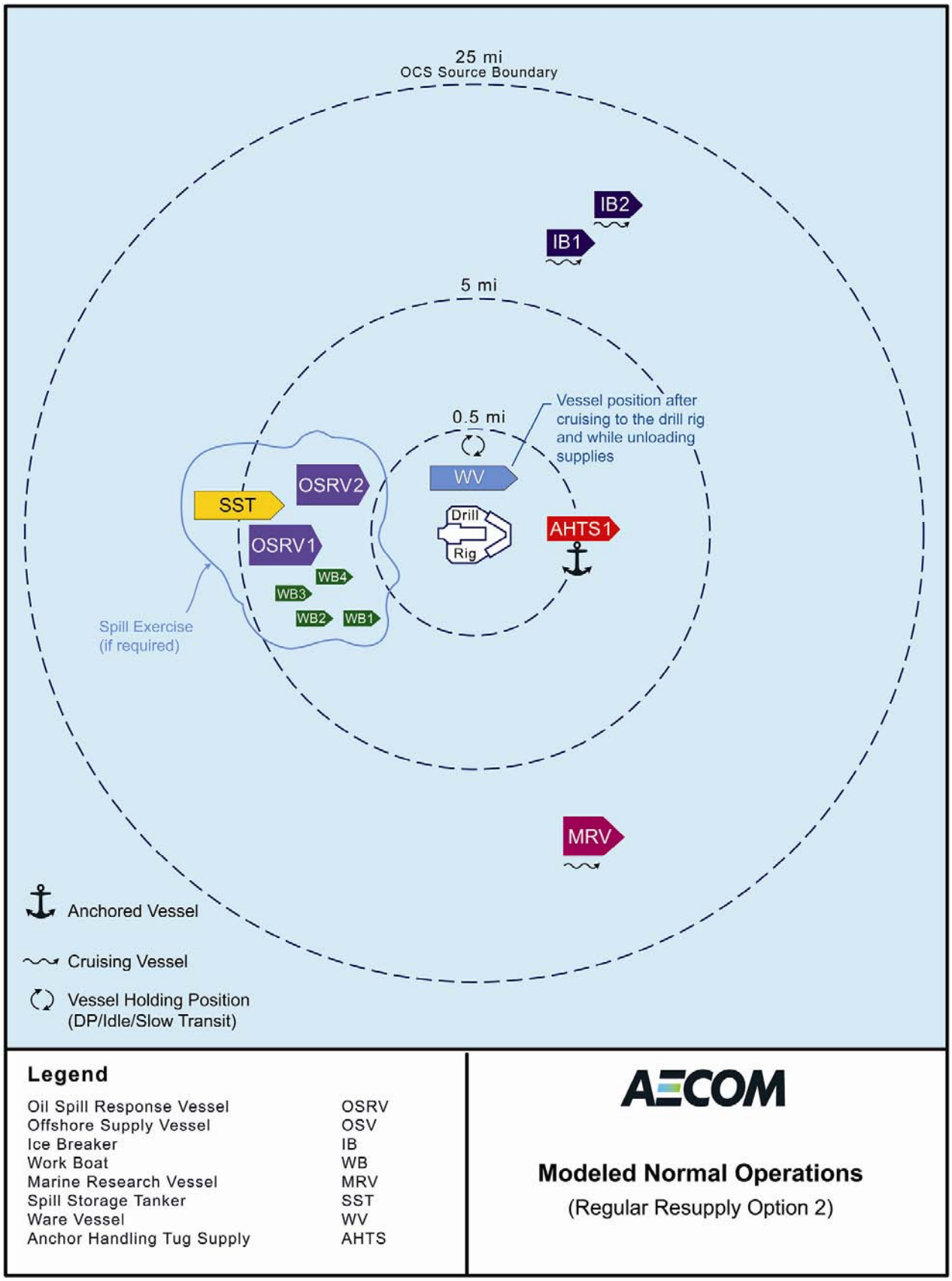


Figure 2-15 Modeled Vessel Arrangement During a Regular Resupply – OPTION 2



2.2 Description of Drill Rig Emission Units

It is anticipated that drilling will be conducted with the Maersk Resolute or that the Resolute will be representative of the drill rig deployed. The Maersk Resolute is one of four similar 350 foot jackup rigs owned by Maersk. The other three rigs are the Resilient, Resolve and Reacher. An overview of these rigs can be found at:

http://www.maersk-drilling.com/fleet/drilling_rigs/FleetItem.aspx?fid=18&cid=3.

The emission rates modeled for this project represent the configuration required for this specific project with respect to operation, fuel combusted and regulatory specifications. Regardless of which drill rig is deployed, it will need to be configured to meet the specifications detailed in the emissions inventory that forms the basis for the modeled emission rates. As will be detailed in Chapter 4, the drill rig emissions are being simulated through two collocated worst-case stacks without downwash; therefore, with the exception of the emissions modeled and to a much lesser extent the stack exit characteristics, the drill rig configuration is irrelevant to the compliance demonstration.

For the planned exploratory program, emissions from the drill rig will be associated with the emission units listed in **Table 2-1**. All of these units are located on the drill rig and combust liquid fuel.

Drill rig general arrangement drawings can be found in Appendix F with relevant information labeled. Relevant drill rig emission unit stack parameters are detailed in Appendix C.

Table 2-1 Representative Drill Rig Emission Units

Emission Unit Description	Rating	Type
Main Drill Rig Engine 1	2,480 kW	IC Engine
Main Drill Rig Engine 2	2,480 kW	IC Engine
Main Drill Rig Engine 3	2,480 kW	IC Engine
Main Drill Rig Engine 4	2,480 kW	IC Engine
Emergency Back-up Engine	968 kW	IC Engine
Cement Engine 1	403 kW	IC Engine
Cement Engine 2	403 kW	IC Engine
Logging Winch	187 kW	IC Engine
Heater 1	3.5 MMBtu/hr	Heater
Heater 2	3.5 MMBtu/hr	Heater
Incinerator	65 TPY	Incinerator

2.3 Description of OCS Source Support Vessels

As previously discussed, COP is seeking to permit two different options for supplying the drill rig which is relevant to the discussion of mobile support vessels provided in this section:

- OPTION 1: The drill rig is resupplied by an Offshore Supply Vessel (OSV) with backup support provided by a second OSV if the first OSV is unavailable.
- OPTION 2: The drill rig is supplied by a Ware Vessel with backup support provided by either an OSV or an Anchor Handing Tug Supply (AHTS) vessel if the Ware Vessel is unavailable.

As detailed in Chapter 4, emissions from the support vessels are either being modeled through two collocated stacks without downwash or as a single volume source; therefore, with the exception of the emissions modeled and to a much lesser extent the stack exit characteristics, the individual vessel configurations are irrelevant to the compliance demonstration.

The following vessel groups have been included in the modeled source inventory. General arrangement information for a representative vessel of each type can be found in Appendix F with relevant information labeled. Stack exit parameters relevant to simulating the vessels are provided in Appendix C.

General Support Vessels:

- Ice Management Vessels – Two ice management vessels (ice breakers) will be staged near the project area to manage ice sheets that may break loose and drift toward the drilling activity. These vessels will generally be operated well upwind of the drilling operation, and will operate a significant amount of the time further than 25 miles from the drill rig. It is possible that the ice breakers may come within 5 miles of the drill rig; however, if ice were to come this close to the drill rig, steps would be taken to remove the drill rig from the sea floor (i.e., the drill rig would no longer be an OCS Source); therefore, the ice breakers are not expected to operate near the rig while it is an OCS Source. It is unlikely that these vessels will be stationary when operating within 25 miles of the drill rig.

- Dedicated OSRV - A Dedicated OSRV will be anchored or moored within approximately 3 miles of the drill rig during drilling activities, unless it is participating in a mandated spill response exercise. The Dedicated OSRV includes two work boats onboard which can be deployed to assist with OSRV activities. The Dedicated OSRV will provide the following:
    - Rapid Spill Response: This vessel is fully equipped for oil spill response and will provide both large and small spill response as well as spill coverage in the event of a spill during fuel and supply transfer at the drill rig.
    - Boom Laying Support: Depending on weather, during fuel and supply transfer at the drill rig, either the Dedicated OSRV or one of its work boats will operate near the drill rig for spill containment. During this activity, the OSRV or the small work boat will lay spill response boom. Once the boom is deployed, the OSRV or work boat will idle near the drill rig. Once the fuel and supply transfer is complete, the OSRV or work boat will retrieve the spill response boom.
    - Emergency Response: This vessel or one of its work boats can provide rapid response in the event of an emergency.

- Anchor Handling Tug Supply (AHTS) Vessel – Initially, with support from two other vessels [i.e., either two OSVs (OPTION 1) or an OSV and an AHTS vessel (OPTION 2)] the AHTS vessel will tow the drill rig to the project site. Emissions from this vessel will only be included in the dispersion modeling from the point the rig becomes an OCS Source, at which point the AHTS is used to position the drill rig as it is being jacked up to preload height. Once preload is complete, the AHTS vessel will detach from the rig and will idle near the drill rig during drilling activities to provide emergency fire/rescue support.

- Marine Research Vessel – A single vessel used to conduct marine animal research and collect other data will operate periodically within 25 miles of the drill rig. It is anticipated that this vessel will not typically operate near the drill rig, and will likely be transiting rather than remaining in one place.

Spill Response Vessels:

Unless a mandated spill response exercise is requested to occur within 25 miles of the drill rig (i.e., the exercise could be conducted outside the 25 mile OCS boundary), this group of vessels will be maintained further than 25 miles from the drill rig. If a spill exercise is conducted within 25 miles of the drill rig, the exercise

is anticipated to last a maximum of two days. Therefore, it will be rare for this group of vessels to be operating within 25 miles of the rig.

- Oil Spill Response Vessel (OSRV) – An oil spill response vessel will be staged further than 25 miles from the drill rig for various spill response related activities. The OSRV will carry two small work boats that can be deployed as needed.
- Spill Storage Tanker – A single vessel used to store fluids used for, and collected during, a spill event may operate within 25 miles of the drill rig. During a spill exercise the spill storage tanker will cruise to a location approximately 5 miles from the drill rig where it will anchor until the exercise is complete.
- Dedicated OSRV – The Dedicated OSRV previously discussed is part of the project spill response vessel fleet and will participate in spill exercises; however, unlike the other spill response vessels this vessel will remain in close proximity to the drill rig when not participating in spill exercises.

Resupply and Towing Support Vessels:

<u>OPTION 1 (Offshore Supply Vessel (OSV) Resupply) Specific Vessels</u>

- Offshore Supply Vessel (OSV) – An OSV, which is smaller than the Ware Vessel described below, will be used to shuttle supplies (i.e., fuel, drilling fluids, pipe, etc.) to the drill rig. When the OSV transfers supplies, it will be maintained adjacent to the drill rig by Dynamic Positioning (DP) and there will be no physical attachment between the OSV and the drill rig except for a fuel line during refueling activities. In the event of poor weather, this vessel may idle within 25 miles of the drill rig while waiting for proper conditions for supply transfer to occur. Resupply trips are only anticipated to occur every 4 days.

- Offshore Supply Vessel (OSV) – An OSV will also have the following roles under OPTION 1:

    - Towing Support: Two of the three vessels used to tow the drill rig to the drilling site will be an OSV under OPTION 1. Emissions from these vessels will only be included in the dispersion modeling from the point the drill rig becomes and OCS Source. At the point the drill rig becomes an OCS Source, the two OSVs will have already detached from the drill rig and will idle near the drill rig until preload hold is complete at which point they will leave the 25 mile OCS boundary.

    - Resupply Backup: A second OSV will be used to resupply the drill rig in the event that the first OSV is unable to provide this function.

<u>OPTION 2 (Ware Vessel Resupply) Specific Vessels</u>

- Ware Vessel – A Ware Vessel will be used to transport large amounts of supplies (i.e., fuel, drilling fluids, pipe, etc.) to the project site. This vessel will utilize Dynamic Positioning (DP) to sit stationary next to the drill rig without being tied to it. There will be no physical attachment between the Ware Vessel and the drill rig except for a fuel line during refueling activities. In the event of poor weather during a resupply trip, this vessel may idle within 25 miles of the drill rig while waiting for proper conditions for the supply transfer to occur. This vessel will only operate within 25 miles of the drill rig when making a resupply trip and will not be involved in any other activity. Resupply trips with a Ware Vessel are only anticipated to occur every 6 days.

- Offshore Supply Vessel (OSV) – An OSV will have the following roles under OPTION 2:

    - Towing Support: One of the three vessels used to tow the drill rig to the drilling site will be an OSV under OPTION 2. At the point the drill rig becomes an OCS Source, the OSV will have already detached from the drill rig and will idle near the drill rig until preload hold is complete at which point it will leave the 25 mile OCS source boundary.

- Resupply Backup: An OSV will be used to resupply the drill rig in the event that the Ware Vessel is unable to provide this function. Because the Ware Vessel holds considerably more supplies than an OSV, an AHTS will operate in conjunction with the resupply backup OSV to replace the single Ware Vessel. However, both backup resupply vessels will not operate within 25 miles of the drill rig at the same time.

- Anchor Handling Tug Supply (AHTS) – An AHTS vessel will have the following roles under OPTION 2:

  - Towing Support: One of three vessels used to tow the drill rig to the project site will be an AHTS vessel under OPTION 2. This AHTS vessel will be used in addition to the AHTS vessel discussed under the heading of “General Support Vessels” above. At the point the drill rig becomes an OCS Source; the AHTS vessel will have detached from the drill rig and will idle near the drill rig until preload hold is complete at which point it will leave the 25 mile OCS boundary.

  - Resupply Backup: An AHTS vessel will be used to resupply the drill rig in the event that the Ware Vessel is unable to provide this function. Because the Ware Vessel holds considerably more supplies than an AHTS vessel, the AHTS vessel will operate in conjunction with the resupply backup OSV to replace the single Ware Vessel. However, both backup resupply vessels will not operate within 25 miles of the drill rig at the same time.

3.0 Dispersion Modeling Methodology

3.1 Dispersion Model Selection

USEPA's Guideline on Air Quality Models (GAQM) (USEPA 2005) lists several dispersion models recommended for use in regulatory air quality analyses. The CALPUFF model was promulgated by the USEPA (USEPA 2003) as the preferred dispersion model to assess:

- Long Range Transport (LRT) – Impacts predicted at transport distances exceeding 50 km.
- Mixed Domain Applications - Impacts predicted on domains including transport distances both less than and greater than 50 km at the same time (40 CFR 51 Appendix W Section 6.2.3(a)).

As discussed in Chapter 1 and depicted in **Figure 1-1**, the closest distance from any COP lease block in the Devil's Paw Prospect to the point of compliance is approximately 108 km (~67 mi). Considering that some support vessels may operate up to 25 miles (40 km) from the drill rig, the shortest distance from any modeled project source to the point of compliance is approximately 68 km (~42 mi). At this distance, a non-steady-state modeling approach that considers spatial and time variations in meteorological conditions, such as CALPUFF, is appropriate. Therefore, the CALPUFF model was selected for the air quality analysis supporting the permit application.

CALPUFF also has the unique ability to account for the effects on dispersion that multiple land use types will have on the modeled emissions as they are transported throughout the modeling domain. This is an important consideration for this study because of how differently the boundary layer is parameterized (and resultant dispersion is impacted) as the project emissions are transported over both ice-free and frozen water and potentially over land before impacting modeled receptors.

3.2 Modeling Domain and Computational Grid

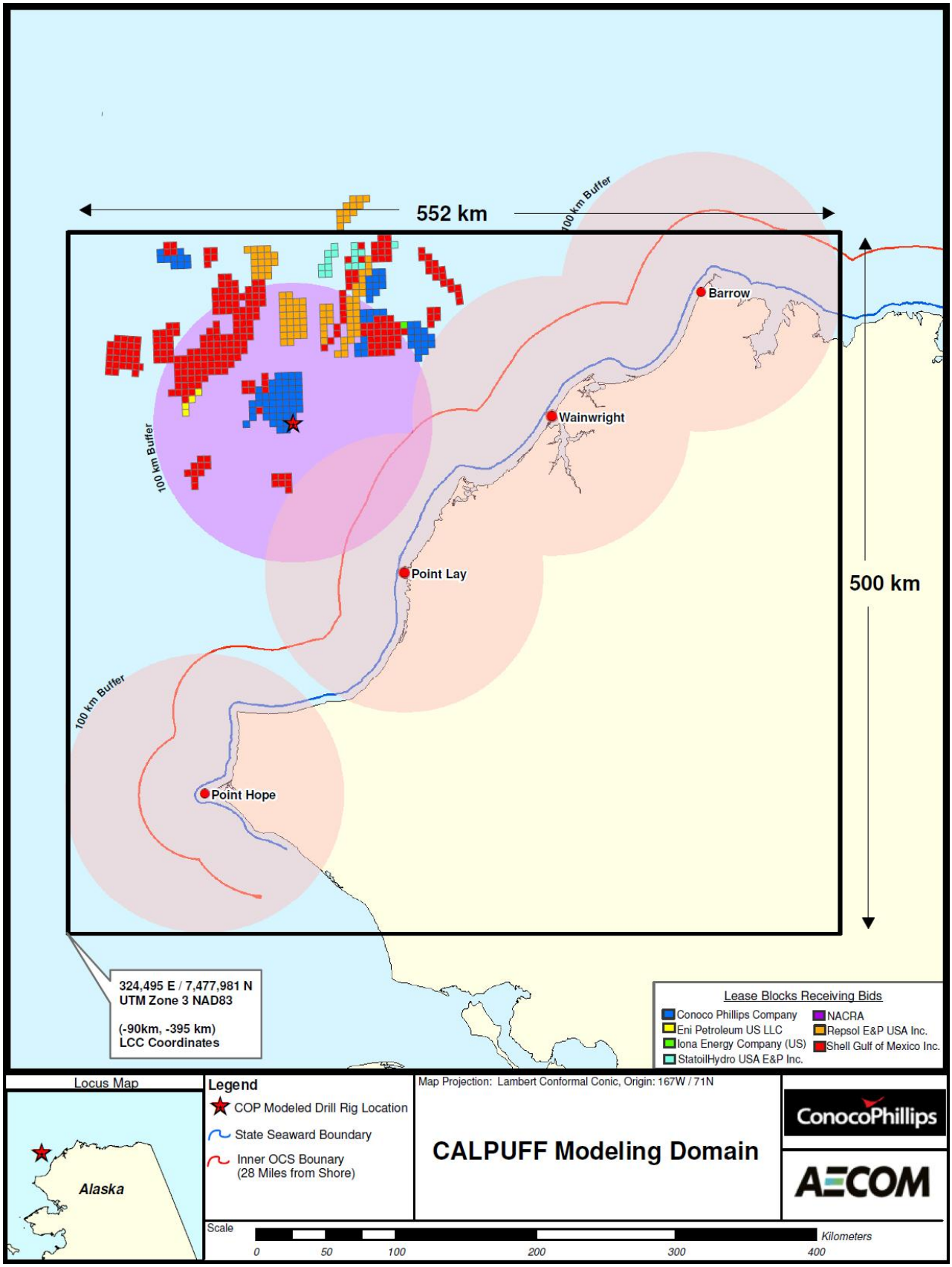
A domain with 4-km grid spacing for the CALMET and CALPUFF grid systems was used for this analysis. The extent of the domain was designed to place a large buffer around the Alaska seaward boundary, coastal communities, and project source locations. The large buffer distance allows for the consideration of puff trajectory recirculation. **Figure 3-1** illustrates the extent of proposed CALPUFF model domain. This design translates to a 552 km (east-west) x 500 km (north-south) domain extent and, at a 4-km resolution, this results in 138 x 125 horizontal grid cells. Consistent with USEPA recommendations (Appendix G), the vertical resolution consists of the following ten layers: 20; 40; 80; 160; 320; 640; 1,200; 2,000; 3,000; and 4,000 meters.

A Lambert Conformal coordinate system was used for the dispersion modeling analysis. The projection was based on the following:

- Central Meridian: 167.0 W
- First Standard Parallel: 65.0 N
- Second Standard Parallel: 75.0 N
- Latitude of Origin: 71.0 N
- Datum: WGS_1984

This is consistent with the approximate center of the modeling domain which will minimize potential skewing of grid North with respect to true North.

Figure 3-1 CALMET/CALPUFF Modeling Domain



Note that a polar stereographic coordinate system was used for the mesoscale meteorological data (Weather Research and Forecast [WRF]) used as input to CALMET. That coordinate system is not an available option in CALMET or CALPUFF (Scire 2011); therefore, CALMET was run using the Lambert Conformal coordinate system. This presents no issues since the CALMET modeling system is designed to incorporate prognostic meteorological data from an external source in many coordinate systems for use as input to the CALMET model. In most cases, the prognostic mesoscale meteorological model will be run on a much larger domain and will use a map projection that is best suited for that specific prognostic model run. Similarly, the CALMET/CALPUFF runs will be designed to use the map projection best suited for that analysis and commonly includes Lambert Conformal or UTM depending on the size of the domain. In order to account for the difference in projections, the CALMET modeling system has an internal coordinate conversion library designed to convert numerous common modeling projections, including Polar Stereographic, to the projection of the CALMET domain, including Lambert Conformal. Both the CALMET preprocessors (CALWRF which converts the raw WRF output to CALMET-ready input) and CALMET itself are designed to seamlessly handle all common modeling map projections including the two that are pertinent to this analysis. A literature review of USEPA and FLM-approved CALMET analyses, along with discussions with the model developer, confirm the functionality of the software to account for projection differences. As a final step, CALMET produces QA files that were used as part of this analysis check to confirm the proper geographic placement of the model input.

3.3 CALMET Meteorological Processor

CALMET Version 5.8 is the companion official USEPA version of the meteorological pre-processor for the CALPUFF modeling system that produces three-dimensional wind fields that incorporate a variety of meteorological data observations and terrain effects.

3.3.1 Mesoscale Meteorological Data

This application of CALMET includes three years (2007, 2008 and 2009) of gridded, prognostic mesoscale meteorological data developed using the Weather Research and Forecasting model (WRF). Advanced meteorological data developed using WRF was used to provide a superior estimate of the initial (Step 1) wind fields. Section 8.3.1.2(d) of the GAQM (USEPA 2005) recommends less than five, but at least three, years of meteorological data in long range transport modeling provided mesoscale meteorological data are used in conjunction with available National Weather Service (NWS) data.

Generally, the GAQM (USEPA 2005) suggests modeling with the upper end of five years in cases when data representativeness is in question such as when mesoscale meteorological fields are not available for long range transport applications (National Weather Service Station observations only). A preference toward the upper end may also be justified in domains with complex wind fields associated with terrain influenced or density driven wind fields. In these cases, modeling with longer meteorological records could offset the larger uncertainties associated with higher interannual variability associated with these situations and using data that is not considered site-specific.

For this application, the CALMET/CALPUFF modeling has been conducted with area specific, state of-science, mesoscale meteorological fields that have been rigorously reviewed and documented. Following USEPA guidance, the WRF meteorological fields were combined with available regional observational data for a modeling domain that is essentially homogenous between the source and receptors. As a result, interannual variability in meteorological conditions and resultant modeled concentrations is expected to be low during the modeling periods and that combined with the use of high quality meteorological data precludes the need to model with the upper limit of 5 years.

Furthermore, modeling has shown that model predicted maximum impacts at the point of compliance are below the Significant Impact Levels which demonstrates that compliance with applicable standards will be insensitive to any interannual variability that may exist outside of the modeled time period.

The 2007 through 2009 WRF data was developed by Alpine Geophysics in collaboration with USEPA Region 10 (Alpine 2011a and Alpine 2011b). The WRF meteorological data was constructed with a 4 km

resolution domain that covers Northwestern Alaska and into the Chukchi Sea. The entire CALMET domain falls within the 4 km WRF domain. **Figure 3-2** shows the CALMET domain superimposed on the 4 km WRF meteorological modeling domain. A description of WRF modeling technical approaches and a comprehensive model performance evaluation is included with the project air quality permit application as Volume III.

3.3.2 Additional Geophysical and Meteorological CALMET Input

The Step 2 wind field was produced using the input of all available NWS hourly surface and twice-daily upper air balloon sounding data within and just outside the modeling domain. Hourly surface data from both first-order and second-order stations were considered in this analysis. A list of the meteorological stations is provided in **Table 3-1**. The available surface meteorological data were obtained from the National Climatic Data Center (NCDC) in the Integrated Surface Hourly (ISH) format and prepared for input to CALMET using the SMERGE pre-processor program (Version 5.652) (Scire 2000). The upper air data was prepared for input to CALMET using the READ62 pre-processor program (Version 5.53).

CALMET requires a surface and upper air observation from at least one station for each hour of the simulation. Since it is rare to have 100% data capture at all stations in the domain inevitably some of the missing data will need to be filled. This application was no exception. Therefore missing data was filled only so far as it is necessary to allow the model to execute successfully.

Surface observational data was filled according to the following procedure:

- Observational data for all surface stations was first filled using procedures recommended by USEPA (Atkinson 1992). This procedure only fills missing periods of 5 hours or less, and all stations were filled in this manner to increase the probability that data from at least one surface station was available for each hour of the simulation to minimize additional filling.

- If additional filling was required it was limited to the Wainwright observational data and only to the extent it was necessary to allow the model to execute successfully. Decoded hourly METAR (Meteorological Aerodrome Report) data from the Wainwright National Weather Service (NWS) Station (Stn ID/Call Sign 700300/PAWI) were used to fill missing periods exceeding 5 hours. METAR data are disseminated by the National Weather Service and archived by various commercial companies. Archived METAR data were obtained online from the Weather Underground (www.wunderground.com).

  While the ISH database does use METAR data in compiling hourly surface observations, the ISH database goes through a QC process that the raw METAR data are not subjected to. Hence, it is possible that there may be a period of missing data in the ISH database even though METAR observations are available. Note that the METAR data used to fill missing ISH data did not appear questionable and were reasonably similar to data bracketing the missing period. Furthermore, the data were verified for consistency with WRF data for the same period. Periods filled using this procedure are documented in **Table 3-2**.

Table 3-3 documents the number of missing hours filled during each step.

Upper air observations were filled using the READ62 pre-processor program and data from the nearest WRF grid node. Filling was conducted for both the Kotzebue and Barrow upper air data sets. Twelve, 23, and 9 hours were filled in the Kotzebue upper air data set in 2007, 2008 and 2009, respectively. Three, 0, and 22 hours were filled in the Barrow upper air data set in 2007, 2008 and 2009, respectively.

Figure 3-2 Overlay of the 4 km WRF Meteorological Modeling Domain and the CALMET Domain

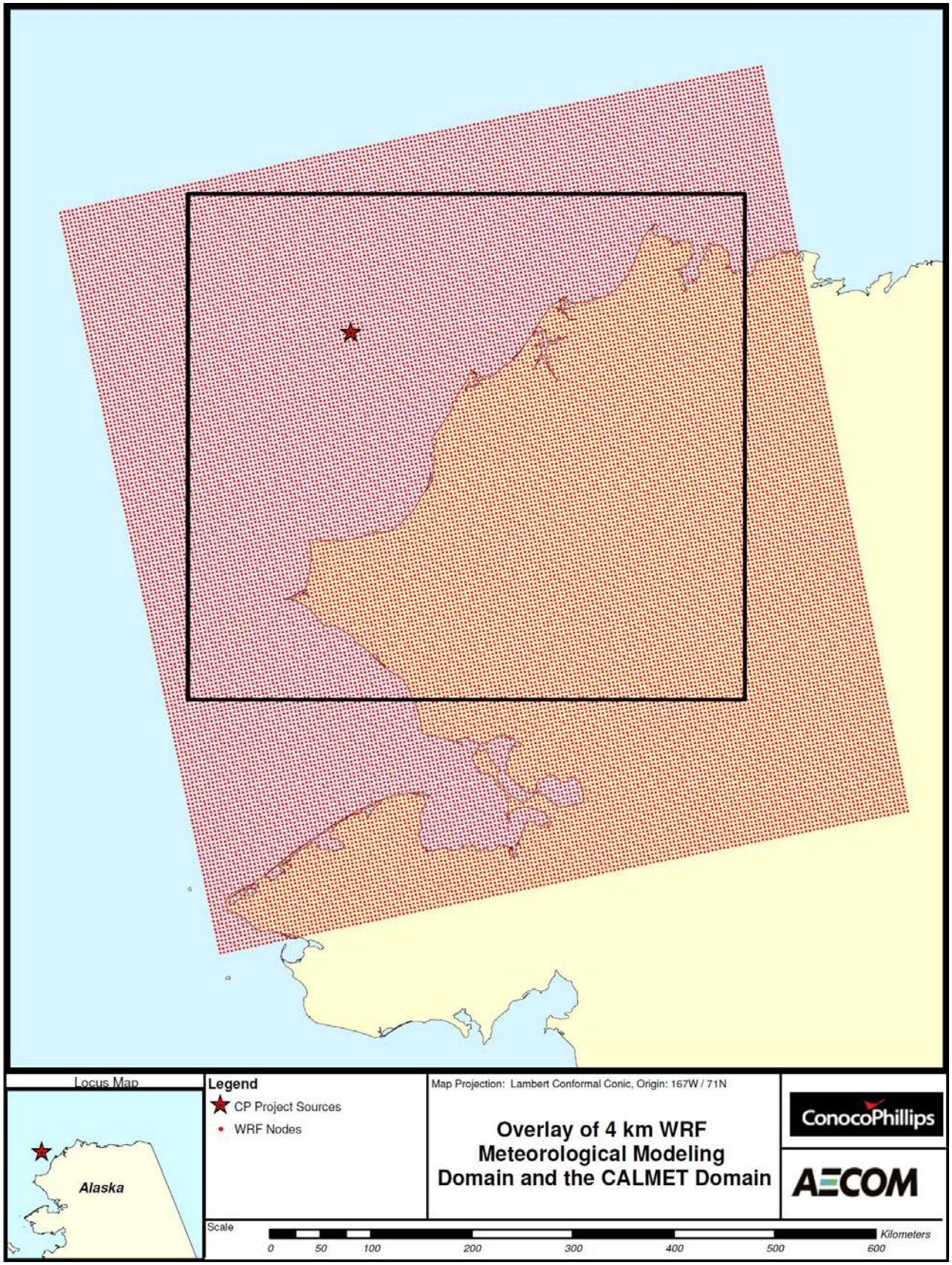


Table 3-1 List of Surface and Upper Air Stations input to CALMET

Station ID	Call Sign	Station Name	Latitude	Longitude	Elevation (meters)
Surface Meteorological Stations					
700300	PAWI	WAINWRIGHT	70.639	-159.995	9
700260	PABR	BARROW	71.287	-156.763	4
701040	PALU	CAPE LISBURNE AFS	68.883	-166.117	3
701043	PAPO	POINT HOPE AIRPORT	68.350	-166.800	4
701210	PPIZ	POINT LAY	69.733	-163.005	8
701335	PAWN	NOATAK	67.566	-162.975	27
701486	PAVL	NIVALINA	67.732	-164.548	3
701718	PAFM	AMBLER	67.100	-157.850	88
702685	PATQ	ATQASUK EDWARD BURN	70.467	-157.436	29
997704	RDDA2	RED DOG DOCK	67.567	-164.650	3
701330	POTZ	KOTZEBUE RALPH WIEN	66.885	-162.597	5
Upper Air Meteorological Stations					
700260	PABR	BARROW	71.287	-156.763	4
701330	POTZ	KOTZEBUE RALPH WIEN	66.885	-162.597	5

Table 3-2 Filled Periods of Wainwright NWS Data Exceeding 5 Hours

Period
July through October 2007
8/27/2007 hour 16 through 8/28/2007 hour 15
9/4/2007 hour 4 through 9/4/2007 hour 17
July through October 2008
8/17/2008 hour 18 through 8/18/2008 hour 15
9/23/2008 hour 9 through 9/23/2008 hour 15
July through October 2009
Filling was not necessary, all data present

Table 3-3 Number of Missing Hours of NWS Data Filled by Each Method

Year	Total Hours Missing [1]	Total Hours Filled	Hours Filled Using USEPA Guidelines (Step 1) [2]	Wainwright Hours Filled from Alternate Observational Data (Step 2) [3]
2007	723	698	662	36
2008	455	430	403	27
2008	768	768	768	0

1 Total hours missing, where there are no observations from any of the surface stations.

2 Additional hours filled using USEPA guidelines on all surface stations.

3 Additional hours filled in the Wainwright surface observation data set in order to make a complete data set, so that there is an observation available for every hour.

Aside from overwater information extracted from the area-specific mesoscale meteorological fields, there are no overwater observations that are complete enough (i.e., meet data recovery over all modeled periods) or of high enough quality (i.e., collected with the proper quality assurance and quality control) to be used in the analysis. Therefore, sea surface temperature was extracted from a node in the mesoscale meteorological fields generated by the WRF model and was included in CALMET as observations in the SEA.DAT file.

Gridded terrain and land use data were also input to CALMET to more accurately characterize the wind field and dispersion throughout the modeling domain. The gridded terrain data was derived using the TERREL pre-processor program (Version 3.684) (Scire 2000) along with digital terrain data from U.S. Geological Survey (USGS) 1:250,000 (3 arc second or 90-meter grid spacing) Digital Elevation Model (DEM) files and the GTOPO30 Global Data (~900 m grid spacing). The gridded land use data was derived using the CTGPROC pre-processing program (Version 2.682) (Scire 2000) along with digital land use data from the USGS in the form of GLCC Database (V2.0) (~1000 m grid resolution). The USGS 1:250,000 Composite Theme Grid land use files typically used in CALMET are not available for Alaska. The gridded terrain output from TERREL and gridded land use output from CTGPROC were combined into one CALMET-ready geophysical file using the MAKEGEO pre-processor program (Version 2.29) (Scire 2000).

Since the GLCC Database (V2.0) digital land use data from the USGS accounts for the presence of water, but does not document if the water is frozen, the gridded land use output from CTGPROC was manually modified to account for the presence of frozen water. The presence of ice was based on ice coverage data from the an analysis algorithm using the 5-minute latitude-longitude grid associated with the 85GHz channel on the Special Sensor Microwave Imager (SSM/I) satellite based instrument (http://www.nws.noaa.gov/ost/climate/STIP/seaice.htm).

It is important that the surface characteristics used by CALMET are consistent with those used to develop the WRF generated mesoscale meteorological fields. Therefore, the presence of ice should be accounted for the output from CTGPROC if it existed in the modeling domain during the modeled periods. Ice coverage maps for 2007, 2008 and 2009 indicated significant presence of ice in the CALMET domain only during the months of July and November. Ice coverage in November during the modeling years extended into the Devil's Paw Prospect for the majority of the month. Since COP does not plan to operate in the Devil's Paw Prospect in the month of November when ice is present, the month of November was not modeled.

The following documents how ice was accounted for in the CALMET domain based on ice coverage during the month of July for all three modeled years:

- July 2007: Negligible ice in the CALMET domain during the entire month. Modeling was conducted from July 1, 2007 through the rest of the drilling season and it was unnecessary to manually modify the gridded land use output from CTGPROC since no ice was present.
- July 2008: Significant ice in the CALMET domain at the beginning of the month retreating out of the CALMET domain by the end of the month. Ice left the 25 mile OCS boundary by July 15, 2008. Modeling was conducted from July 15, 2008 through the rest of the drilling season using the gridded land use output from CTGPROC that was manually modified to account for the presence of ice in the CALMET domain. The approximate position of the ice on July 15, 2008 was used to represent the ice coverage for the entire month. **Figure 3-3** shows the position of the ice by week and the ice coverage used to represent the month of July 2008.
- July 2009: Significant ice in the CALMET domain at the beginning of the month retreating out of the CALMET domain by the end of the month. Ice left the 25 mile OCS boundary by July 15, 2009. Modeling was conducted from July 15, 2009 through the rest of the drilling season using the gridded land use output from CTGPROC that was manually modified to account for the presence of ice in the CALMET domain. The approximate position of the ice on July 15, 2009 was used to represent the ice coverage for the entire month. **Figure 3-4** shows the position of the ice by week and the ice coverage used to represent the month of July 2009.

3.3.3 CALMET Options

The CALMET control input file contains numerous switches and settings that drive how the 3-dimensional wind-field was produced. In August 2009, the USEPA Model Clearinghouse (in cooperation with the Federal Land Managers [FLMs]) issued a memo containing recommended settings for use in CALMET. A copy of the memo is included in Appendix G.

For this application, CALMET was run with all USEPA-FLM recommended values. Most other values that require user-definition and have not been specified in the memo are meant to be tailored to specific applications. These values pertain to selection of file names, specification of beginning and ending time period for the simulation, and map projection (discussed in Section 3.2). The exceptions are outlined in **Table 3-1** (list of all surface and upper air stations) and **Table 3-4** (specification of a reference surface and upper air station).

3.4 CALPUFF Application

In accordance with guidance provided by USEPA OAQPS and USEPA Region 10, the current guideline version of CALPUFF, Version 5.8, was executed in a refined mode to estimate the air quality impacts associated with the proposed project.

Evaluation of air quality impacts were only considered for the months that the drill rig could potentially operate from July through November and only during predominantly ice-free periods within those months based on the specific years modeled. As discussed in Section 3.3.2, the following periods were modeled:

- July 1 through October 31, 2007
- July 15 through October 31, 2008
- July 15 through October 31, 2009

3.5 CALPUFF Options

Similar to CALMET, the CALPUFF control input file also contains numerous switches and settings that drive how certain data will be processed. In March 2006, the USEPA Model Clearinghouse issued a memo containing recommended settings for use in CALPUFF. A copy of the memo is included in Appendix H.

For this application, CALPUFF was run with all USEPA recommended settings, with the exception of stack-tip downwash and chemical transformation. Chemical transformations were not modeled in order to simplify this analysis and remove the number of assumptions. Instead, USEPA recommended screening methods involving post-processing of model predicted impacts were used in lieu chemical transformations in CALPUFF and are detailed further in Section 3.6.

Stack-tip downwash was turned off so that horizontal stacks could be simulated in accordance with existing USEPA recommendations. The USEPA recommended method for simulating horizontal stacks is further detailed in Section 4.1.

It should be noted that without chemical transformation modeled in CALPUFF, the model will not convert SO_2 to SO_4 which will produce higher SO_2 concentrations than if chemical transformations were modeled and SO_2 was allowed to convert to SO_4. Furthermore, since refined NO_x to NO_2 chemical transformation modeling was not performed, in-stack NO_x/NO_2 ratios were not required for this modeling effort.

Most other CALPUFF settings that require user-definition and have not been specified in the March 2006 memo are meant to be tailored to specific applications. Much like CALMET, these values pertain to selection of file names, specification of beginning and ending time period for the simulation, and map projection (discussed in Section 3.2). The exceptions are outlined in **Table 3-5**.

Figure 3-3 Sea Ice Coverage in the CALMET Domain during July 2008

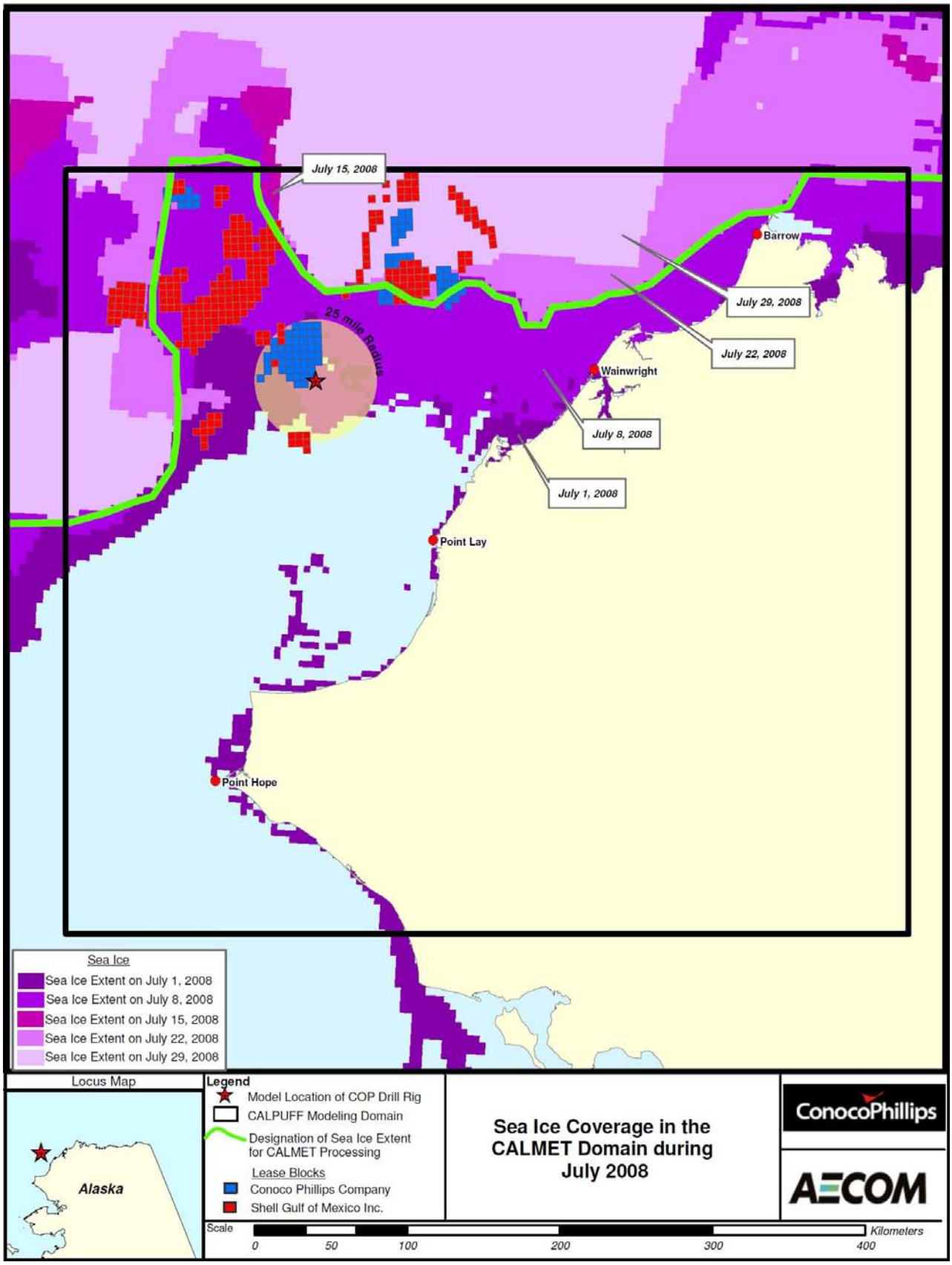


Figure 3-4 Sea Ice Coverage in the CALMET Domain during July 2009

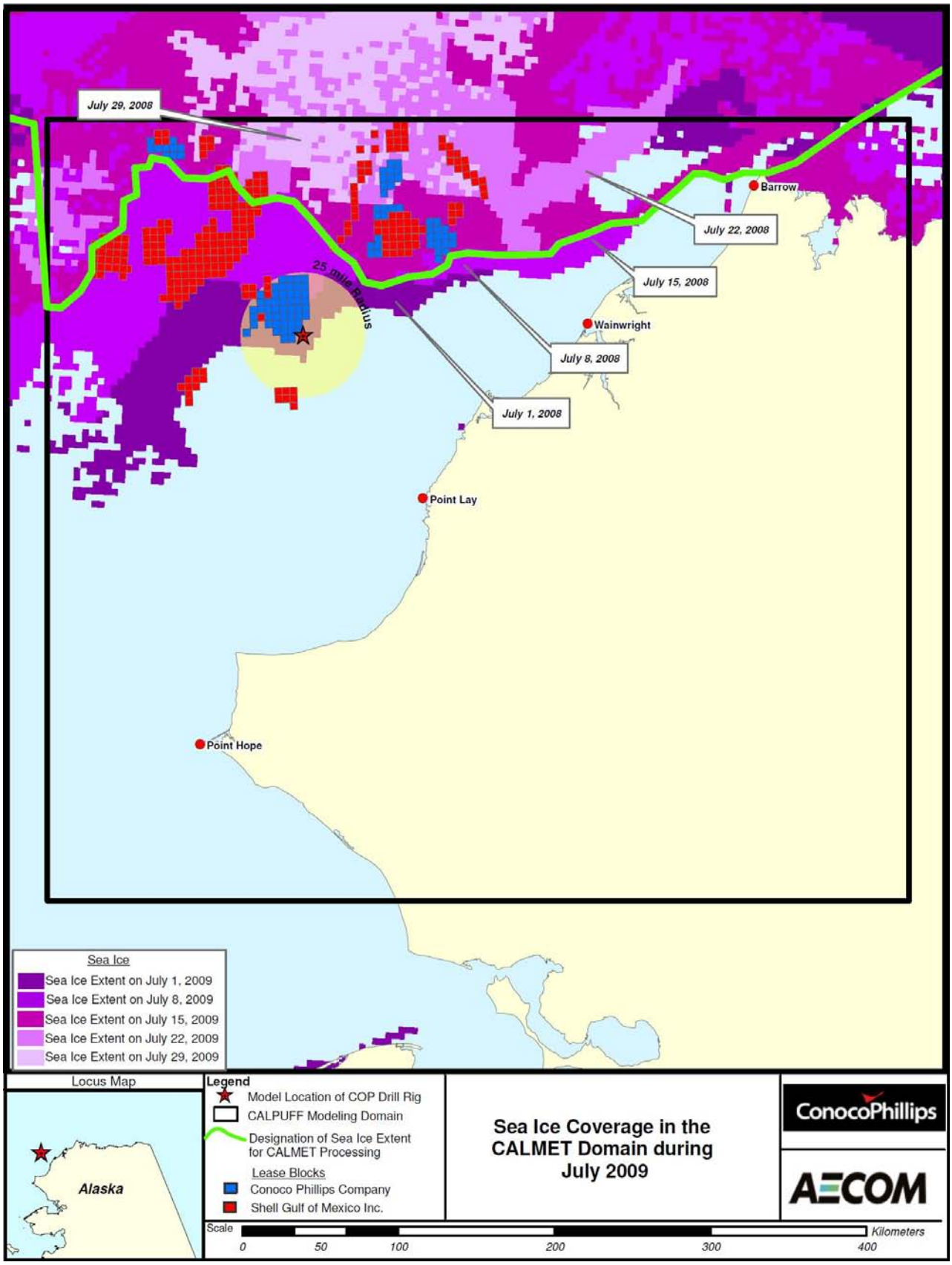


Table 3-4 CALMET User-Defined Settings

Parameter	Description	Default Value	COP Analysis Value	Notes
Group 5				
ISURFT	Sfc met station to use for sfc temp	No Default	Wainwright, AK	The Wainwright National Weather Service (NWS) station is the closest surface station to the proposed drilling location with acceptable data capture.
IUPT	UA station to use for the domain-scale lapse rate	No Default	Barrow, AK	The Wainwright National Weather Service (NWS) station is the closest upper air station to the proposed drilling location with acceptable data capture.

Table 3-5 Non-Default or User-Defined CALPUFF Options

Parameter	Description	Default Value	COP Analysis Value	Notes
Group 1				
NSPEC	Number of chemical species	5	4	The following species were modeled: SO_2, NO_x, PM, CO and lead.
NSE	Number of chemical species emitted	3	4	The following species were emitted: SO_2, NO_x, PM, CO and lead.
Group 2				
MCHEM	Selection of chemical transformation mechanism	1	0	No chemical transformations were modeled. Existing USEPA guidance was followed to estimate NO_2 and $PM_{2.5}$ impacts, detailed further in Section 3.6. It will conservatively be assumed that no SO_2 will convert to SO_4
MWET	Wet removal modeled?	1	0	Wet removal was not performed.
MDRY	Dry deposition modeled?	1	0	Dry deposition was not modeled.
MREG	Check for regulatory default options	1	0	MREG=1 performs checks to ensure that the regulatory default methods are used. MCHEM=0 is non-regulatory, thus if MREG were set =1 execution of CALPUFF would result in a fatal error. MREG was set not to perform any regulatory checks to allow the model to run successfully.
Group 3				
CSPEC	Modeled chemical species	No Default	SO_2, NO_x, PM, CO & lead	Concentrations of SO_2, NO_x, PM, CO, and lead were predicted.
Group 5				
IDRY	Create dry flux file	1	0	Dry deposition calculations were not performed.
IWET	Create wet flux file	1	0	Wet deposition calculations were not performed.
IVIS	Create RH file for visibility processing	1	0	Visibility calculations were not performed.
IPRTU	Print output units (1 – g/m**3; g/m**2/s)	1	3	Output in units of micrograms.

3.5.1 Receptors

As required for a Part 71 permit application, compliance with applicable ambient air quality standards were conducted at the nearest point of compliance which is the Alaska seaward boundary. Receptors were placed along the Alaska seaward boundary in 1-kilometer increments from Barrow to Point Hope. Receptor coordinates were developed using the Lambert Conformal coordinate system discussed in Section 3.2. No over land receptors were modeled; therefore, it was not necessary to develop terrain elevations for receptors from DEM files and using the TERREL pre-processor program. **Figure 3-5** shows the modeled receptor locations.

The Alaska seaward boundary definition used for placing the receptors was obtained from the NOAA Coastal Services Center's Marine Jurisdiction Data Bundle (NOAA 2009) which is a spatial dataset for use and consumption to aid in marine spatial planning and offshore alternative energy siting projects.

Concentration gradients in the vicinity of the highest model predicted project impacts do not exceed 0.05 $\mu g/m^3$ per kilometer across all pollutants and averaging periods[1]. Furthermore, maximum model predicted impacts are well below any National Ambient Air Quality Standard. Therefore, a 1-kilometer receptor spacing is appropriate to characterize maximum ambient air quality impacts and further refinements were not necessary to ensure that maximum impacts have been characterized properly.

3.5.2 CALPOST Processor

The CALPOST program is the CALPUFF modeling system's post-processor. CALPOST version 6.292 (Earth Tech, Inc. 2006) was used in this analysis. This version of the program includes updated processing options to develop impacts suitable for comparison to the recently promulgated 1-hour NO_2 and SO_2 NAAQS.

3.6 Chemical Transformations

Though CALPUFF has the capability of simulating chemical transformations, this capability was not used and instead, chemical transformations were handled outside the model using approved USEPA screening techniques.

As recommended by USEPA, for 1-hour NO_2, the 80% ambient ratio method was used to convert model predicted NO_x concentrations to NO_2 (USEPA 2011). For annual NO_2, the 75% ambient ratio method was used to convert model predicted NO_x concentrations to NO_2. (40 CFR 51 Appendix W Section 5.2.4c).

As recommended by the USEPA Office of Air Quality Planning and Standards (USEPA 2010b), secondary particulate formation can be addressed by modeling only direct $PM_{2.5}$ emissions and using a design value calculated as the average of the highest daily impact on a receptor by receptor basis across all modeled years. For 24-hour $PM_{2.5}$ this represents a screening level approach and accounts for secondary particulate formation. This approach was used to account for secondary particulate formation.

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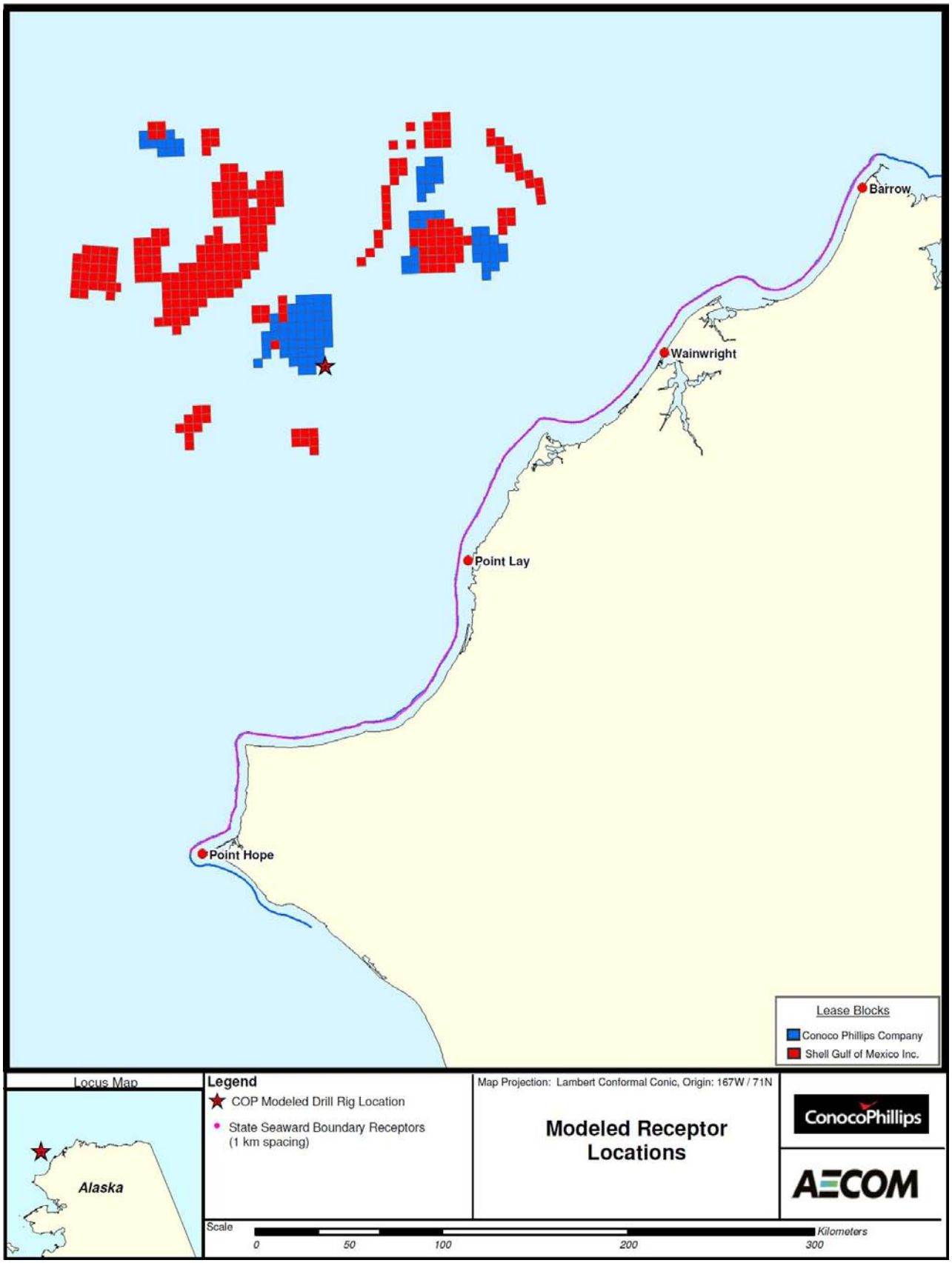
[1] The maximum concentration gradient was predicted for maximum 1-hour NO_2 impacts which ranged from -0.007 to 0.05 $\mu g/m^3$ per km in the vicinity of the maximum impact. Concentration gradients near the $PM_{2.5}$ maximum impact ranged from -0.0028 to 0.0028 $\mu g/m^3$ per km in the vicinity of the maximum impact.

Figure 3-5 Modeled Receptor Locations



4.0 Source Simulation

This chapter details the technical approaches used to simulate project emissions in order to predict impacts using the CALPUFF dispersion model to demonstrate that project emissions do not cause or contribute to a violation of applicable standards at the point of compliance.

Project emissions are only considered while the drill rig is an OCS Source and include emissions from the OCS Source (i.e., the drill rig and vessels physically attached to it), and from vessels that are not part of the OCS Source but support it (i.e., spill response vessels, ice management vessels, supply vessels, etc.). Vessel emissions are considered part of the project whenever those vessels are operating within 25 miles of the OCS Source.

As discussed in Section 1.3 the drill rig is only considered an OCS Source when is achieves zero air gap during the jacking up process and ceases to be an OCS source once it is jacked down to zero air gap.

The simulation was developed with the following goals:

- Develop a single worst-case simulation that could be used to represent the ambient air quality impacts from all potential OCS Source and supporting vessel operating scenarios.
- Develop a simulation based on inherent operational limitations with minimal assumptions so that enforceable limits will not be required on specific emission units, vessel operation, vessel location or physical vessel configuration.

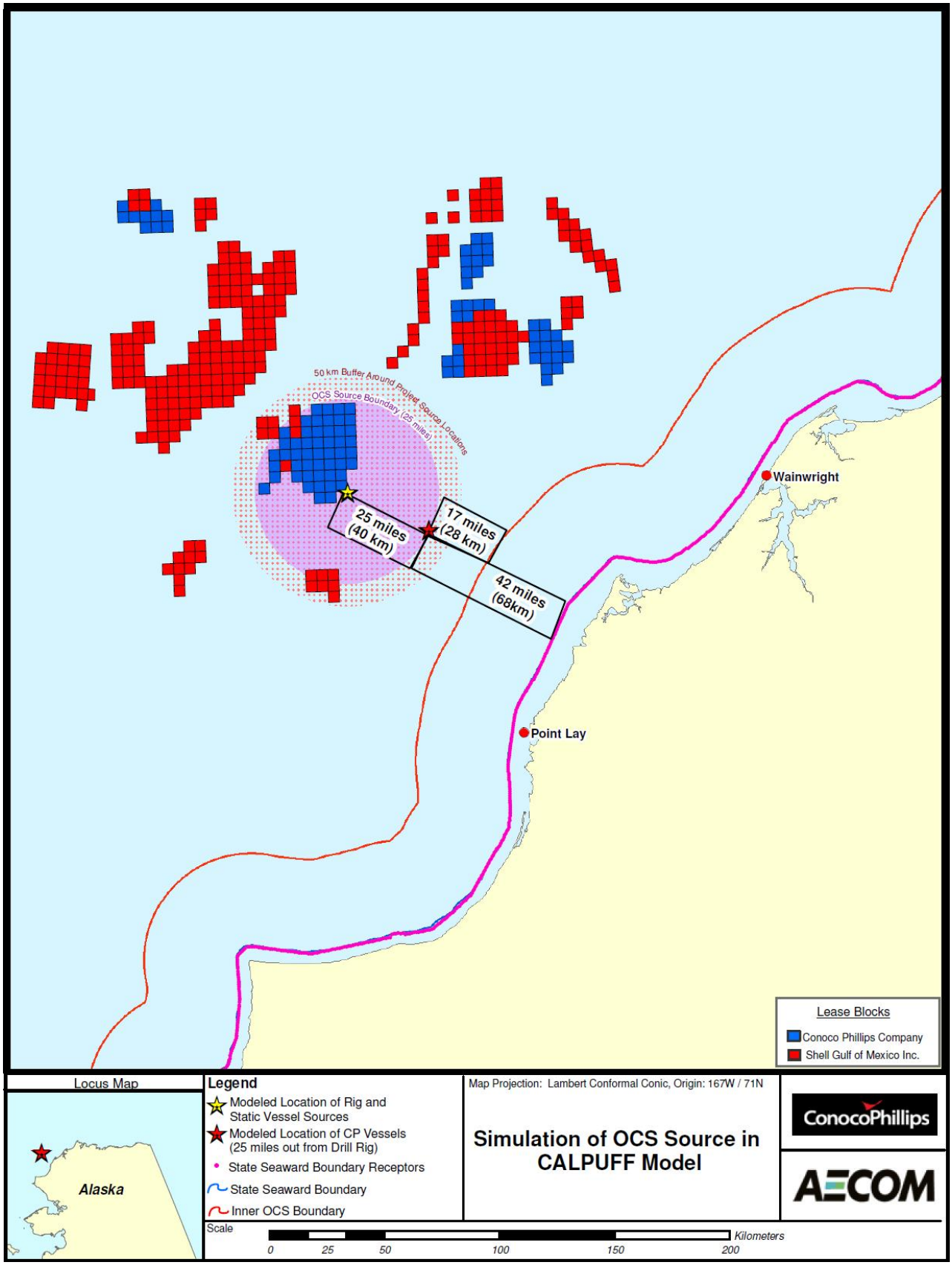
To achieve these goals, the simulation included the following:

- The OCS Source was positioned on the Devil's Paw Prospect lease closest to the Alaska seaward boundary. This not only maximizes downwind impacts by placing the source as close to receptors as possible but also ensures the results and conclusions are independent of OCS Source location on the Devil's Paw Prospect.
- All drill rig emissions and the emissions from vessels that remain relatively static near the drill rig were simulated through one worst-case horizontal and one worst-case vertical stack. This not only maximizes downwind impacts by collocating emissions but also ensures the analysis is independent of vessel and drill rig specific configurations.
- All mobile support vessel emissions were modeled from a single small volume source positioned on the OCS Source boundary nearest the Alaska seaward boundary. This not only maximizes downwind impacts by placing the emissions as close to receptors as possible but also ensures the analysis is independent of vessel configuration and location.
- Total project modeled emissions were based on the simultaneous and collocated operation of the drill rig and support vessels even though these sources are unlikely to operate together within 25 miles of the OCS Source at any time. For example, modeled emissions represent resupplying the drill rig during a spill response exercise called in the midst of a major ice incursion which will not occur.

The location of modeled sources on the Devil's Paw Prospect relative to the OCS source boundary and the point of compliance is shown in **Figure 4-1**.

As will be shown in Chapter 5, even though the simulation was developed with multiple layers of conservative assumptions, model predicted project impacts at the point of compliance are below the SILs and compliance with applicable standards is shown without the need for a cumulative impact analysis. Therefore, the dispersion modeling simulation discussed in this chapter does not need to include a description of the simulation of an offsite source inventory either explicitly through modeling or implicitly through a background concentration.

Figure 4-1 Simulation of the OCS Source in the Dispersion Model



4.1 Simulation of Drill Rig Sources and Nearby Static Vessels

As discussed in Section 2.1 and Section 2.3 the AHTS vessel and the Dedicated OSRV will remain anchored and within approximately 3 miles of the drill rig for the largest part of the drilling season. Therefore, it is appropriate to model the emissions from these two vessels at the same location as those of the drill rig.

A conservative, simplified representation of the jackup drill rig and nearby static vessels was simulated in CALPUFF by modeling all the emissions from two collocated worst-case point sources without downwash and located at the edge of the Devil's Paw Prospect lease block closest to the shore (lease block #6234). These activities are for the most part static; therefore, simulating them as a point source is consistent with the nature of the activity. **Figure 4-1** depicts the modeled location.

This approach is independent of the location of vessels relative to other vessels and vessels relative to the drill rig. It is also independent of the relative location of stacks to each other or to nearby structures. Therefore, the simulation will be largely independent of the specific vessels or drill rig deployed and the way they are deployed relative to each other. Simulating the emissions from this set of sources in this manner maximizes model predicted impacts in the following ways:

- The modeled location is close to the point of compliance – The modeled emissions are not only located on the lease block closest to shore, but on the edge of that lease block. This not only maximizes downwind impacts by placing the emissions as close as possible to receptors but also ensures the analysis is independent of OCS Source location on the Devil's Paw Prospect. The closer a source is to the receptors, the shorter the plume transport distance. Minimizing the plume transport distance minimizes the amount a plume will spread, or disperse, which maximizes downwind impacts. By similar reasoning, if the OCS Source were modeled on any other Devil's Paw Prospect lease, it would be further from receptors and impacts would be less; therefore, impacts based on the chosen location will be representative of any other location on the Devil's Paw Prospect.
- All modeled emissions are collocated – The modeled emissions from emission units that may be as much as 3 miles apart are simulated as being emitted from a single point. This is conservative since the emissions from these vessels will never be collocated with those of the drill rig. Furthermore, the emissions from individual emission units on a particular vessel or drill rig will never be collocated. Decreasing the separation distance between sources maximizes plume overlap increasing the chance that plumes from different emission units will impact the same receptor at the same time increasing impacts. In this case, all emissions are modeled from the same point; therefore, plume overlap is 100%. This approach makes the analysis independent of specific vessel to vessel and vessel to drill rig orientations and separation distances. Furthermore, the analysis is independent of the relative location of individual exhaust stacks on the drill rig or any particular vessel.
- Downwash is not included – Excluding building downwash will help to minimize initial plume dispersion. Minimizing initial plume dispersion will minimize plume dispersion at the modeled receptors maximizing predicted project impacts. The absence of building downwash also makes the simulation independent of source to building relationships making it independent of specific drill rig or vessel configurations.

Sensitivity of the compliance demonstration to the modeled source type for this set of sources was evaluated by modeling them as a volume source. This evaluation is included in Appendix I and demonstrates that the compliance demonstration is not sensitive to the source type selected for this set of sources.

All emissions from this set of sources were modeled through two collocated stacks, one representing horizontal stacks and one representing vertical stacks. Stack exit parameters for the two point sources were developed to maximize impacts at the point of compliance using a conservative variation of USEPA's M-Value technique (USEPA 1992). For this application, the M-Value for a particular emission unit was set equal to the product of the stack height (meters), exit temperature (Kelvin), and volumetric flow rate (m^3/s). This is a more conservative approach to calculating the M-Value because it does not include the emission rate in the denominator; therefore, it does not account for the emission potential of particular emission unit making the

analysis independent of emission unit operation. Taking this approach, stack parameters associated with emission units that seldom operate factor equally with those that operate continuously.

Following the standard M-Value approach, an M-Value was determined for each emission unit. The emissions from all emission units with a particular stack orientation were modeled from the stack with the lowest M-Value. This analysis was conducted separately for emission units with horizontal and vertical stacks since horizontal stacks are treated differently in CALPUFF. The M-Value analysis for this set of sources is presented in Appendix C.

Though selecting a representative stack based on the M-Value approach is typically associated with a near-field analysis, it is equally applicable to a far-field analysis since it minimizes initial dispersion (i.e., favors the stack with the lowest volumetric flow rate and temperature) and keeps the plume centerline close to the sea surface (i.e., favors the stack with the lowest release height). For a long range transport analysis without terrain, this will maximize model predicted impacts in the following ways:

- Minimizing initial dispersion minimizes final dispersion maximizing plume concentrations and downwind impacts.
- Since the highest plume concentrations are nearest the plume centerline, keeping the plume centerline closer to the surface of the water maximizes ground level concentrations. This assertion is only true given that CALPUFF is being run without chemistry or deposition; therefore, no pollutant mass will be lost in transport processes particularly for plumes close to the surface of the water.

Sensitivity of the compliance demonstration to the M-Value approach was evaluated by modeling this set of sources with stack parameters based on the emission unit with the highest M-Value. This evaluation is included in Appendix I and demonstrates that the compliance demonstration is not sensitive to the modeled stack parameters selected for this set of sources.

Horizontal stacks were simulated in a manner consistent with Model Clearinghouse decisions and procedures summarized in the AERMOD Implementation Guide (USEPA 2009) for stacks modeled without downwash. Procedures for AERMOD are applicable to CALPUFF since both rely on similar initial release parameterizations and downwash algorithms. The following procedure was used to simulate horizontal stacks:

- All Point Sources: Stack tip downwash was turned off for all sources.
- Vertical Point Sources: The release height was reduced by three times the stack diameter to maximize stack tip downwash. No other stack parameters were adjusted.
- Horizontal Point Sources: The exit velocity was set to 0.001 m/s to minimize vertical momentum. The diameter was increased to conserve the volumetric flow rate. No other stack parameters were adjusted.

Following the M-Value analysis detailed in Appendix C, and making the appropriate adjustments for simulating horizontal releases, the resulting modeled stack parameters for the two collocated sources representing the drill rig and nearby static vessels is shown in **Table 4-1**. Based on the M-Value analysis, the representative stacks for vertical and horizontal stack are the logging winch on the drill rig and the emergency generator on the OSRV, respectively.

4.2 Simulation of Support Vessels

All emissions associated with all aspects of the mobile support vessels (cruising, idling and dynamic positioning) were modeled from a single 1 km square volume source located 25 miles from the drill rig in between the drill rig and the closest point of compliance regardless of where that activity will actually occur within the OCS source boundary.

Sensitivity of the compliance demonstration to the location of the volume source on the OCS source boundary relative to the drill rig was evaluated by modeling the volume source at two different alignments between the

drill rig and the point of compliance. This evaluation is included in Appendix I and demonstrates that the compliance demonstration is not sensitive to the location of the volume source on the OCS source boundary.

The emissions modeled from this volume source represent emissions from 10 vessels operating within the same 1 km square all the time. The emissions modeled from this small volume source include:

- Emissions from two ice breakers managing ice.
- All emissions from a spill response exercise consisting of four work boats, one OSRV, and one spill response storage tanker.
- Emissions from a marine research vessel.
- All emissions from either one OSV or Ware Vessel cruising to the drill rig, transferring supplies (Dynamic Positioning) and cruising away from the drill rig.

This clearly overstates the impacts from this set of vessels since they will rarely operate at the same time, never within 10 km of each other, and because it concentrates the activities in an area too small to support any single activity let alone all of them. For example, among many possible scenarios, the emissions modeled from this volume source represents resupplying the drill rig during a spill response exercise called in the midst of a major ice incursion which will not occur.

The modeled source parameters for the volume source which are summarized in **Table 4-2** were developed as follows:

- Release Height:

  The release height is equivalent to the lowest release height of any of the exhaust stacks included on the vessels represented by the single volume source excluding those of the work boats. Work boats are rarely used and have exhaust stacks that release horizontally at the waterline making them unrepresentative of any other vessel that might be deployed. As detailed in Appendix C, the lowest release height among the stacks associated with the vessels represented by the volume source is 3.2 meters which is associated with the horizontal release from two of the OSV thruster engines.

  The lowest release height was selected to keep the volume source plume close to the surface of the water. Since the highest plume concentrations are nearest the plume centerline, keeping the plume centerline closer to the surface of the water maximizes surface level concentrations. This assertion is only true given that CALPUFF is being run without chemistry or deposition; therefore, no pollutant mass will be lost in transport processes particularly for plumes close to the surface of the water.

  Sensitivity of the compliance demonstration to the volume source release height was evaluated by modeling the volume source with a release height equivalent to that of the highest vessel stack from among all vessels included in the volume source. This evaluation is included in Appendix I and demonstrates that the compliance demonstration is not sensitive to the volume source parameterization.

- Initial Lateral Dimension:

  Following the AERMOD User's Guide (USEPA 2004) for a single volume source the initial lateral dimension was set to the length of a side divided by 4.3. In this case, the length of a side is 1 km. This distance is consistent with twice the turn radius of the smaller vessels represented by the volume source. Therefore, the initial lateral dimension is 0.233 km.

- Initial Vertical Dimension:

  Following AERMOD User's Guide (USEPA 2004) for a single elevated volume source not on or adjacent to a building the initial vertical dimension has been set to the vertical dimension of the

source divided by 4.3. In this case, the vertical dimension of the source is equivalent to the release height determined above. Therefore, the initial vertical dimension is 0.744 meters.

Representing all the emissions as a single volume source located on the edge of the OCS Source boundary makes the simulation and subsequent conclusions independent of the following:

- Individual vessel configuration (i.e., the location of stacks relative to each other and vessel structures).
- Orientation of vessels relative to each other.
- Location of vessels on the Devil's Paw Prospect.

Table 4-1 Modeled Stack Parameters for Point Sources Representing the Drill Rig and Nearby Static Vessels

Source Group	Modeled Point Source Parameters[1]			
	Height (m)	Temperature (K)	Velocity (m/s)	Diameter (m)
Drill Rig and Static Vessel Vertical Emission Units	12.9 (13.5)	589	13.6	0.203
Drill Rig and Static Vessel Horizontal Emission Units	7.3	589	0.001 (38.8)	25 (0.13)

1 Actual stack parameters are shown in parentheses if they are different from the modeled parameters. For vertical stacks, the difference is the result of reducing the actual height by three times the diameter to maximize stack tip downwash. For the horizontal stacks, the difference is the result of the approach used to simulate horizontal releases by eliminating the vertical momentum while conserving the volumetric flow rate.

Table 4-2 Modeled Source Parameters for the Volume Source Representing all Mobile Vessel Emissions

Source Group	Modeled Volume Source Parameters		
	Release Height (m)	Initial Lateral Dimension (m)	Initial Vertical Dimension (m)
All Mobile Vessels	3.2	233	0.744

4.3 Determination of Maximum Short-Term Modeled Emissions

All project emissions were modeled from a total of 3 sources: 2 point sources representing the drill rig and nearby static vessels and one volume source representing mobile vessel emissions. This approach removes the variables of individual vessel location and the location of individual stacks on vessels from the analysis while ensuring conservatism and robust results. Furthermore, maximum hourly emissions were modeled regardless of averaging period. Therefore, developing the maximum emissions to model for averaging periods less than 24-hours involved: 1) identifying unique potential short-term operating scenarios, 2) calculating the maximum hourly emission rate for each of the three modeled sources for each operating scenario, and 3) selecting the highest emission rates among the different operating scenarios to model. Calculated hourly emission rates for each emission unit and totals by operating scenario are documented in Appendix B along with a summary of the highest emission rate for each modeled source from across all scenarios. Those modeled emission rates are summarized in **Table 4-3**.

4.3.1 Identification of Potential Short-Term Operating Scenarios

The identification of unique potential short-term operating scenarios was developed based on an examination of the activities that could occur concurrently during a drilling season which were presented in Chapter 2.

First/Last 24-Hours – Given the operational profile presented in Section 2.1, two major activities can occur in the first 24-hours after becoming an OCS Source. First, the drill rig is jacked to its final height and the drill rig is readied to receive supplies and begin normal operation. This involves many steps and various support vessels. Second, a resupply vessel makes the trip to the drill rig and then transfers supplies. During the first 24-hours, spill response exercises will not occur; therefore, this scenario cannot produce worst-case ambient air quality impacts given the lack of these emissions. With the exception of the resupply, the last 24-hours mirrors the first 24-hours. Therefore, the jackdown process results in fewer short-term emissions than the jackup process. **Table 4-4** and **Table 4-5** show which vessels will be active in addition to the drill rig during the first and last 24-hours of the OCS Source.

During normal operations, the vessels involved in a resupply trip will be very different between a Regular Resupply and a Refueling Resupply since the refueling resupply cannot occur during a spill response exercise. However, because a spill response exercise will not occur within the first 24-hours, the resupply trip could be either a refueling trip or a regular resupply trip and the vessels involved and documented in **Table 4-4** would be the same.

Initial Resupply/Refueling – As described in Section 2.1, within the first days of becoming an OCS Source, there will be an attempt to load the drill rig with supplies and/or fuel as quickly as possible. During this time as many supply trips will made as possible each day; however, at no point will more than one resupply vessel (i.e., OSV or Ware Vessel or their backups) be within 25 miles of the drill rig at one time. During this period, the potential exists that a spill response exercise could occur; however, if one does occur, the drill rig cannot be refueled due to the absence of the Dedicated OSRV. Therefore, a refueling event will always produce fewer emissions compared to a Regular Resupply. **Table 4-6** and **Table 4-7** show which vessels will be active in addition to the drill rig during the Initial Resupply and Initial Refueling scenarios.

Regular Resupply/Refueling – Under normal circumstances, the drill rig will be will be routinely resupplied or refueled by either an OSV or Ware Vessel or their backups. Since weather or sea state could affect the ability of the resupply vessel to approach the drill rig and transfer supplies, it is assumed that the resupply vessel can remain within 25 miles of the drill rig for 24-hours though the supply transfer will generally be limited to 6 hours next to the drill rig. However, at no point will more than one resupply vessel be within 25 miles of the drill rig at one time. As with the Initial Resupply and Initial Refueling scenarios, the potential exists that a spill response

Table 4-3 Maximum Modeled Short-Term (ST) and Long-Term (LT) Emission Rates

Source	NO_x (g/s)		CO (g/s)		SO_2 (g/s)		$PM_{10}/PM_{2.5}$ (g/s)		lead (g/s)
	ST	LT	ST	LT	ST	LT	ST	LT	3-Month
Point (Vertical)	1.07E+01	5.57E+00	7.07E+00	9.27E-01	5.89E-02	9.81E-03	6.77E-01	8.09E-01	3.76E-03
Point (Horizontal)	8.13E+00	2.36E+00	1.22E+01	3.91E+00	2.10E-02	7.05E-03	8.39E-01	2.93E-01	1.81E-04
Volume	6.53E+01	1.20E+01	7.36E+01	1.13E+01	2.74E-01	3.45E-02	5.86E+00	8.61E-01	2.02E-03

Notes:

ST Modeled emission rate for predicting air quality impacts for the 1-hour, 3-hour, 8-hour, and 24-hour averaging periods.

LT Modeled emission rate for predicting impacts for a 123 day (4-month) averaging period. To compare model predicted impacts to annual standards, the predicted 4-month average impact must be multiplied by 4/12 to account for the fact that the OCS Source produces no ambient air quality impacts outside of the 4-month modeled drilling season.

exercises could occur during a resupply trip; however, if one does occur, the drill rig cannot be refueled due to the absence of the Dedicated OSRV. Therefore, a Refueling Resupply will always produce fewer emissions than a Regular Resupply. **Table 4-8** and **Table 4-9** show which vessels will be active in addition to the drill rig during the Regular Resupply and Regular Refueling scenarios.

An examination of **Table 4-4** through **Table 4-9** leads to two important observations that simplifies identifying the worst-case emissions to model. First, compared to refueling scenarios, the Initial Resupply and Regular Resupply scenarios will produce the highest emissions in a 24-hour period because more vessels have the potential to operate in a 24-hour period. Second, because all emission units on a particular vessel are assumed to be operating at any given time, there is no distinction between the Initial Resupply scenario and the Regular Resupply scenario. Therefore, when evaluating which scenarios produce the highest short-term emissions in Appendix B, it is only necessary to compare the highest total emissions for each modeled source determined for OPTION 1 and OPTION 2 for the First 24-Hours and a Regular Resupply Scenario. As detailed in Appendix B, generally, the highest short-term emissions are associated with the Regular Resupply scenario OPTION 2 – Ware Vessel resupply.

4.3.2 Calculating the Maximum Hourly Emission Rate for each Scenario Evaluated

Generally, short-term emissions determined for each unique scenario were calculated assuming all emission units on each vessel and the drill rig will operate for a full 24-hours. Based on this approach, the 1-hour, 3-hour, 8-hour and 24-hour emission rates will be identical for a particular pollutant.

Modeling emissions calculated this way will grossly overstate impacts for averaging periods less than 24-hours because the modeled emission rate represents the simultaneous operation of all emission units on a particular vessel even though many of those emission units could not operate at the same time. Though there are many examples, the following highlight this point:

- For an OSV or Ware Vessel conducting a resupply trip, emissions from the vessel dynamic positioning next to the drill rig are modeled at the same time as emissions from the vessel cruising to the drill rig. These emissions could not occur simultaneously.
- For all vessels, emissions from testing the emergency generators are modeled at the same time as emissions from all other vessel emission units. This scenario implies emergency generator testing will occur while the vessel is fully engaged in executing specific duties (i.e., engaged in transferring supplies or participating in a spill response exercise) rather than when the vessel has idle time which is when the testing is likely to occur.

In a similar sense, impacts predicted for the 24-hour averaging period will be overstated because modeled 24-hour emissions assume all emission units will operate for a full 24-hour period when in fact most will not. Though there are many examples, the following highlight this point:

- For an OSV or Ware Vessel conducting a resupply trip, emissions for the vessel dynamic positioning next to the drill rig while supplies are transferred are modeled as occurring for 24-hours when in fact this activity will take less than 6 hours. Similarly, emissions from cruising to and from the drill rig are modeled as occurring for 24-hours when this activity will typically only occur over a 4-hour period (2 hours cruising to the drill rig and 2 hours cruising away from the drill rig).
- For all vessels, emissions from testing the emergency generators are modeled as occurring for a full 24-hour period though the testing is unlikely to last more than one hour in any 24-hour period.

Recognizing this conservatism in developing model short-term emissions particularly in light of the conservative manner in which those emissions were simulated to maximize the impact of modeled emissions, the approach used to develop short-term emissions was refined for determining NO_x emissions to avoid grossly overstating the model predicted impacts. While the maximum emissions were still selected for each of the three modeled sources from among all the potential short-term operating scenarios identified above, the assumptions regarding which emissions units were active on a particular vessel during a given hour were refined to only account for the emissions from those units with a high probability of producing maximum model

predicted impacts and those with a high probability of operating simultaneously in a given hour. The following provide examples of this refinement.

- For a given vessel, emissions from emission units dedicated to cruising were not considered when calculating the maximum vessel hourly NO_x emissions because emissions from a cruising vessel will produce lower air quality impacts than those from a static vessel. Lower impacts are expected from a cruising vessel because the vessel will only impact a specific receptor for a short portion of an hour when the receptor is exactly downwind of the cruising vessel. Being lined up for a very short period of time in the case of a cruising vessel produces lower impacts when averaged over an hour when compared to a vessel which is static and upwind of a receptor for the entire hour.
- For vessels that have several non-overlapping operating modes such as dynamic positioning, idling and cruising, only one of the operating modes was assumed to occur when calculating vessel emissions. The analysis of worst-case vessel emissions favored the static operating modes with the highest emissions which in most cases occur for vessels dynamically positioning while transferring supplies. It is important to note that even though most vessels will only dynamically position when they are next to the drill rig, these emissions were modeled at the edge of the OCS source boundary 25 miles closer to the point of compliance than they would actually occur. This is an example of how the simulation was designed to increase the impact of modeled emissions.
- For a given vessel, there are certain inherent operational limitations that would typically prevent certain emission units from operating at the same time as others. For example, testing emergency generators is unlikely to occur at the same time that the vessel is fully engaged in executing specific duties (i.e., engaged in transferring supplies or participating in a spill response exercise). Therefore, on a particular vessel, the emergency generators were not assumed to operate if the vessel was engaged in performing its primary duty. Similarly, if a vessel has multiple generators and only one is likely to operate at a time while the vessel is performing its regular duty, then only the emissions from one generator were modeled.

Once these various refinements were factored in for each vessel, the total NO_x emissions from each of the potential short-term scenarios identified were compared for each of the three modeled sources and the highest for each source was modeled. An examination of the NO_x emission rate associated with each emission unit on each vessel listed in Appendix B makes it clear which operating modes and emission units were considered in the total emission rate determination.

4.4 Determination of Worst-Case Three-Month Modeled Emission Rates (Lead Only)

The lead NAAQS is a three month standard. In a single three month period it was assumed that all activities associated with a complete drilling season could occur. Therefore, all activities associated with a particular resupply option (OPTION 1 – Resupply by OSV or OPTION 2 – Resupply by Ware Vessel) were modeled occurring simultaneously during the entire three month period. As a result there was no need to identify individual operating scenarios within each resupply option and calculate emissions for each operating scenario separately. Therefore, to choose the highest emissions to model, 3-month emissions rates were calculated for each emission unit, the 3-month emission rates were totaled by resupply option for each of the three modeled sources and the highest emission rate for each source was modeled. Generally speaking, emissions for OPTION 2 (Resupply by Ware Vessel) resulted in the highest emission rates for each of the three modeled sources.

For each emission unit, the modeled three month emission rate was calculated differently depending on the number of days the unit was assumed to operate during a typical drilling season.

- For emission units assumed to operate for 3-months or more, the maximum hourly lead emission rate was modeled for that unit.
- For emission units assumed to operate less than 3-months, the three month modeled emission rate was the product of the maximum hourly emission rate multiplied by the number of days the emission

unit was assumed to operate divided by 90 days (i.e., the fewest number of days in a three month period).

Three month lead emission rates for all emission units are presented in Appendix B along with a summary of total three month modeled emission rates by modeled source type for each resupply option. The final modeled emission rate for each of the three sources is presented in **Table 4-3**.

4.5 Determination of Worst-Case Long-Term Modeled Emission Rates

During the drilling season, all activities can occur. Therefore, to predict impacts to compare to the annual standards all activities associated with a particular resupply option (OPTION1 – Resupply by OSV or OPTION2 – Resupply by Ware Vessel) were modeled occurring simultaneously during the entire modeled drilling season. Accordingly, there was no need to identify individual operating scenarios within each resupply option and calculate emissions for each operating scenario separately. Therefore, to choose the highest emissions to model, 4-month emissions rates were calculated for each emission unit, the 4-month emission rates were totaled by resupply option for each of the three modeled sources and the highest emission rate for each source was modeled. Generally speaking, emissions for OPTION2 (Resupply by Ware Vessel) resulted in the highest emissions for each of the three modeled sources.

Though the drilling season could occur over a 5-month period from July through November if the Devil's Paw Prospect were to remain ice free, 4-month emission rates were calculated and modeled since the modeled drilling season only lasted from July through October as a result of ice in the Devil's Paw Prospect in November during each of the three modeled years (2007, 2008 and 2009).

To calculate a 4-month emission rate for each emission unit, the annual potential to emit for each emission unit was assumed to be released in the 4-month modeled drilling season. Therefore, the 4-month emission rate is equivalent to the annual potential to emit converted to grams per second based on a 4-month year.

Four month emission rates for all emission units are presented in Appendix B along with a summary of total four month emission rates by source type for each resupply option. The final modeled emission rate for each of the three sources is presented in **Table 4-3**.

Since modeling was only conducted for a 4-month period and modeled emission rates were calculated assuming that the entire annual potential to emit was released in a 4-month period, model predicted impacts must be multiplied by the ratio of 4/12 before comparing to the annual standards to account for the fact that the OCS Source produces no ambient air quality impacts outside of the 4-month modeled drilling season.

Table 4-4 Potential Short-Term Jackup Resupply Scenarios (First 24-Hours)

Vessel	Option 1 OSV Resupply			Option 2 Ware Vessel Resupply			
	1a (Jackup)	1a (Supply Primary)	1c (Supply Backup)	2a (Jackup)	2b (Supply Primary)	2c (Supply Backup 1)	2d (Supply Backup 2)
Drill Rig	X	X	X	X	X	X	X
Ice Breaker 1	X	X	X	X	X	X	X
Ice Breaker 2	X	X	X	X	X	X	X
Marine Research Vessel	X	X	X	X	X	X	X
AHTS 1 (Fire Response)	X (TOW)	X	X	X (TOW)	X	X	X
Spill Exercises							
OSRV 1 (Dedicated)	X	X	X	X	X	X	X
OSRV 2 (Spill Exercises)	O	O	O	O	O	O	O
4 Work Boats (Spill Exercises)	O	O	O	O	O	O	O
Spill Storage Tanker (Spill Exercises)	O	O	O	O	O	O	O
Resupply							
OSV 1 (Tow/Resupply)	X (TOW)	O	X	X (TOW)	O	X	O
OSV 2 (Tow/Resupply)	X (TOW)	X	O	NA	NA	NA	NA
Ware Vessel (Resupply)	NA	NA	NA	O	X	O	O
AHTS 2 (Tow/Resupply)	NA	NA	NA	X (TOW)	O	O	X

Notes:

X = Denotes that the vessel is active during the scenario.

O = Denotes that the vessel does not operate within the 25 mile OCS source boundary during the scenario.

NA = Indicates that the vessel is not part of the inventory for a given option.

Table 4-5 Potential Short-Term Jackdown Scenarios (Last 24-Hours)

Vessel	Option 1 OSV Resupply			Option 2 Ware Vessel Resupply			
	1a (Jack down)	1a (Supply Primary)	1c (Supply Backup)	2a (Jack down)	2b (Supply Primary)	2c (Supply Backup 1)	2d (Supply Backup 2)
Drill Rig	X	O	O	X	O	O	O
Ice Breaker 1	X	O	O	X	O	O	O
Ice Breaker 2	X	O	O	X	O	O	O
Marine Research Vessel	X	O	O	X	O	O	O
AHTS 1 (Fire Response)	X (TOW)	O	O	X (TOW)	O	O	O
Spill Exercises							
OSRV 1 (Dedicated)	X	O	O	X	O	O	O
OSRV 2 (Spill Exercises)	O	O	O	O	O	O	O
4 Work Boats (Spill Exercises)	O	O	O	O	O	O	O
Spill Storage Tanker (Spill Exercises)	O	O	O	O	O	O	O
Tow/Resupply							
OSV 1 (Tow/Resupply)	X (TOW)	O	O	X (TOW)	O	O	O
OSV 2 (Tow/Resupply)	X (TOW)	O	O	NA	NA	NA	NA
Ware Vessel (Resupply)	NA	NA	NA	O	O	O	O
AHTS 2 (Tow/Resupply)	NA	NA	NA	X (TOW)	O	O	O

Notes:

X = Denotes that the vessel is active during the scenario.

O = Denotes that the vessel does not operate within the 25 mile OCS source boundary during the scenario.

NA = Indicates that the vessel is not part of the inventory for a given option.

Table 4-6 Potential Short-Term Initial Resupply Scenarios

Vessel	Option 1 OSV Resupply		Option 2 Ware Vessel Resupply		
	1a (Primary)	1a (Backup)	2a (Primary)	2b (Backup)	2c (Backup)
Drill Rig	X	X	X	X	X
Ice Breaker 1	X	X	X	X	X
Ice Breaker 2	X	X	X	X	X
Marine Research Vessel	X	X	X	X	X
AHTS 1 (Fire Response)	X	X	X	X	X
Spill Exercises					
OSRV 1 (Dedicated)	X	X	X	X	X
OSRV 2 (Spill Exercises)	X	X	X	X	X
Work Boat 1 through 4 (Spill Exercises)	X	X	X	X	X
Spill Storage Tanker (Spill Exercises)	X	X	X	X	X
Resupply					
OSV 1 (Resupply)	X	O	O	X	O
OSV 2 (Resupply)	O	X	NA	NA	NA
Ware Vessel (Resupply)	NA	NA	X	O	O
AHTS 2 (Resupply)	NA	NA	O	O	X

Notes:

X = Denotes that the vessel is active during the scenario.

O = Denotes that the vessel does not operate within the 25 mile OCS source boundary during the scenario.

NA = Indicates that the vessel is not part of the inventory for a given option.

Table 4-7 Potential Short-Term Initial Refueling Scenarios

Vessel	Option 1 OSV Resupply		Option 2 Ware Vessel Resupply		
	1a (Primary)	1a (Backup)	2a (Primary)	2b (Backup)	2c (Backup)
Drill Rig	X	X	X	X	X
Ice Breaker 1	X	X	X	X	X
Ice Breaker 2	X	X	X	X	X
Marine Research Vessel	X	X	X	X	X
AHTS 1 (Fire Response)	X	X	X	X	X
Spill Exercises					
OSRV 1 (Dedicated)	X	X	X	X	X
OSRV 2 (Spill Exercises)	O	O	O	O	O
Work Boat 1 through 4 (Spill Exercises)	O	O	O	O	O
Spill Storage Tanker (Spill Exercises)	O	O	O	O	O
Resupply					
OSV 1 (Resupply)	X	O	O	X	O
OSV 2 (Resupply)	O	X	NA	NA	NA
Ware Vessel (Resupply)	NA	NA	X	O	O
AHTS 2 (Resupply)	NA	NA	O	O	X

Notes:

X = Denotes that the vessel is active during the scenario.

O = Denotes that the vessel does not operate within the 25 mile OCS source boundary during the scenario.

NA = Indicates that the vessel is not part of the inventory for a given option.

Table 4-8 Potential Short-Term Normal Operations Regular Resupply Scenarios

Vessel	Option 1 OSV Resupply		Option 2 Ware Vessel Resupply		
	1a (Primary)	1a (Backup)	2a (Primary)	2b (Backup)	2c (Backup)
Drill Rig	X	X	X	X	X
Ice Breaker 1	X	X	X	X	X
Ice Breaker 2	X	X	X	X	X
Marine Research Vessel	X	X	X	X	X
AHTS 1 (Fire Response)	X	X	X	X	X
Spill Exercises					
OSRV 1 (Dedicated)	X	X	X	X	X
OSRV 2 (Spill Exercises)	X	X	X	X	X
Work Boat 1 through 4 (Spill Exercises)	X	X	X	X	X
Spill Storage Tanker (Spill Exercises)	X	X	X	X	X
Resupply					
OSV 1 (Resupply)	X	O	O	X	O
OSV 2 (Resupply)	O	X	NA	NA	NA
Ware Vessel (Resupply)	NA	NA	X	O	O
AHTS 2 (Resupply)	NA	NA	O	O	X

Notes:

X = Denotes that the vessel is active during the scenario.

O = Denotes that the vessel does not operate within the 25 mile OCS source boundary during the scenario.

NA = Indicates that the vessel is not part of the inventory for a given option.

Table 4-9 Potential Short-Term Normal Operations Refueling Resupply Scenarios

Vessel	Option 1 OSV Resupply		Option 2 Ware Vessel Resupply		
	1a (Primary)	1a (Backup)	2a (Primary)	2b (Backup)	2c (Backup)
Drill Rig	X	X	X	X	X
Ice Breaker 1	X	X	X	X	X
Ice Breaker 2	X	X	X	X	X
Marine Research Vessel	X	X	X	X	X
AHTS 1 (Fire Response)	X	X	X	X	X
Spill Exercises					
OSRV 1 (Dedicated))	X	X	X	X	X
OSRV 2 (Spill Exercises)	O	O	O	O	O
Work Boat 1 through 4 (Spill Exercises)	O	O	O	O	O
Spill Storage Tanker (Spill Exercises)	O	O	O	O	O
Resupply					
OSV 1 (Resupply)	X	O	O	X	O
OSV 2 (Resupply)	O	X	NA	NA	NA
Ware Vessel (Resupply)	NA	NA	X	O	O
AHTS 2 (Resupply)	NA	NA	O	O	X

Notes:

X = Denotes that the vessel is active during the scenario.

O = Denotes that the vessel does not operate within the 25 mile OCS source boundary during the scenario.

NA = Indicates that the vessel is not part of the inventory for a given option.

5.0 Project Ambient Air Quality Impact Analysis

The project ambient air quality impact analysis is presented in the Chapter. With the exception of ozone, the ambient air quality impact analysis has been conducted using the technical approaches presented in Chapters 3 and 4. The ozone analysis, which did not rely on dispersion modeling, is detailed in a separate section below.

5.1 Using the Significant Impact Levels (SILs) to Demonstrate Compliance with Applicable Standards

It is a longstanding USEPA position that a project will not be considered to cause or contribute to a predicted NAAQS violation if the estimated air quality impact as a result of the project is at or below the SILs (40 CFR 51.165(b)(2)). Therefore, if project impacts are shown to be at or below the SILs at the Alaska seaward boundary, compliance with all applicable standards is shown and conducting a cumulative impact analysis is not required.

Since a SIL has not been established for lead, a not-to-exceed value of 0.006 $\mu g/m^3$ on a rolling 3-month basis and 0.06 $\mu g/m^3$ on a quarterly basis will be used to demonstrate that project impacts will not cause or contribute to a violation of the NAAQS for lead. This value was set following the approach taken by USEPA where the SIL associated with the 1-hour NO_2 NAAQS was set at 4% of the NAAQS following historical precedence (USEPA 2010a).

With the exception of the new probabilistic standards (1-hour NO_2, 1-hour SO_2 and 24-hour $PM_{2.5}$), the SIL is a not to exceed value for all pollutants and averaging periods. However, for the new probabilistic standards, the SIL is the highest of the multi-year averages of the maximum modeled 1-hour, or 24-hour concentrations predicted each year at each receptor, based on two or more years of available site specific meteorological data (USEPA 2011, USEPA 2010b).

5.2 Project Ambient Air Quality Impact Analysis

A comparison of project impacts to the Significant Impact Levels (SILs) is presented in **Table 5-1**. The results of this analysis demonstrates that model predicted impacts are well below the SILs for all pollutants and averaging periods. As such, the project does not cause or contribute to a violation of any NAAQS and compliance with all applicable ambient air quality standards is shown without conducting a cumulative impact analysis [40 CFR 51.165(b)(2), 40 CFR 51 Appendix W Section 10.2.3.2, New Source Review Workshop Manual (USEPA 1990)].

As discussed in Section 4.5, modeling was conducted for a 4-month period and modeled emission rates represent the entire annual potential to emit released in a 4-month period; therefore, model predicted impacts were multiplied by the ratio of 4/12 before comparing to the annual standards to account for the fact that the OCS Source produces no ambient air quality impacts outside of the 4-month modeled drilling season.

It is important to note that if project impacts are at or below the SILs at the Alaska seaward boundary, they will be below the SILs at any more distant onshore location including the communities of Barrow, Wainwright, Point Lay, and Point Hope.

Though not necessary, USEPA Region 10 asked that a project cumulative impact analysis at the Alaska seaward boundary be conducted. That analysis is presented in Appendix A for informational purposes.

A digital record containing supporting files has been compiled, placed on a hard drive and has been transmitted separately to USEPA Region 10. The digital record contains pertinent information supporting the ambient air quality impact analysis presented in this Chapter including the meteorological input data and all modeling input and output files supporting the ambient air quality impact analysis.

5.3 Ambient Ozone Air Quality Impact Analysis

Ozone is a regional pollutant that is the result of chemical reactions over a period of hours or days. Ground level ozone can be formed through many complex chemical reactions that include NO_x, VOC and CO (known as ozone precursors) in the presence of sunlight. The sources of ozone precursors are typically combustion sources such as power plants, refineries automobiles, and oil and gas production. The land area closest to COP's exploration operations in the Chukchi Sea is part of the State of Alaska's Northern Interstate Air Quality Control Region (AQCR) (40 CFR § 81.246), which is designated as either attainment or unclassifiable for all criteria pollutants, including ozone (40 CFR § 81.301).

Currently, there is no USEPA-recommended modeling approach for conducting the ozone ambient air quality impact analyses. The USEPA's Guideline on Air Quality Models (40 CFR 51 Appendix W), which defines the modeling methodologies, states that the "Simulation of ozone formation and transport is a highly complex and resource intensive exercise," and further that the "Choice of methods used to assess the impact of an individual source depends on the nature of the source and its emissions. Thus, model users should consult with the Regional Office to determine the most suitable approach on a case-by-case basis."

Given the magnitude of project emissions, designation of the AQCR as attainment or unclassifiable as well as recently approved methodologies to qualitatively describe the expected ozone impacts from the Shell OCS Source (see Statement of Basis – Permit No. R10OCS/PSD-AK-09-01), COP has investigated and summarized several aspects of the ozone conditions on the Alaskan North Slope. This includes a review of the recent emission trends of ozone precursors, a review of existing monitoring data, and a review of recent literature that details polar ozone trends and chemistry.

According to the 2008 National Emission Inventory (NEI), estimated emissions of ozone precursors from all sources in North Slope Borough were approximately 37,300 tons per year of NO_x and 1,300 tons per year of VOC. These 2008 emissions represent a decrease of 11% and 28% from the 2002 NEI inventory values for NO_x and VOCs, respectively. The potential emissions from COPs exploration operations are expected to be approximately 225 tons per year of NO_x and 29 tons per year of VOC, while potential emissions from Shell's nearby exploration operations are expected to be approximately 1,181 tons per year of NO_x and 108 tons per year of VOC. In total, these two projects will add 1,406 tons per year of NO_x and 137 tons per year of VOC.

The National Oceanic and Atmospheric Administration's (NOAA) Earth System Research Laboratory (ESRL) Global Monitoring Division (GMD) has been recording tropospheric ozone measurements since 1973 at Barrow. These observations provide a continuous and robust dataset that are useful to assess ozone trends, averages and other useful information for the North Slope area. The Barrow data was extensively analyzed by Helmig et. al. (2007), who calculated a median ozone value of 27.6 parts per billion by volume (ppbv) at Barrow from 1975 - 2005. Other high latitude, similarly-sited stations in the Northern Hemisphere had calculated medians of 33.5 ppbv and 33.7 ppbv according to this study. It was found that the ozone levels at Barrow are generally stable on an hourly, daily and a long-term average basis. On average, only 1.8% (± 3.1 %) of the hourly data exceeds the 1.5 times the annual median ozone value, the criteria in the study to denote extreme high events. Over the long term, no statistically significant trend has been observed in the Barrow data although a slight increase has been observed since 1975 of 0.05 (± 0.08) ppbv per year.

In terms of local ozone production, according to Helmig et. al. "…models show that a considerable amount of ozone can be photochemically formed near the surface during daytime hours over polar snow." However, an analysis of the diurnal ozone pattern at Barrow indicates a very small, ~1 ppbv, amplitude within the daily ozone cycle that indicates very little local ozone formation. It is expected that the complex snow chemistry, clean (low NO_x) maritime air, enhanced ozone deposition and halogen chemistry act as ozone sinks and negate any local production. In addition, monitored ozone data represent the net effects of atmospheric mixing and dynamics as opposed to an artificial surface layer in a photochemical model that cannot account for actual mixing and the known ozone sinks.

Analysis of other recent ozone observations at other locations on the Alaskan North Slope due to oil and gas development are provided below. These ozone measurement programs include:

- Barrow (2003 - 2005),
- BPXA-Badami (1999),
- BPXA-Prudhoe Bay (2006 - 2007),
- CPAI-Alpine (Nov 2004 - Dec 2005),
- CPAI-Kuparuk River (Jun 2001 - June 2002), and
- Wainwright (November 2008 – October 2009).

The measurements from these sites indicate that the maximum 1-hour concentration was 73 ppbv while the maximum 8-hour measurement was 50 ppbv. The hourly concentration represents 61 percent the hourly NAAQS while the 8-hour concentration represents 67 percent of the 8-hour NAAQS. (Shell 11/23/09 Supp. App.). More recent data from Wainwright Permanent and Point Lay sites indicate that during the 2010 drilling season (July - November), the maximum 1-hour concentration was 39 ppbv and the 8-hour concentration was 38 ppbv at the Wainwright Permanent site while the maximum 1-hour concentration was 40 ppbv and the 8-hour concentration was 40 ppbv at Point Lay.

Given the low level of ozone precursor emissions from COP and Shell's exploration operations in comparison to declining regional emissions of ozone precursors; the moderate and stable levels of the observed ozone on the Alaskan North Slope including at the locations of Wainwright Permanent, Point Lay and Barrow; and the lack of observed local ozone production in the area, the impact of the ozone precursor emissions from COP and Shell's exploration operations to the formation of ozone in the region is expected to be small.

Table 5-1 Model Predicted Project Ambient Air Quality Impacts Compared to the SILs at the Alaska Seaward Boundary

Pollutant	Period	Predicted Project Impact [1] ($\mu g/m^3$)	SIL ($\mu g/m^3$)	Percent of SIL
Sulfur Dioxide (SO_2)	1-hour	0.033	7.9	0.4
	3-hour	0.032	25	0.1
	24-hour	0.012	5	0.2
	Annual	0.00008	1	0.01
Nitrogen Dioxide (NO_2) [2]	1-hour	6.2	7.5	83
	Annual	0.023	1	2
Carbon Monoxide (CO)	1-hour	10.3	2,000	0.5
	8-hour	5.7	500	1
PM_{10}	24-hour	0.32	5	6
	Annual	0.003	1	0.3
$PM_{2.5}$ [3]	24-hour	0.32	1.2	26
	Annual	0.003	0.3	0.9
Lead [4]	3-month	0.00002	0.006	0.3
	Quarterly	0.00002	0.06	0.03

1 Modeling only includes the ConocoPhillips OCS Source.

- With the exception of 1-hour SO_2 and NO_2, and 24-hour $PM_{2.5}$ the SIL is compared to the highest predicted concentration for the specific averaging time.
- For 1-hour SO_2 and NO_2, and 24-hour $PM_{2.5}$, the SIL is compared to the highest of the multi-year averages of the maximum modeled 1-hour, or 24-hour concentrations predicted each year at each receptor, based on two or more years of available site specific meteorological data (USEPA 2011, USEPA 2010b).

2 As recommended by USEPA, for 1-hour NO_2, the 80% ambient ratio method was used to convert NO_x to NO_2 (USEPA 2011). For annual NO_2, the 75% ambient ratio method was used to convert NO_x to NO_2. (40 CFR 51 Appendix W Section 5.2.4c).

3 Multi-year average of the maximum model predicted impact from modeling conducted using 3 years of representative meteorological input data. For 24-hour $PM_{2.5}$ this represents a screening level approach and accounts for secondary particulate formation according to the USEPA Office of Air Quality Planning and Standards (USEPA 2010b).

4 No SIL has been established for lead; therefore, the SIL represents 4% of the respective NAAQS. This value was set following the approach taken by USEPA where the SIL associated with the 1 hour NO_2 NAAQS was set at 4% of the NAAQS following historical precedence (USEPA 2010a).

6.0 References

AECOM Environment (AECOM 2011a). Supplemental Information and Response to Comments: Modeling Protocol for an Ambient Air Quality Impact Analysis for Proposed Exploratory Drilling (Devil's Paw Prospect) in the Chukchi Sea. Submitted by AECOM to Herman Wong (USEPA Region 10). November 19, 2011.

AECOM 2011b. Modeling Protocol for an Ambient Air Quality Impact Analysis for Proposed Exploratory Drilling (Devil's Paw Prospect) in the Chukchi Sea. Submitted by AECOM to Herman Wong (USEPA Region 10). October 21, 2011.

Alpine Geophysics (Alpine 2011a). Modeling Protocol: ConocoPhillips Chukchi Sea WRF Modeling Application (Revised). Submitted to USEPA Region 10 November 1, 2011.

Alpine 2011b. Modeling Protocol: ConocoPhillips Chukchi Sea WRF Modeling Application. Submitted to USEPA Region 10 October 14, 2011.

Atkinson, D. and R. F. Lee. (Atkinson 1992). "Procedures for Substituting Values for Missing NWS Meteorological Data for Use in Regulatory Air Quality Models", July 7, 1992; Available at: http://www.epa.gov/scram001/metguidance.htm.

Earth Tech, Inc. 2006. Development of the Next Generation Air Quality Models for Outer Continental Shelf (OCS) Applications, Final Report: Volume 3, CALPUFF Users Guide, (CALPUFF and postprocessors) Concord, Massachusetts. March 2006.

Helmig, D.; S. J. Oltmans; D. Carlson; J. Lamarque; A. Jones; C. Labuschagne; K. Anlauf and K. Hayden (2007), A review of surface ozone in the polar regions, Atmospheric Environment, 41(24), 5138-5161.

NOAA 2009. Originator: Department of Commerce (DOC), National Oceanic and Atmospheric Administration (NOAA), Coastal Services Center. Title: Marine Jurisdictions Geospatial_Data_Presentation_Form: vector digital data. Online_Linkage: http://csc.noaa.gov/mbwg/htm/multipurpose.html. Publication_Date: 08/2009.

Scire, J. S. (Scire 2011). Email from Joseph S. Scire, CCM, Principal Scientist (Exponent) to Jason Reed, CCM, Senior Scientist (AECOM) re: CALMET Polar Stereographic Project Option. November 11, 2011.

Scire 2000. Scire, J. S., F. R. Robe, M. E. Fernau, R. J. Yamartino. A User's Guide for the CALMET Meteorological Model (Version 5). Earth Tech, Inc. Concord, Massachusetts.

United States Environmental Protection Agency (USEPA) 2011. Memorandum: Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 National Ambient Air Quality Standard. From Tyler Fox to Regional Air Division Directors. March 1, 2011.

USEPA 2010a. Memorandum: General Guidance for Implementing the 1-hour NO_2 National Ambient Air Quality Standard in Prevention of Significant Deterioration Permits, Including an Interim 1-hour NO_2 Significant Impact Level. From Anna Marie Wood (USEPA Air Quality Policy Division) to Regional Air Division Directors. June 28, 2010.

USEPA 2010b. Modeling Procedures for Demonstrating Compliance with the $PM_{2.5}$ NAAQS. Memorandum from Stephen D. Page Director of the USEPA Office of Air Quality Planning and Standards. March 23, 2010.

USEPA 2009. AERMOD Implementation Guide. AERMOD Implementation Workgroup. U. S. Environmental Protection Agency Office of Air Quality Planning and Standards Air Quality Assessment Division Research Triangle Park, North Carolina. http://www.epa.gov/ttn/scram/7thconf/aermod/aermod_implmtn_guide_19March2009.pdf. March 19, 2009.

USEPA 2005. Guideline on Air Quality Models (GAQM) (Revised). Codified in the Appendix W to 40 CFR Part 51. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. November 2005.

USEPA 2004. User's Guide for the AMS/EPA Regulatory Model –AERMOD. U.S. Environmental Protection Agency Office of Air Quality Planning and Standards Emissions Monitoring and Analysis Division Research Triangle Park, North Carolina. EPA-454/B-03-001. September 2004.

USEPA 2003. Federal Register Notice Dated April 15, 2003.

USEPA 1992. Screening Procedures for Estimating the Air Quality Impact of Stationary Sources, Revised – EPA-454/R-92-019. United States Environmental Protection Agency Office of Air Radiation – Office of Air Quality Planning and Standards. Research Triangle Park, North Carolina 27711. October 1992.

USEPA 1990. New Source Review Workshop Manual. Draft. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711. October 1990.

Appendix A
Additional Information Requested by USEPA Region 10

Additional Information Requested by USEPA Region 10

1.0 Introduction

This appendix presents the results of the project cumulative impact analysis at the Alaska seaward boundary. This analysis has been conducted at the request of USEPA Region 10.

1.1 Cumulative Impact Analysis Technical Approach

The project cumulative impacts were determined by adding model predicted impacts from the project and nearby offsite sources to an appropriate regional background concentration that represents all non-modeled sources. Modeling was conducted with the CALPUFF dispersion model using the technical approaches presented in the application. The following subsections present additional technical approaches required to conduct the cumulative impact analysis.

1.1.1 Modeled Offsite Inventory

The only nearby offsite source that needed to be modeled explicitly for the cumulative impact analysis was the Shell Gulf of Mexico Inc. (Shell) OCS Source. Shell has submitted a complete PSD permit application and has been issued a final permit for exploration activities to be potentially located near the project area in the Chukchi Sea. Though Shell is unlikely to operate anywhere on the Devil's Paw Prospect, to be conservative, it was assumed that Shell's operation was located in the lease block adjacent to the modeled COP drill rig location (lease block #6323). This was done to maximize the potential for plume overlap with COP while maintaining a relatively close proximity to the point of compliance. This approach also makes the results and conclusions independent of the relative location of the COP and Shell OCS sources.

Emissions from the Shell OCS Source were modeled in a conservative, simplified manner similar to the approach used for COP sources. A single merged point source was developed to represent Shell drillship and nearby static vessel emissions and a single volume source was used to represent all Shell mobile support vessel emissions. A complete description of how the Shell OCS Source simulation was developed including the calculation of modeled emission rates is presented in Appendix E.

1.1.2 Regional Background Concentrations

To demonstrate compliance with the NAAQS, the cumulative modeled impact of the proposed project's sources and offsite sources (the design concentration) are added to a regional background concentration which is designed to represent those sources not explicitly modeled. An analysis of regional background concentrations was conducted and is documented in Appendix D.

To develop the regional background concentrations, measurements recorded at the two ambient monitoring stations located in Wainwright, Alaska (Near-Term and Permanent) and the station located in Point Lay, Alaska were analyzed to determine the background concentrations for CO, NO_2, SO_2, PM_{10}, $PM_{2.5}$ and lead. The maximum short-term and long-term averaging period concentrations measured across all three stations and years of data collected during the drilling season were used to represent all non-modeled sources. Using the overall highest monitored background values represents a "first-tier" approach that may be applied to a NAAQS compliance analysis without further justification.

1.2 Cumulative Impact Analysis at the Alaska Seaward Boundary

As requested by USEPA, a cumulative impacts analysis for all criteria pollutants and averaging periods was also conducted for the project at the Alaska seaward boundary. The results of the full cumulative impact analysis is shown in **Table A-1** and clearly shows that the project will not cause or contribute to a violation of the NAAQS at the Alaska seaward boundary. This result is expected given that project impacts were shown in Chapter 5 to be below the SILs.

2.0 References

United States Environmental Protection Agency (USEPA) 2011. Memorandum: Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 National Ambient Air Quality Standard. From Tyler Fox to Regional Air Division Directors. March 1, 2011.

USEPA 2010a. Modeling Procedures for Demonstrating Compliance with the $PM_{2.5}$ NAAQS. Memorandum from Stephen D. Page Director of the USEPA Office of Air Quality Planning and Standards. March 23, 2010.

Table A-1 Project Cumulative Air Quality Impact Analysis at the Alaska Seaward Boundary

Pollutant	Period	Model Predicted Cumulative Impact [1] ($\mu g/m^3$)	Existing Background ($\mu g/m^3$)	Total ($\mu g/m^3$)	NAAQS ($\mu g/m^3$)	Percent of NAAQS
Sulfur Dioxide (SO_2)	1-hour [2]	0.023	23.6	24	196	12
	3-hour [3]	7.2	18.3	26	1,300	2
	24-hour [3]	2.9	13.1	16	365	4
	Annual [4]	0.00038	4.7	4.7	80	6
Nitrogen Dioxide (NO_2) [8]	1-hour [5]	2.2	65.8	68	188	36
	Annual [4]	0.050	1.9	1.9	100	2
Carbon Monoxide (CO)	1-hour [3]	10	1,030	1,040	40,000	3
	8-hour [3]	5.5	1,030	1,036	10,000	10
PM_{10}	24-hour [4]	0.35	60.7	61	150	41
$PM_{2.5}$	24-hour [7]	0.31	11.0	11	35	32
	Annual [4]	0.0043	1.2	1.2	15	8
Lead	3-Month [6]	0.00002	0.002	0.0020	0.15	1
	Quarterly [4]	0.00002	0.002	0.0020	1.5	0

1 Includes the contribution from both the ConocoPhillips and Shell OCS sources.

2 The design value is the 3-year average of the annual 99th-percentile of 1-hour daily maximum modeled concentrations using 3 years of representative meteorological input data.

3 The design value is the maximum of the highest-second-high modeled concentrations using 3 years of representative meteorological input data.

4 The design value is the maximum modeled concentration for the period using 3 years of representative meteorological input data.

5 The design value is the 3-year average of the annual 98th-percentile of 1-hour daily maximum modeled concentrations using 3 years of representative meteorological input data.

6 The CALPUFF post-processor, CALPOST, cannot calculate a rolling 3-month maximum for comparison to the lead NAAQS; therefore, the model predicted impact is the maximum 30 day average which is a conservative surrogate for the rolling 3-month maximum.

7 The design value is the 3-year average of the maximum 24-hour modeled concentrations using 3 years of representative meteorological input data. This screening level approach to predicting the design value accounts for secondary particulate formation according to the USEPA Office of Air Quality Planning and Standards (USEPA 2010a).

8 As recommended by USEPA, for 1-hour NO_2, the 80% ambient ratio method was used to convert NO_x to NO_2 (USEPA 2011). For annual NO_2, the 75% ambient ratio method was used to convert NO_x to NO_2. (40 CFR 51 Appendix W Section 5.2.4c).

Appendix B
Modeled COP OCS Source Emission Rate Development

Short-term and Annual Modeled Emission Rate Determination

In an effort to simplify the modeling while still retaining a conservative estimate of emissions, all OCS Source and associated support vessel emission units were modeled as part of three sources (two point and one volume source, respectively) based on their stack orientation and service type. The three modeled sources are described below:

- Point Source 1: All vertically oriented emission units on the drill rig and nearby static support vessels.
- Point Source 2: All horizontally oriented emission units on the drill rig and nearby static support vessels.
- Volume Source: All emission units on mobile support vessels.

Nearby static support vessels are those that will remain relatively static near the drill rig for the largest part of the drilling season. Mobile support vessels are those with the ability to transit both in an out of the 25 mile OCS boundary throughout the drilling season. Static support vessels include the Anchor Handling Tug Supply (AHTS) vessel and the Dedicated Oil Spill Response Vessel (OSRV). Mobile support vessels include the two Ice Management Vessels, the Secondary OSRV, the two Offshore Supply Vessels (OSVs), the Ware Vessel, the Marine Research Vessel and the Spill Storage Tanker.

Table B-1 below lists the short-term emission rates by emission unit for all pollutants modeled while **Table B-2** lists the annual emission rates. Using these emission rates, the maximum short-term emissions option was determined from among the following worst-case options identified in the application:

- Options Associated with the First 24-Hours of the OCS Source:
  - Option 1 – Initial Resupply with and Offshore Supply Vessel (OSV)
    - 1a Drill Rig Jackup
    - 1b Primary Resupply with an OSV
    - 1c Backup Resupply with a backup OSV
  - Option 2 – Initial Resupply with a Ware Vessel
    - 2a Drill rig Jackup
    - 2b Primary Resupply with a Ware Vessel
    - 2c Backup Resupply with an OSV
    - 2d Backup Resupply with a AHTS vessel
- Options Associated with a Regular Resupply:
  - Option 1 - Resupply with and Offshore Supply Vessel (OSV)
    - 1a Primary Resupply with an OSV
    - 1b Backup Resupply with a backup OSV
  - Option 2 - Resupply with a Ware Vessel
    - 2a Primary Resupply with a Ware Vessel

- 2b Backup Resupply with an OSV
- 2c Backup Resupply with a AHTS vessel

Similarly, the maximum long-term emissions option was determined from among the following worst-case options identified in the application:

- Option 1 - Resupply with an Offshore Supply Vessel (OSV)
- Option 2 – Resupply with a Ware Vessel

As discussed in the application, recognizing the conservatism in developing model short-term emissions particularly in light of the conservative manner in which those emissions were simulated to maximize the impact of modeled emissions, the approach used to develop short-term emissions was refined for determining NO_x emissions to avoid grossly overstating the model predicted impacts. While the maximum emissions were still selected for each of the three modeled sources from among all the potential short term operating scenarios, the assumptions regarding which emissions units were active on a particular vessel during a given hour were refined to only account for the emissions from those units with a high probability of producing maximum model predicted impacts and those with a high probability of operating simultaneously in a given hour. An examination of the NO_x emission rate associated with each emission unit on each vessel listed in **Table B-1** makes it clear which operating modes and emission units were considered in the total emission rate determination. Those with zero emission rates were not considered.

Table B-3 through **Table B-8** list the emission rates by option and highlight the maximum emissions option used to model each of the three sources.

Table B-1 Short-Term Emissions Inventory for the COP Devil's Paw Prospect Exploratory Drilling Program

Emission Unit	Type	Rating	Service Type	Unit Stack Orientation	NO_x Maximum Hourly Emission Rate		CO Maximum Hourly Emission Rate		SO_2 Maximum Hourly Emission Rate		$PM_{10}/PM_{2.5}$ Maximum Hourly Emission Rate		Pb Maximum Hourly Emission Rate[2]	
					(lbs/hr)	(g/s)	(lbs/hr)	(g/s)	(lbs/hr)	(g/s)	(lbs/hr)	(g/s)	(lbs/hr)	(g/s)
Drill Rig Equipment														
Main Drill Rig Engine 1	Wärtsilä 8L26A2	2,480 kW	Drilling Mode	Horizontal	1.00E+01	1.26E+00	1.87E+01	2.36E+00	3.37E-02	4.25E-03	1.33E+00	1.68E-01	3.53E-04	4.45E-05
Main Drill Rig Engine 2	Wärtsilä 8L26A2	2,480 kW	Drilling Mode	Horizontal	1.00E+01	1.26E+00	1.87E+01	2.36E+00	3.37E-02	4.25E-03	1.33E+00	1.68E-01	3.53E-04	4.45E-05
Main Drill Rig Engine 3	Wärtsilä 8L26A2	2,480 kW	Drilling Mode	Horizontal	1.00E+01	1.26E+00	1.87E+01	2.36E+00	3.37E-02	4.25E-03	1.33E+00	1.68E-01	3.53E-04	4.45E-05
Main Drill Rig Engine 4	Wärtsilä 8L26A2	2,480 kW	Drilling Mode	Horizontal	1.00E+01	1.26E+00	1.87E+01	2.36E+00	3.37E-02	4.25E-03	1.33E+00	1.68E-01	3.53E-04	4.45E-05
Emergency Back-up Engine	Caterpillar Diesel 3508 B	968 kW	Drilling Mode	Horizontal	0.00E+00	0.00E+00	7.28E+00	9.17E-01	1.31E-02	1.65E-03	5.20E-01	6.56E-02	8.63E-06	1.09E-06
Cement Engine 1	Caterpillar 15 DITA	403 kW	Drilling Mode[1]	Horizontal	1.23E+01	1.54E+00	9.76E-01	1.23E-01	5.86E-03	7.39E-04	2.66E-01	3.36E-02	6.74E-06	8.49E-07
Cement Engine 2	Caterpillar 15 DITA	403 kW	Drilling Mode[1]	Horizontal	1.23E+01	1.54E+00	9.76E-01	1.23E-01	5.86E-03	7.39E-04	2.66E-01	3.36E-02	6.74E-06	8.49E-07
Logging Winch	Caterpiller C7 Acert Engine	187 kW	Drilling Mode	Vertical	5.73E+00	7.21E-01	4.53E-01	5.71E-02	2.69E-03	3.38E-04	1.24E-01	1.56E-02	6.43E-06	8.10E-07
Heater 1	TBD	3.5 MMBtu/hr*	Drilling Mode	Vertical	5.30E-01	6.68E-02	1.32E-01	1.67E-02	5.36E-03	6.75E-04	2.86E-02	3.61E-03	3.15E-05	3.97E-06
Heater 2	TBD	3.5 MMBtu/hr*	Drilling Mode	Vetical	5.30E-01	6.68E-02	1.32E-01	1.67E-02	5.36E-03	6.75E-04	2.86E-02	3.61E-03	3.15E-05	3.97E-06
Incinerator	TBD	N/A	Drilling Mode[1]	Vertical	2.76E-01	3.48E-02	2.72E-01	3.43E-02	3.45E-01	4.35E-02	1.91E-01	2.40E-02	2.94E-02	3.70E-03
Ice Breaker 1														
Main Engine 1	Wärtsilä Vasa 16V32/6000kW	7,500 kW	Cruising	Vertical	3.83E+01	4.83E+00	4.43E+01	5.58E+00	8.62E-02	1.09E-02	3.23E+00	4.07E-01	5.10E-04	6.43E-05
Main Engine 2	Wärtsilä Vasa 16V32/6000kW	7,500 kW	Cruising	Vertical	3.83E+01	4.83E+00	4.43E+01	5.58E+00	8.62E-02	1.09E-02	3.23E+00	4.07E-01	5.10E-04	6.43E-05
Main Engine 3	Wärtsilä Vasa 12V32/4500kW	7,500 kW	Cruising	Vertical	2.88E+01	3.62E+00	3.32E+01	4.18E+00	6.47E-02	8.15E-03	2.42E+00	3.05E-01	3.83E-04	4.82E-05
Main Engine 4	Wärtsilä Vasa 12V32/4500kW	7,500 kW	Cruising	Vertical	2.88E+01	3.62E+00	3.32E+01	4.18E+00	6.47E-02	8.15E-03	2.42E+00	3.05E-01	3.83E-04	4.82E-05
Harbor Generator	Wärtsilä Vasa 4R22 - 710 kW	952 hp	Cruising	Horizontal	0.00E+00	0.00E+00	1.72E+00	2.17E-01	1.02E-02	1.29E-03	4.69E-01	5.91E-02	7.16E-07	9.02E-08
Emergency Generator	Caterpillar 3412 - 300 kW	402 hp	Cruising	Horizontal	0.00E+00	0.00E+00	7.27E-01	9.16E-02	4.31E-03	5.43E-04	1.98E-01	2.50E-02	3.02E-07	3.81E-08
Boiler 1	Aquamaster Rauma Unex BH-2000	3.70 MMBtu/hr*	Cruising	Vertical	5.60E-01	7.06E-02	1.40E-01	1.76E-02	5.66E-03	7.13E-04	3.02E-02	3.81E-03	1.04E-05	1.31E-06
Boiler 2	Aquamaster Rauma Unex BH-2000	3.70 MMBtu/hr*	Cruising	Vertical	5.60E-01	7.06E-02	1.40E-01	1.76E-02	5.66E-03	7.13E-04	3.02E-02	3.81E-03	1.04E-05	1.31E-06
Incinerator	Aquamaster Rauma Unex BH-2000	N/A	Cruising	Vertical	2.63E-01	3.31E-02	8.75E-01	1.10E-01	2.19E-01	2.76E-02	6.13E-01	7.72E-02	5.82E-03	7.34E-04
Ice Breaker 2														
Main Engine 1	Wärtsilä Vasa 16V32/6000kW	7,500 kW	Cruising	Vertical	3.83E+01	4.83E+00	4.43E+01	5.58E+00	8.62E-02	1.09E-02	3.23E+00	4.07E-01	5.10E-04	6.43E-05
Main Engine 2	Wärtsilä Vasa 16V32/6000kW	7,500 kW	Cruising	Vertical	3.83E+01	4.83E+00	4.43E+01	5.58E+00	8.62E-02	1.09E-02	3.23E+00	4.07E-01	5.10E-04	6.43E-05
Main Engine 3	Wärtsilä Vasa 12V32/4500kW	7,500 kW	Cruising	Vertical	2.88E+01	3.62E+00	3.32E+01	4.18E+00	6.47E-02	8.15E-03	2.42E+00	3.05E-01	3.83E-04	4.82E-05
Main Engine 4	Wärtsilä Vasa 12V32/4500kW	7,500 kW	Cruising	Vertical	2.88E+01	3.62E+00	3.32E+01	4.18E+00	6.47E-02	8.15E-03	2.42E+00	3.05E-01	3.83E-04	4.82E-05
Harbor Generator	Wärtsilä Vasa 4R22 - 710 kW	952 hp	Cruising	Horizontal	0.00E+00	0.00E+00	1.72E+00	2.17E-01	1.02E-02	1.29E-03	4.69E-01	5.91E-02	7.16E-07	9.02E-08
Emergency Generator	Caterpillar 3412 - 300 kW	402 hp	Cruising	Horizontal	0.00E+00	0.00E+00	7.27E-01	9.16E-02	4.31E-03	5.43E-04	1.98E-01	2.50E-02	3.02E-07	3.81E-08
Boiler 1	Aquamaster Rauma Unex BH-2000	3.70 MMBtu/hr*	Cruising	Vertical	5.60E-01	7.06E-02	1.40E-01	1.76E-02	5.66E-03	7.13E-04	3.02E-02	3.81E-03	1.04E-05	1.31E-06
Boiler 2	Aquamaster Rauma Unex BH-2000	3.70 MMBtu/hr*	Cruising	Vertical	5.60E-01	7.06E-02	1.40E-01	1.76E-02	5.66E-03	7.13E-04	3.02E-02	3.81E-03	1.04E-05	1.31E-06
Incinerator	Aquamaster Rauma Unex BH-2000	N/A	Cruising	Vertical	2.63E-01	3.31E-02	8.75E-01	1.10E-01	2.19E-01	2.76E-02	6.13E-01	7.72E-02	5.82E-03	7.34E-04
Anchor Handling Tug Supply Vessel (AHTS)														
Main Engine 1	Caterpillar 3608	2,710 kW	Cruising/Mooring Assist	Vertical	0.00E+00	0.00E+00	1.03E+01	1.30E+00	2.01E-02	2.53E-03	7.53E-01	9.48E-02	1.13E-06	1.43E-07
Main Engine 2	Caterpillar 3608	2,710 kW	Cruising/Mooring Assist	Vertical	0.00E+00	0.00E+00	1.03E+01	1.30E+00	2.01E-02	2.53E-03	7.53E-01	9.48E-02	1.13E-06	1.43E-07
Tow Winch Engine	Caterpillar 3508	750 kW	Mooring Assist	Vertical	0.00E+00	0.00E+00	1.82E+00	2.29E-01	1.08E-02	1.36E-03	4.96E-01	6.24E-02	8.50E-07	1.07E-07
Thruster Engine 1	Caterpillar 3508	750 kW	Mooring Assist	Vertical	0.00E+00	0.00E+00	2.76E+00	3.48E-01	5.39E-03	6.79E-04	2.02E-01	2.54E-02	4.25E-07	5.36E-08
Thruster Engine 2	Caterpillar C-32	750 kW	Mooring Assist	Vertical	0.00E+00	0.00E+00	2.76E+00	3.48E-01	5.39E-03	6.79E-04	2.02E-01	2.54E-02	4.25E-07	5.36E-08
Generator 1	Caterpillar 3412	500 kW	Anchored/Cruising/Mooring Assist	Vertical	7.65E+00	9.64E-01	6.06E-01	7.63E-02	3.59E-03	4.52E-04	1.65E-01	2.08E-02	3.77E-05	4.75E-06
Generator 2	Caterpillar 3412	500 kW	DP	Vertical	0.00E+00	0.00E+00	3.63E-01	4.58E-02	2.15E-03	2.71E-04	9.91E-02	1.25E-02	2.26E-05	2.85E-06
Emergency Generator	Caterpillar 3306	206 kW	Non-propulsion	Vertical	0.00E+00	0.00E+00	4.99E-01	6.29E-02	2.96E-03	3.73E-04	1.36E-01	1.71E-02	2.08E-07	2.61E-08

Note:

- A NO_x emission rate of 0 indicates the emission unit was not included in the total emission rate determination for a particular vessel and operating scenario.
- All B-1 footnotes are shown at the end of the Table.

Table B-1 Short-Term Emissions Inventory for the COP Devil's Paw Prospect Exploratory Drilling Program (CONTINUED)

Emission Unit	Type	Rating	Service Type	Unit Stack Orientation	NO_x Maximum Hourly Emission Rate		CO Maximum Hourly Emission Rate		SO_2 Maximum Hourly Emission Rate		$PM_{10}/PM_{2.5}$ Maximum Hourly Emission Rate		Pb Maximum Hourly Emission Rate[2]	
					(lbs/hr)	(g/s)	(lbs/hr)	(g/s)	(lbs/hr)	(g/s)	(lbs/hr)	(g/s)	(lbs/hr)	(g/s)
Anchor Handling Tug Supply Vessel (AHTS) - Supply Duty														
Main Engine 1	Caterpillar 3608	2,710 kW	Cruising/Mooring Assist	Vertical	0.00E+00	0.00E+00	1.54E+01	1.94E+00	2.01E-02	2.53E-03	7.53E-01	9.48E-02	6.67E-05	8.40E-06
Main Engine 2	Caterpillar 3608	2,710 kW	Cruising/Mooring Assist	Vertical	0.00E+00	0.00E+00	1.54E+01	1.94E+00	2.01E-02	2.53E-03	7.53E-01	9.48E-02	6.67E-05	8.40E-06
Tow Winch Engine	Caterpillar 3508	750 kW	Mooring Assist	Vertical	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thruster Engine 1	Caterpillar 3508	750 kW	Mooring Assist	Vertical	5.95E+00	7.49E-01	4.13E+00	5.20E-01	5.39E-03	6.79E-04	2.02E-01	2.54E-02	3.57E-05	4.50E-06
Thruster Engine 2	Caterpillar C-32	750 kW	Mooring Assist	Vertical	5.95E+00	7.49E-01	4.13E+00	5.20E-01	5.39E-03	6.79E-04	2.02E-01	2.54E-02	3.57E-05	4.50E-06
Generator 1	Caterpillar 3412	500 kW	Anchored/Cruising/Mooring Assist	Vertical	0.00E+00	0.00E+00	2.75E+00	3.47E-01	3.59E-03	4.52E-04	1.65E-01	2.08E-02	2.00E-05	2.51E-06
Generator 2	Caterpillar 3412	500 kW	DP	Vertical	5.55E+00	6.99E-01	1.65E+00	2.08E-01	2.15E-03	2.71E-04	9.91E-02	1.25E-02	1.20E-05	1.51E-06
Emergency Generator	Caterpillar 3306	206 kW	Non-propulsion	Vertical	0.00E+00	0.00E+00	3.04E+00	3.83E-01	3.96E-03	4.99E-04	1.82E-01	2.30E-02	2.08E-07	2.61E-08
Oil Spill Response Vessel 1 (Dedicated OSRV)														
Main Engine 1	Caterpillar 3516C	3,070 bhp	Cruising	Vertical	3.28E+01	4.13E+00	8.09E+00	1.02E+00	1.57E-02	1.97E-03	5.87E-01	7.39E-02	1.19E-04	1.50E-05
Main Engine 2	Caterpillar 3516C	3,070 bhp	Cruising	Vertical	3.28E+01	4.13E+00	8.09E+00	1.02E+00	1.57E-02	1.97E-03	5.87E-01	7.39E-02	1.19E-04	1.50E-05
Thruster Engine 1	Brunvoll CPP Drop Down Azimuth	1,100 hp	Laying Boom	Vertical	0.00E+00	0.00E+00	6.05E+00	7.62E-01	2.35E-03	2.96E-04	8.78E-02	1.11E-02	7.41E-07	9.33E-08
Thruster Engine 2	Brunvoll CPP Tunnel	1,100 hp	Laying Boom	Horizontal	0.00E+00	0.00E+00	6.05E+00	7.62E-01	2.14E-03	2.70E-04	8.02E-02	1.01E-02	6.77E-07	8.53E-08
Thruster Engine 3	Brunvoll CPP Tunnel (Stern)	1,100 hp	Laying Boom	Horizontal	0.00E+00	0.00E+00	6.05E+00	7.62E-01	1.44E-03	1.81E-04	5.37E-02	6.77E-03	4.53E-07	5.71E-08
Generator 1	Caterpillar C-32	710 kW	Cruising/DP/Laying Boom[1]	Vertical	4.97E+00	6.27E-01	1.72E+00	2.17E-01	2.33E-03	2.94E-04	4.69E-01	5.91E-02	2.38E-05	3.00E-06
Generator 2	Caterpillar C-32	710 kW	Cruising/DP/Laying Boom	Vertical	0.00E+00	0.00E+00	1.72E+00	2.17E-01	2.33E-03	2.94E-04	4.69E-01	5.91E-02	2.38E-05	3.00E-06
Emergency Generator	Caterpillar C9D	279 hp	Cruising/DP	Horizontal	0.00E+00	0.00E+00	5.04E-01	6.35E-02	2.99E-03	3.77E-04	1.38E-01	1.73E-02	2.10E-07	2.64E-08
Oil Spill Response Vessel 2														
Main Engine 1	Caterpillar 3516C	3,070 bhp	Cruising	Vertical	3.28E+01	4.13E+00	8.09E+00	1.02E+00	1.57E-02	1.97E-03	5.87E-01	7.39E-02	8.25E-06	1.04E-06
Main Engine 2	Caterpillar 3516C	3,070 bhp	Cruising	Vertical	3.28E+01	4.13E+00	8.09E+00	1.02E+00	1.57E-02	1.97E-03	5.87E-01	7.39E-02	8.25E-06	1.04E-06
Thruster Engine 1	Brunvoll CPP Drop Down Azimuth	1,100 hp	Laying Boom	Vertical	0.00E+00	0.00E+00	6.05E+00	7.62E-01	2.35E-03	2.96E-04	8.78E-02	1.11E-02	7.41E-07	9.33E-08
Thruster Engine 2	Brunvoll CPP Tunnel	1,100 hp	Laying Boom	Horizontal	0.00E+00	0.00E+00	6.05E+00	7.62E-01	2.14E-03	2.70E-04	8.02E-02	1.01E-02	6.77E-07	8.53E-08
Thruster Engine 3	Brunvoll CPP Tunnel (Stern)	1,100 hp	Laying Boom	Horizontal	0.00E+00	0.00E+00	6.05E+00	7.62E-01	1.44E-03	1.81E-04	5.37E-02	6.77E-03	4.53E-07	5.71E-08
Generator 1	Caterpillar C-32	710 kW	Cruising/DP/Laying Boom[1]	Vertical	4.97E+00	6.27E-01	1.72E+00	2.17E-01	2.33E-03	2.94E-04	4.69E-01	5.91E-02	6.14E-07	7.74E-08
Generator 2	Caterpillar C-32	710 kW	Cruising/DP/Laying Boom	Vertical	0.00E+00	0.00E+00	1.72E+00	2.17E-01	2.33E-03	2.94E-04	4.69E-01	5.91E-02	6.14E-07	7.74E-08
Emergency Generator	Caterpillar C9D	279 hp	Cruising/DP	Horizontal	0.00E+00	0.00E+00	5.04E-01	6.35E-02	2.99E-03	3.77E-04	1.38E-01	1.73E-02	2.10E-07	2.64E-08
Offshore Supply Vessels (OSV1 & OSV2)														
Main Engine 1	Caterpillar 3516C	3,151 hp	Cruising/Idling	Vertical	0.00E+00	0.00E+00	1.16E+01	1.46E+00	1.51E-02	1.90E-03	5.64E-01	7.10E-02	4.99E-05	6.29E-06
Main Engine 2	Caterpillar 3516C	3,151 hp	Cruising/Idling	Vertical	0.00E+00	0.00E+00	1.16E+01	1.46E+00	1.51E-02	1.90E-03	5.64E-01	7.10E-02	4.99E-05	6.29E-06
Thruster Engine 1	Caterpillar C-32	950 hp	DP	Vertical	1.12E+01	1.42E+00	7.80E+00	9.83E-01	9.10E-03	1.15E-03	3.41E-01	4.29E-02	6.03E-05	7.60E-06
Thruster Engine 2	Caterpillar C-32	950 hp	DP	Horizontal	1.12E+01	1.42E+00	7.80E+00	9.83E-01	9.10E-03	1.15E-03	3.41E-01	4.29E-02	6.03E-05	7.60E-06
Thruster Engine 3	Caterpillar C-32	950 hp	DP	Horizontal	1.12E+01	1.42E+00	7.80E+00	9.83E-01	9.10E-03	1.15E-03	3.41E-01	4.29E-02	6.03E-05	7.60E-06
Generator	Caterpillar C-18	400 kW	Cruising/DP	Vertical	6.34E+00	7.99E-01	4.41E+00	5.55E-01	5.46E-03	6.88E-04	2.64E-01	3.33E-02	3.03E-05	3.82E-06
Generator	Caterpillar C-18	400 kW	Cruising/DP	Vertical	6.34E+00	7.99E-01	4.41E+00	5.55E-01	5.46E-03	6.88E-04	2.64E-01	3.33E-02	3.03E-05	3.82E-06
Generator	Caterpillar C-18	400 kW	Cruising/DP	Vertical	0.00E+00	0.00E+00	4.41E+00	5.55E-01	5.46E-03	6.88E-04	2.64E-01	3.33E-02	3.04E-05	3.83E-06
Emergency Generator	Caterpillar 3306	99 kW	Cruising/DP	Horizontal	0.00E+00	0.00E+00	1.09E+00	1.37E-01	1.62E-03	2.04E-04	6.54E-02	8.24E-03	1.14E-07	1.43E-08

Note:

- A NO_x emission rate of 0 indicates the emission unit was not included in the total emission rate determination for a particular vessel and operating scenario.
- All B-1 footnotes are shown at the end of the Table.

Table B-1 Short-Term Emissions Inventory for the COP Devil's Paw Prospect Exploratory Drilling Program (CONTINUED)

Emission Unit	Type	Rating	Service Type	Unit Stack Orientation	NO_x Maximum Hourly Emission Rate		CO Maximum Hourly Emission Rate		SO_2 Maximum Hourly Emission Rate		$PM_{10}/PM_{2.5}$ Maximum Hourly Emission Rate		Pb Maximum Hourly Emission Rate[2]	
					(lbs/hr)	(g/s)	(lbs/hr)	(g/s)	(lbs/hr)	(g/s)	(lbs/hr)	(g/s)	(lbs/hr)	(g/s)
Ware Vessel (WV) w/ OSV/AHSV backup														
Main Engine 1	Caterpillar 3516C	2,387 kW	Cruising	Vertical	0.00E+00	0.00E+00	1.35E+01	1.70E+00	1.76E-02	2.22E-03	6.59E-01	8.30E-02	5.55E-05	7.00E-06
Main Engine 2	Caterpillar 3516C	2,387 kW	Cruising	Vertical	0.00E+00	0.00E+00	1.35E+01	1.70E+00	1.76E-02	2.22E-03	6.59E-01	8.30E-02	5.55E-05	7.00E-06
Main Engine 3	Caterpillar 3516C	2,387 kW	DP/Idling	Vertical	1.81E+01	2.28E+00	1.26E+01	1.58E+00	1.64E-02	2.06E-03	6.13E-01	7.72E-02	1.18E-04	1.48E-05
Main Engine 4	Caterpillar 3516C	2,387 kW	DP/Idling	Vertical	1.81E+01	2.28E+00	1.26E+01	1.58E+00	1.64E-02	2.06E-03	6.13E-01	7.72E-02	1.18E-04	1.48E-05
Generator 1	Caterpillar C-18	504 kW	Cruising/DP/Idling[1]	Vertical	7.14E+00	9.00E-01	5.55E+00	6.99E-01	6.47E-03	8.15E-04	3.33E-01	4.19E-02	3.35E-05	4.22E-06
Generator 2	Caterpillar C-18	504 kW	Cruising/DP/Idling[1]	Vertical	7.14E+00	9.00E-01	5.55E+00	6.99E-01	6.47E-03	8.15E-04	3.33E-01	4.19E-02	3.35E-05	4.22E-06
Generator 3	Caterpillar C-18	504 kW	Cruising/DP/Idling	Vertical	0.00E+00	0.00E+00	5.55E+00	6.99E-01	6.47E-03	8.15E-04	3.33E-01	4.19E-02	3.35E-05	4.22E-06
Emergency Generator	Caterpiller 3306	170 kW	Cruising/DP/Idling	Vertical	0.00E+00	0.00E+00	4.12E-01	5.19E-02	2.59E-03	3.26E-04	1.12E-01	1.42E-02	1.82E-07	2.29E-08
34' Boom Work Boats - 4														
WB-1 Propulsion Engine 1	Cummins QSB5.9-305CD	300 hp	Cruising	Horizontal	3.07E+00	3.87E-01	1.03E-01	1.29E-02	3.05E-03	3.85E-04	1.48E-01	1.86E-02	1.29E-06	1.62E-07
WB-1 Propulsion Engine 2	Cummins QSB5.9-305CD	300 hp	Cruising	Horizontal	3.07E+00	3.87E-01	1.03E-01	1.29E-02	3.05E-03	3.85E-04	1.48E-01	1.86E-02	1.29E-06	1.62E-07
WB-2 Propulsion Engine 1	Cummins QSB5.9-305CD	300 hp	Cruising	Horizontal	3.07E+00	3.87E-01	1.03E-01	1.29E-02	3.05E-03	3.85E-04	1.48E-01	1.86E-02	1.29E-06	1.62E-07
WB-2 Propulsion Engine 2	Cummins QSB5.9-305CD	300 hp	Cruising	Horizontal	3.07E+00	3.87E-01	1.03E-01	1.29E-02	3.05E-03	3.85E-04	1.48E-01	1.86E-02	1.29E-06	1.62E-07
WB-3 Propulsion Engine 1	Cummins QSB5.9-305CD	300 hp	Cruising	Horizontal	3.07E+00	3.87E-01	1.03E-01	1.29E-02	3.05E-03	3.85E-04	1.48E-01	1.86E-02	1.29E-06	1.62E-07
WB-3 Propulsion Engine 2	Cummins QSB5.9-305CD	300 hp	Cruising	Horizontal	3.07E+00	3.87E-01	1.03E-01	1.29E-02	3.05E-03	3.85E-04	1.48E-01	1.86E-02	1.29E-06	1.62E-07
WB-4 Propulsion Engine 1	Cummins QSB5.9-305CD	300 hp	Cruising	Horizontal	3.07E+00	3.87E-01	1.03E-01	1.29E-02	3.05E-03	3.85E-04	1.48E-01	1.86E-02	1.29E-06	1.62E-07
WB-4 Propulsion Engine 2	Cummins QSB5.9-305CD	300 hp	Cruising	Horizontal	3.07E+00	3.87E-01	1.03E-01	1.29E-02	3.05E-03	3.85E-04	1.48E-01	1.86E-02	1.29E-06	1.62E-07
Marine Research Vessel														
Main Engine	Caterpillar	850 hp	Cruising	Vertical	2.04E+01	2.57E+00	4.68E+00	5.89E-01	9.11E-03	1.15E-03	3.41E-01	4.30E-02	4.79E-05	6.04E-06
Generator 1	Caterpillar	135 kW	Cruising	Vertical	4.13E+00	5.21E-01	3.27E-01	4.12E-02	1.94E-03	2.44E-04	8.92E-02	1.12E-02	1.02E-05	1.29E-06
Generator 2	Caterpillar	90 kW	Cruising	Vertical	2.76E+00	3.47E-01	2.18E-01	2.75E-02	1.29E-03	1.63E-04	5.95E-02	7.49E-03	6.80E-06	8.57E-07
Generator 3	Caterpillar	40 kW	Cruising	Vertical	1.22E+00	1.54E-01	9.69E-02	1.22E-02	5.75E-04	7.24E-05	2.64E-02	3.33E-03	3.02E-06	3.81E-07
Spill Storage Tanker														
Main Engine 1	Aframax class sized	19,460 bhp	Cruising	Vertical	0.00E+00	0.00E+00	1.07E+02	1.35E+01	2.09E-01	2.63E-02	7.81E+00	9.83E-01	8.63E-06	1.09E-06
Generator 1	Aframax class sized	600 kW	Anchored/Cruising	Vertical	1.84E+01	2.31E+00	4.42E+00	5.57E-01	8.62E-03	1.09E-03	3.96E-01	5.00E-02	2.19E-06	2.76E-07
Generator 2	Aframax class sized	600 kW	Cruising	Vertical	0.00E+00	0.00E+00	4.42E+00	5.57E-01	8.62E-03	1.09E-03	3.96E-01	5.00E-02	2.19E-06	2.76E-07
Generator 3	Aframax class sized	600 kW	Anchored	Vertical	0.00E+00	0.00E+00	4.42E+00	5.57E-01	8.62E-03	1.09E-03	3.96E-01	5.00E-02	2.19E-06	2.76E-07
Emergency Generator	Aframax class sized	350 kW	Anchored	Vertical	0.00E+00	0.00E+00	8.48E-01	1.07E-01	5.03E-03	6.33E-04	2.31E-01	2.91E-02	3.53E-07	4.44E-08
Boiler 1	Mac-55B	212 MMBtu/hr	Anchored/Cruising	Vertical	3.20E+01	4.04E+00	8.01E+00	1.01E+00	3.24E-01	4.08E-02	1.73E+00	2.18E-01	4.65E-05	5.86E-06
Boiler 2	Mac-55B	212 MMBtu/hr	Anchored	Vertical	0.00E+00	0.00E+00	8.02E+00	1.01E+00	3.24E-01	4.08E-02	1.73E+00	2.18E-01	4.65E-05	5.86E-06

Note:

- A NO_x emission rate of 0 indicates the emission unit was not included in the total emission rate determination for a particular vessel and operating scenario.
- All B-1 footnotes are shown at the end of the Table.

Table B-1 Short-Term Emissions Inventory for the COP Devil's Paw Prospect Exploratory Drilling Program (CONTINUED)

Table B-1 Footnotes

1 For certain units, NO_x emission rates differ from those presented in Volume I of the application because they are based on fuel consumption (gallons/hour) of the unit as shown below:

$$E_{NO_x}(\frac{lb}{hr}) = 3.2\ \frac{lb}{MMBtu}\ x\ 29\ \frac{gal}{hr}\ x\ 132{,}096\ \frac{Btu}{gal}\ x\ \frac{MMBtu}{10^6\ Btu} = 12.26\ \frac{lb}{hr}$$

$$E_{NO_x}(\frac{lb}{hr}) = 13.9\ \frac{g}{kW \cdot hr}\ x\ 32\ \frac{gal}{hr}\ x\ 132{,}096\ \frac{Btu}{gal}\ x\ \frac{1kW}{1.3405\,hp}\ x\ \frac{hp \cdot hr}{7{,}000\,Btu}\ x\ \frac{1lb}{454\,g} = 7.14\ \frac{lb}{hr}$$

Individual Unit Fuel Consumption:

Emission Unit	Emission Factor	Fuel Consumption (gal/hr)	NO_x Emission Rate (lbs/hr)
Drill Rig Cement Engine	3.2 lb/MMBtu	29	12.26
Drill Rig Incinerator	3 lbs/ton	276 lbs/hr (no more than 0.7 tons/day)	0.28
Oil Spill Response Vessel Generator 1	13.9 g/kW-hr	11.54	4.97
Ware Vessel Generator 1	13.9 g/kW-hr	32	7.14
Ware Vessel Generator 2	13.9 g/kW-hr	32	7.14

2 Maximum pound per hour Pb hourly emission rates represent annualized emission rates based on total operating time during three month period.

Table B-2 Long-Term Emissions Inventory for the COP Devil's Paw Prospect Exploratory Drilling Program

Emission Unit	Type	Rating	Unit Stack Orientation	NO_x Annual Emission Rate		CO Annual Emission Rate		SO_2 Annual Emission Rate		$PM_{10}/PM_{2.5}$ Annual Emission Rate		Pb Annual Emission Rate	
				(tpy)	(g/s)	(tpy)	(g/s)	(tpy)	(g/s)	(tpy)	(g/s)	(tpy)	(g/s)
Drill Rig Equipment													
Main Drill Rig Engine 1	Wärtsilä 8L26A2	2,480 kW	Horizontal	6.06E+00	5.17E-01	1.14E+01	9.70E-01	2.05E-02	1.75E-03	7.66E-01	6.54E-02	3.88E-04	3.31E-05
Main Drill Rig Engine 2	Wärtsilä 8L26A2	2,480 kW	Horizontal	6.06E+00	5.17E-01	1.14E+01	9.70E-01	2.05E-02	1.75E-03	7.66E-01	6.54E-02	7.65E-04	6.53E-05
Main Drill Rig Engine 3	Wärtsilä 8L26A2	2,480 kW	Horizontal	5.98E+00	5.11E-01	1.12E+01	9.58E-01	2.02E-02	1.72E-03	7.56E-01	6.46E-02	3.83E-04	3.27E-05
Main Drill Rig Engine 4	Wärtsilä 8L26A2	2,480 kW	Horizontal	5.97E+00	5.10E-01	1.12E+01	9.55E-01	2.01E-02	1.72E-03	7.54E-01	6.44E-02	3.82E-04	3.26E-05
Emergency Back-up Engine	Caterpillar Diesel 3508 B	968 kW	Horizontal	1.03E+00	8.78E-02	2.73E-01	2.33E-02	4.92E-04	4.20E-05	1.84E-02	1.57E-03	9.32E-06	7.95E-07
Cement Engine 1	Caterpillar 15 DITA	403 kW	Horizontal	8.08E-01	6.90E-02	6.39E-02	5.46E-03	3.84E-04	3.28E-05	1.75E-02	1.49E-03	7.28E-06	6.21E-07
Cement Engine 2	Caterpillar 15 DITA	403 kW	Horizontal	8.08E-01	6.90E-02	6.39E-02	5.46E-03	3.84E-04	3.28E-05	1.75E-02	1.49E-03	7.28E-06	6.21E-07
Logging Winch	Caterpiller C7 Acert Engine	187 kW	Vertical	7.82E-01	6.67E-02	6.18E-02	5.28E-03	3.67E-04	3.13E-05	1.69E-02	1.44E-03	6.95E-06	5.93E-07
Heater 1	TBD	3.5 MMBtu/hr*	Vertical	6.36E-01	5.43E-02	1.59E-01	1.36E-02	6.43E-03	5.49E-04	3.43E-02	2.93E-03	3.78E-05	3.23E-06
Heater 2	TBD	3.5 MMBtu/hr*	Vetical	6.36E-01	5.43E-02	1.59E-01	1.36E-02	6.43E-03	5.49E-04	3.43E-02	2.93E-03	3.78E-05	3.23E-06
Incinerator	TBD	N/A	Vertical	9.80E-02	8.37E-03	3.27E-01	2.79E-02	8.17E-02	6.97E-03	2.29E-01	1.95E-02	6.96E-03	5.94E-04
Ice Breaker 1													
Main Engine 1	Wärtsilä Vasa 16V32/6000kW	7,500 kW	Vertical	1.29E+01	1.10E+00	1.49E+01	1.27E+00	2.91E-02	2.48E-03	1.09E+00	9.30E-02	5.51E-04	4.71E-05
Main Engine 2	Wärtsilä Vasa 16V32/6000kW	7,500 kW	Vertical	1.29E+01	1.10E+00	1.49E+01	1.27E+00	2.91E-02	2.48E-03	1.09E+00	9.30E-02	5.51E-04	4.71E-05
Main Engine 3	Wärtsilä Vasa 12V32/4500kW	7,500 kW	Vertical	9.70E+00	8.28E-01	1.12E+01	9.56E-01	2.18E-02	1.86E-03	8.17E-01	6.97E-02	4.13E-04	3.53E-05
Main Engine 4	Wärtsilä Vasa 12V32/4500kW	7,500 kW	Vertical	9.70E+00	8.28E-01	1.12E+01	9.56E-01	2.18E-02	1.86E-03	8.17E-01	6.97E-02	4.13E-04	3.53E-05
Harbor Generator	Wärtsilä Vasa 4R22 - 710 kW	952 hp	Horizontal	8.70E-02	7.43E-03	6.88E-03	5.88E-04	4.08E-05	3.48E-06	1.88E-03	1.60E-04	7.73E-07	6.60E-08
Emergency Generator	Caterpillar 3412 - 300 kW	402 hp	Horizontal	3.68E-02	3.14E-03	2.91E-03	2.48E-04	1.72E-05	1.47E-06	7.93E-04	6.77E-05	3.27E-07	2.79E-08
Boiler 1	Aquamaster Rauma Unex BH-2000	3.70 MMBtu/hr*	Vertical	1.89E-01	1.61E-02	4.73E-02	4.03E-03	1.91E-03	1.63E-04	1.02E-02	8.71E-04	1.12E-05	9.59E-07
Boiler 2	Aquamaster Rauma Unex BH-2000	3.70 MMBtu/hr*	Vertical	1.89E-01	1.61E-02	4.73E-02	4.03E-03	1.91E-03	1.63E-04	1.02E-02	8.71E-04	1.12E-05	9.59E-07
Incinerator	Aquamaster Rauma Unex BH-2000	N/A	Vertical	8.86E-02	7.56E-03	2.95E-01	2.52E-02	7.38E-02	6.30E-03	2.07E-01	1.76E-02	6.29E-03	5.37E-04
Ice Breaker 2													
Main Engine 1	Wärtsilä Vasa 16V32/6000kW	7,500 kW	Vertical	1.29E+01	1.10E+00	1.49E+01	1.27E+00	2.91E-02	2.48E-03	1.09E+00	9.30E-02	5.51E-04	4.71E-05
Main Engine 2	Wärtsilä Vasa 16V32/6000kW	7,500 kW	Vertical	1.29E+01	1.10E+00	1.49E+01	1.27E+00	2.91E-02	2.48E-03	1.09E+00	9.30E-02	5.51E-04	4.71E-05
Main Engine 3	Wärtsilä Vasa 12V32/4500kW	7,500 kW	Vertical	9.70E+00	8.28E-01	1.12E+01	9.56E-01	2.18E-02	1.86E-03	8.17E-01	6.97E-02	4.13E-04	3.53E-05
Main Engine 4	Wärtsilä Vasa 12V32/4500kW	7,500 kW	Vertical	9.70E+00	8.28E-01	1.12E+01	9.56E-01	2.18E-02	1.86E-03	8.17E-01	6.97E-02	4.13E-04	3.53E-05
Harbor Generator	Wärtsilä Vasa 4R22 - 710 kW	952 hp	Horizontal	8.70E-02	7.43E-03	6.88E-03	5.88E-04	4.08E-05	3.48E-06	1.88E-03	1.60E-04	7.73E-07	6.60E-08
Emergency Generator	Caterpillar 3412 - 300 kW	402 hp	Horizontal	3.68E-02	3.14E-03	2.91E-03	2.48E-04	1.72E-05	1.47E-06	7.93E-04	6.77E-05	3.27E-07	2.79E-08
Boiler 1	Aquamaster Rauma Unex BH-2000	3.70 MMBtu/hr*	Vertical	1.89E-01	1.61E-02	4.73E-02	4.03E-03	1.91E-03	1.63E-04	1.02E-02	8.71E-04	1.12E-05	9.59E-07
Boiler 2	Aquamaster Rauma Unex BH-2000	3.70 MMBtu/hr*	Vertical	1.89E-01	1.61E-02	4.73E-02	4.03E-03	1.91E-03	1.63E-04	1.02E-02	8.71E-04	1.12E-05	9.59E-07
Incinerator	Aquamaster Rauma Unex BH-2000	N/A	Vertical	8.86E-02	7.56E-03	2.95E-01	2.52E-02	7.38E-02	6.30E-03	2.07E-01	1.76E-02	6.29E-03	5.37E-04
Anchor Handling Tug Supply Vessel (AHTS)													
Main Engine 1	Caterpillar 3608	2,710 kW	Vertical	2.91E-01	2.49E-02	3.36E-02	2.87E-03	6.54E-05	5.59E-06	2.45E-03	2.09E-04	1.24E-06	1.06E-07
Main Engine 2	Caterpillar 3608	2,710 kW	Vertical	2.91E-01	2.49E-02	3.36E-02	2.87E-03	6.54E-05	5.59E-06	2.45E-03	2.09E-04	1.24E-06	1.06E-07
Tow Winch Engine	Caterpillar 3508	750 kW	Vertical	4.13E-02	3.53E-03	1.64E-03	1.40E-04	9.70E-06	8.28E-07	4.46E-04	3.81E-05	1.84E-07	1.57E-08
Thruster Engine 1	Caterpillar 3508	750 kW	Vertical	1.09E-01	9.27E-03	1.24E-02	1.06E-03	2.42E-05	2.07E-06	9.07E-04	7.75E-05	4.59E-07	3.92E-08
Thruster Engine 2	Caterpillar C-32	750 kW	Vertical	1.09E-01	9.27E-03	1.24E-02	1.06E-03	2.42E-05	2.07E-06	9.07E-04	7.75E-05	4.59E-07	3.92E-08
Generator 1	Caterpillar 3412	500 kW	Vertical	4.66E+00	3.98E-01	3.66E-01	3.12E-02	2.17E-03	1.85E-04	9.97E-02	8.51E-03	4.11E-05	3.50E-06
Generator 2	Caterpillar 3412	500 kW	Vertical	2.75E+00	2.34E-01	0.00E+00	0.00E+00	1.29E-03	1.10E-04	5.93E-02	5.06E-03	2.44E-05	2.08E-06
Emergency Generator	Caterpillar 3306	206 kW	Vertical	2.52E-02	2.15E-03	2.00E-03	1.70E-04	1.18E-05	1.01E-06	5.44E-04	4.65E-05	2.24E-07	1.91E-08

Table B-2 Long-Term Emissions Inventory for the COP Devil's Paw Prospect Exploratory Drilling Program (CONTINUED)

Emission Unit	Type	Rating	Unit Stack Orientation	NO_x Annual Emission Rate		CO Annual Emission Rate		SO_2 Annual Emission Rate		$PM_{10}/PM_{2.5}$ Annual Emission Rate		Pb Annual Emission Rate	
				(tpy)	(g/s)	(tpy)	(g/s)	(tpy)	(g/s)	(tpy)	(g/s)	(tpy)	(g/s)
Oil Spill Response Vessel 1 (Dedicated OSRV)													
Main Engine 1	Caterpillar 3516C	3,070 bhp	Vertical	1.42E+01	1.21E+00	3.76E+00	3.21E-01	6.77E-03	5.78E-04	2.53E-01	2.16E-02	1.28E-04	1.09E-05
Main Engine 2	Caterpillar 3516C	3,070 bhp	Vertical	1.42E+01	1.21E+00	3.76E+00	3.21E-01	6.77E-03	5.78E-04	2.53E-01	4.42E-01	1.28E-04	1.09E-05
Thruster Engine 1	Brunvoll CPP Drop Down Azimuth	1,100 hp	Vertical	4.75E-01	4.06E-02	1.09E-01	9.30E-03	4.22E-05	3.60E-06	1.58E-03	1.39E-02	8.00E-07	6.83E-08
Thruster Engine 2	Brunvoll CPP Tunnel	1,100 hp	Horizontal	4.75E-01	4.06E-02	1.09E-01	9.30E-03	3.86E-05	3.29E-06	1.44E-03	1.39E-02	7.31E-07	6.24E-08
Thruster Engine 3	Brunvoll CPP Tunnel (Stern)	1,100 hp	Horizontal	4.75E-01	4.06E-02	1.09E-01	9.30E-03	2.58E-05	2.21E-06	9.67E-04	1.39E-02	4.90E-07	4.18E-08
Generator 1	Caterpillar C-32	710 kW	Vertical	1.30E+01	1.11E+00	1.03E+00	8.81E-02	1.40E-03	1.20E-04	2.73E-01	2.81E-01	2.65E-05	2.26E-06
Generator 2	Caterpillar C-32	710 kW	Vertical	1.30E+01	1.11E+00	1.03E+00	8.81E-02	1.40E-03	1.20E-04	8.44E-03	8.44E-03	2.65E-05	2.26E-06
Emergency Generator	Caterpillar C9D	279 hp	Horizontal	2.55E-02	2.18E-03	2.02E-03	1.72E-04	1.20E-05	1.02E-06	2.73E-01	5.50E-04	2.27E-07	1.93E-08
Oil Spill Response Vessel 2													
Main Engine 1	Caterpillar 3516C	3,070 bhp	Vertical	9.83E-01	8.39E-02	2.61E-01	2.23E-02	4.70E-04	4.01E-05	1.76E-02	1.50E-03	8.91E-06	7.60E-07
Main Engine 2	Caterpillar 3516C	3,070 bhp	Vertical	9.83E-01	8.39E-02	2.61E-01	2.23E-02	4.70E-04	4.01E-05	1.76E-02	3.07E-02	8.91E-06	7.60E-07
Thruster Engine 1	Brunvoll CPP Drop Down Azimuth	1,100 hp	Vertical	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thruster Engine 2	Brunvoll CPP Tunnel	1,100 hp	Horizontal	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thruster Engine 3	Brunvoll CPP Tunnel (Stern)	1,100 hp	Horizontal	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Generator 1	Caterpillar C-32	710 kW	Vertical	3.26E-01	2.78E-02	2.58E-02	2.20E-03	3.50E-05	2.99E-06	7.04E-03	7.04E-03	6.63E-07	5.66E-08
Generator 2	Caterpillar C-32	710 kW	Vertical	3.26E-01	2.78E-02	2.58E-02	2.20E-03	3.50E-05	2.99E-06	7.04E-03	7.04E-03	6.63E-07	5.66E-08
Emergency Generator	Caterpillar C9D	279 hp	Horizontal	2.55E-02	2.18E-03	2.02E-03	1.72E-04	0.00E+00	0.00E+00	0.00E+00	5.50E-04	2.27E-07	1.93E-08
Offshore Supply Vessels (OSV1 & OSV2)													
Main Engine 1	Caterpillar 3516C	3,151 hp	Vertical	4.14E+00	3.53E-01	2.87E+00	2.45E-01	3.75E-03	3.20E-04	1.40E-01	1.20E-02	7.10E-05	6.06E-06
Main Engine 2	Caterpillar 3516C	3,151 hp	Vertical	4.14E+00	3.53E-01	2.87E+00	2.45E-01	3.75E-03	3.20E-04	1.40E-01	1.20E-02	7.10E-05	6.06E-06
Thruster Engine 1	Caterpillar C-32	950 hp	Vertical	4.25E+00	3.63E-01	2.95E+00	2.52E-01	3.44E-03	2.94E-04	1.29E-01	1.10E-02	6.52E-05	5.56E-06
Thruster Engine 2	Caterpillar C-32	950 hp	Horizontal	4.25E+00	3.63E-01	2.95E+00	2.52E-01	3.44E-03	2.94E-04	1.29E-01	1.10E-02	6.52E-05	5.56E-06
Thruster Engine 3	Caterpillar C-32	950 hp	Horizontal	4.25E+00	3.63E-01	2.95E+00	2.52E-01	3.44E-03	2.94E-04	1.29E-01	1.10E-02	6.52E-05	5.56E-06
Generator	Caterpillar C-18	400 kW	Vertical	2.01E+00	1.72E-01	1.40E+00	1.19E-01	1.73E-03	1.48E-04	8.37E-02	7.15E-03	3.28E-05	2.80E-06
Generator	Caterpillar C-18	400 kW	Vertical	2.01E+00	1.72E-01	1.40E+00	1.19E-01	1.73E-03	1.48E-04	8.37E-02	7.15E-03	3.28E-05	2.80E-06
Generator	Caterpillar C-18	400 kW	Vertical	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Emergency Generator	Caterpillar 3306	99 kW	Horizontal	6.28E-03	5.36E-04	4.36E-03	3.72E-04	6.47E-06	5.52E-07	2.62E-04	2.23E-05	1.23E-07	1.05E-08
Ware Vessel (WV) w/ OSV/AHSV backup													
Main Engine 1	Caterpillar 3516C	2,387 kW	Vertical	3.50E+00	2.98E-01	2.43E+00	2.07E-01	3.17E-03	2.70E-04	1.19E-01	1.01E-02	6.00E-05	5.12E-06
Main Engine 2	Caterpillar 3516C	2,387 kW	Vertical	3.50E+00	2.98E-01	2.43E+00	2.07E-01	3.17E-03	2.70E-04	1.19E-01	1.01E-02	6.00E-05	5.12E-06
Main Engine 3	Caterpillar 3516C	2,387 kW	Vertical	7.41E+00	6.33E-01	5.15E+00	4.40E-01	6.72E-03	5.73E-04	2.51E-01	2.15E-02	1.27E-04	1.09E-05
Main Engine 4	Caterpillar 3516C	2,387 kW	Vertical	7.41E+00	6.33E-01	5.15E+00	4.40E-01	6.72E-03	5.73E-04	2.51E-01	2.15E-02	1.27E-04	1.09E-05
Generator 1	Caterpillar C-18	504 kW	Vertical	2.36E+00	2.01E-01	1.64E+00	1.40E-01	1.91E-03	1.63E-04	9.82E-02	8.38E-03	3.62E-05	3.09E-06
Generator 2	Caterpillar C-18	504 kW	Vertical	2.36E+00	2.01E-01	1.64E+00	1.40E-01	1.91E-03	1.63E-04	9.82E-02	8.38E-03	3.62E-05	3.09E-06
Generator 3	Caterpillar C-18	504 kW	Vertical	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Emergency Generator	Caterpiller 3306	170 kW	Vertical	2.08E-02	1.78E-03	1.65E-03	1.41E-04	1.04E-05	8.84E-07	4.49E-04	3.84E-05	1.96E-07	1.67E-08

Table B-2 Long-Term Emissions Inventory for the COP Devil's Paw Prospect Exploratory Drilling Program (CONTINUED)

Emission Unit	Type	Rating	Unit Stack Orientation	NO_x Annual Emission Rate		CO Annual Emission Rate		SO_2 Annual Emission Rate		$PM_{10}/PM_{2.5}$ Annual Emission Rate		Pb Annual Emission Rate	
				(tpy)	(g/s)	(tpy)	(g/s)	(tpy)	(g/s)	(tpy)	(g/s)	(tpy)	(g/s)
34' Boom Work Boats - 4													
WB-1 Propulsion Engine 1	Cummins QSB5.9-305CD	300 hp	Horizontal	7.37E-02	6.29E-03	2.46E-03	2.10E-04	7.33E-05	6.26E-06	3.55E-03	3.03E-04	1.39E-06	1.19E-07
WB-1 Propulsion Engine 2	Cummins QSB5.9-305CD	300 hp	Horizontal	7.37E-02	6.29E-03	2.46E-03	2.10E-04	7.33E-05	6.26E-06	3.55E-03	3.03E-04	1.39E-06	1.19E-07
WB-2 Propulsion Engine 1	Cummins QSB5.9-305CD	300 hp	Horizontal	7.37E-02	6.29E-03	2.46E-03	2.10E-04	7.33E-05	6.26E-06	3.55E-03	3.03E-04	1.39E-06	1.19E-07
WB-2 Propulsion Engine 2	Cummins QSB5.9-305CD	300 hp	Horizontal	7.37E-02	6.29E-03	2.46E-03	2.10E-04	7.33E-05	6.26E-06	3.55E-03	3.03E-04	1.39E-06	1.19E-07
WB-3 Propulsion Engine 1	Cummins QSB5.9-305CD	300 hp	Horizontal	7.37E-02	6.29E-03	2.46E-03	2.10E-04	7.33E-05	6.26E-06	3.55E-03	3.03E-04	1.39E-06	1.19E-07
WB-3 Propulsion Engine 2	Cummins QSB5.9-305CD	300 hp	Horizontal	7.37E-02	6.29E-03	2.46E-03	2.10E-04	7.33E-05	6.26E-06	3.55E-03	3.03E-04	1.39E-06	1.19E-07
WB-4 Propulsion Engine 1	Cummins QSB5.9-305CD	300 hp	Horizontal	7.37E-02	6.29E-03	2.46E-03	2.10E-04	7.33E-05	6.26E-06	3.55E-03	3.03E-04	1.39E-06	1.19E-07
WB-4 Propulsion Engine 2	Cummins QSB5.9-305CD	300 hp	Horizontal	7.37E-02	6.29E-03	2.46E-03	2.10E-04	7.33E-05	6.26E-06	3.55E-03	3.03E-04	1.39E-06	1.19E-07
Marine Research Vessel													
Main Engine	Caterpillar	850 hp	Vertical	6.12E+00	5.22E-01	1.40E+00	1.20E-01	2.73E-03	2.33E-04	1.02E-01	8.73E-03	5.18E-05	4.42E-06
Generator 1	Caterpillar	135 kW	Vertical	1.24E+00	1.06E-01	9.81E-02	8.38E-03	5.82E-04	4.97E-05	2.68E-02	2.28E-03	1.10E-05	9.41E-07
Generator 2	Caterpillar	90 kW	Vertical	8.27E-01	7.06E-02	6.54E-02	5.58E-03	3.88E-04	3.31E-05	1.78E-02	1.52E-03	7.35E-06	6.27E-07
Generator 3	Caterpillar	40 kW	Vertical	3.67E-01	3.14E-02	2.91E-02	2.48E-03	1.72E-04	1.47E-05	7.93E-03	6.77E-04	3.27E-06	2.79E-07
Spill Storage Tanker													
Main Engine 1	Aframax class sized	19,460 bhp	Vertical	1.10E+00	9.41E-02	2.53E-01	2.16E-02	4.92E-04	4.20E-05	1.84E-02	1.57E-03	9.32E-06	7.96E-07
Generator 1	Aframax class sized	600 kW	Vertical	2.66E-01	2.27E-02	6.41E-02	5.48E-03	1.25E-04	1.07E-05	5.75E-03	4.91E-04	2.37E-06	2.02E-07
Generator 2	Aframax class sized	600 kW	Vertical	0.00E+00	0.00E+00	2.11E-01	1.80E-02	1.25E-04	1.07E-05	5.75E-03	4.91E-04	2.37E-06	2.02E-07
Generator 3	Aframax class sized	600 kW	Vertical	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Emergency Generator	Aframax class sized	350 kW	Vertical	8.44E-01	7.21E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Boiler 1	Mac-55B	212 MMBtu/hr	Vertical	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.54E-03	7.29E-04	4.56E-02	3.89E-03	5.02E-05	4.28E-06
Boiler 2	Mac-55B	212 MMBtu/hr	Vertical	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

* = Heat Input Rate

Table B-3 Point Source 1 (Vertical Emission Units) Short-Term Emissions by Option

	NO_x Total Emissions		CO Total Emissions		SO_2 Total Emissions		PM_{10}/ $PM_{2.5}$ Total Emissions		Pb Total Emissions	
	(lb/hr)	(g/s)	(lb/hr)	(g/s)	(lb/hr)	(g/s)	(lb/hr)	(g/s)	(lb/hr)	(g/s)
First 24-Hour Options										
Option 1a	8.52E+01	1.07E+01	5.61E+01	7.07E+00	4.67E-01	5.89E-02	5.38E+00	6.77E-01	2.98E-02	3.76E-03
Option 1b	8.52E+01	1.07E+01	5.61E+01	7.07E+00	4.67E-01	5.89E-02	5.38E+00	6.77E-01	2.98E-02	3.76E-03
Option 1c	8.52E+01	1.07E+01	5.61E+01	7.07E+00	4.67E-01	5.89E-02	5.38E+00	6.77E-01	2.98E-02	3.76E-03
Option 2a	8.52E+01	1.07E+01	5.61E+01	7.07E+00	4.67E-01	5.89E-02	5.38E+00	6.77E-01	2.98E-02	3.76E-03
Option 2b	8.52E+01	1.07E+01	5.61E+01	7.07E+00	4.67E-01	5.89E-02	5.38E+00	6.77E-01	2.98E-02	3.76E-03
Option 2c	8.52E+01	1.07E+01	5.61E+01	7.07E+00	4.67E-01	5.89E-02	5.38E+00	6.77E-01	2.98E-02	3.76E-03
Option 2d	8.52E+01	1.07E+01	5.61E+01	7.07E+00	4.67E-01	5.89E-02	5.38E+00	6.77E-01	2.98E-02	3.76E-03
Regular Resupply Options										
Option 1a	8.52E+01	1.07E+01	5.61E+01	7.07E+00	4.67E-01	5.89E-02	5.38E+00	6.77E-01	2.98E-02	3.76E-03
Option 1b	8.52E+01	1.07E+01	5.61E+01	7.07E+00	4.67E-01	5.89E-02	5.38E+00	6.77E-01	2.98E-02	3.76E-03
Option 2a	**8.52E+01**	**1.07E+01**	**5.61E+01**	**7.07E+00**	**4.67E-01**	**5.89E-02**	**5.38E+00**	**6.77E-01**	**2.98E-02**	**3.76E-03**
Option 2b	8.52E+01	1.07E+01	5.61E+01	7.07E+00	4.67E-01	5.89E-02	5.38E+00	6.77E-01	2.98E-02	3.76E-03
Option 2c	8.52E+01	1.07E+01	5.61E+01	7.07E+00	4.67E-01	5.89E-02	5.38E+00	6.77E-01	2.98E-02	3.76E-03

Table B-4 Point Source 2 (Horizontal Emission Units) Short-Term Emissions by Option

	NO_x Total Emissions		CO Total Emissions		SO_2 Total Emissions		PM_{10}/ $PM_{2.5}$ Total Emissions		Pb Total Emissions	
	(lb/hr)	(g/s)	(lb/hr)	(g/s)	(lb/hr)	(g/s)	(lb/hr)	(g/s)	(lb/hr)	(g/s)
First 24-Hour Options										
Option 1a	6.45E+01	8.13E+00	9.67E+01	1.22E+01	1.66E-01	2.10E-02	6.66E+00	8.39E-01	1.44E-03	1.81E-04
Option 1b	6.45E+01	8.13E+00	9.67E+01	1.22E+01	1.66E-01	2.10E-02	6.66E+00	8.39E-01	1.44E-03	1.81E-04
Option 1c	6.45E+01	8.13E+00	9.67E+01	1.22E+01	1.66E-01	2.10E-02	6.66E+00	8.39E-01	1.44E-03	1.81E-04
Option 2a	6.45E+01	8.13E+00	9.67E+01	1.22E+01	1.66E-01	2.10E-02	6.66E+00	8.39E-01	1.44E-03	1.81E-04
Option 2b	6.45E+01	8.13E+00	9.67E+01	1.22E+01	1.66E-01	2.10E-02	6.66E+00	8.39E-01	1.44E-03	1.81E-04
Option 2c	6.45E+01	8.13E+00	9.67E+01	1.22E+01	1.66E-01	2.10E-02	6.66E+00	8.39E-01	1.44E-03	1.81E-04
Option 2d	6.45E+01	8.13E+00	9.67E+01	1.22E+01	1.66E-01	2.10E-02	6.66E+00	8.39E-01	1.44E-03	1.81E-04
Regular Resupply Options										
Option 1a	6.45E+01	8.13E+00	9.67E+01	1.22E+01	1.66E-01	2.10E-02	6.66E+00	8.39E-01	1.44E-03	1.81E-04
Option 1b	6.45E+01	8.13E+00	9.67E+01	1.22E+01	1.66E-01	2.10E-02	6.66E+00	8.39E-01	1.44E-03	1.81E-04
Option 2a	**6.45E+01**	**8.13E+00**	**9.67E+01**	**1.22E+01**	**1.66E-01**	**2.10E-02**	**6.66E+00**	**8.39E-01**	**1.44E-03**	**1.81E-04**
Option 2b	6.45E+01	8.13E+00	9.67E+01	1.22E+01	1.66E-01	2.10E-02	6.66E+00	8.39E-01	1.44E-03	1.81E-04
Option 2c	6.45E+01	8.13E+00	9.67E+01	1.22E+01	1.66E-01	2.10E-02	6.66E+00	8.39E-01	1.44E-03	1.81E-04

Table B-5 Volume Source Short-Term Emissions by Option

	NO_x Total Emissions		CO Total Emissions		SO_2 Total Emissions		PM_{10}/ $PM_{2.5}$ Total Emissions		Pb Total Emissions	
	(lb/hr)	(g/s)	(lb/hr)	(g/s)	(lb/hr)	(g/s)	(lb/hr)	(g/s)	(lb/hr)	(g/s)
First 24-Hour Options (Vertical Units)										
Option 1a	3.24E+02	4.08E+01	3.62E+02	4.56E+01	1.13E+00	1.43E-01	2.67E+01	3.37E+00	1.56E-02	1.96E-03
Option 1b	3.12E+02	3.93E+01	3.39E+02	4.28E+01	1.10E+00	1.39E-01	2.56E+01	3.22E+00	1.55E-02	1.95E-03
Option 1c	3.12E+02	3.93E+01	3.39E+02	4.28E+01	1.10E+00	1.39E-01	2.56E+01	3.22E+00	1.55E-02	1.95E-03
Option 2a	3.20E+02	4.04E+01	3.63E+02	4.57E+01	1.13E+00	1.43E-01	2.68E+01	3.37E+00	1.56E-02	1.96E-03
Option 2b	3.25E+02	4.09E+01	3.52E+02	4.43E+01	1.12E+00	1.41E-01	2.63E+01	3.31E+00	1.56E-02	1.96E-03
Option 2c	3.12E+02	3.93E+01	3.39E+02	4.28E+01	1.10E+00	1.39E-01	2.56E+01	3.22E+00	1.55E-02	1.95E-03
Option 2d	3.08E+02	3.89E+01	3.41E+02	4.29E+01	1.11E+00	1.39E-01	2.56E+01	3.23E+00	1.54E-02	1.95E-03
Regular Resupply Options (Vertical Units)										
Option 1a	4.44E+02	5.60E+01	5.24E+02	6.61E+01	2.06E+00	2.59E-01	4.16E+01	5.24E+00	1.57E-02	1.98E-03
Option 1b	4.44E+02	5.60E+01	5.24E+02	6.61E+01	2.06E+00	2.59E-01	4.16E+01	5.24E+00	1.57E-02	1.98E-03
Option 2a	**4.71E+02**	**5.93E+01**	**5.49E+02**	**6.92E+01**	**2.09E+00**	**2.64E-01**	**4.30E+01**	**5.42E+00**	**1.59E-02**	**2.00E-03**
Option 2b	4.44E+02	5.60E+01	5.24E+02	6.61E+01	2.06E+00	2.59E-01	4.16E+01	5.24E+00	1.57E-02	1.98E-03
Option 2c	4.38E+02	5.52E+01	5.27E+02	6.64E+01	2.06E+00	2.60E-01	4.17E+01	5.25E+00	1.57E-02	1.98E-03
First 24-Hour Options (Horizontal Units)										
Option 1a	2.25E+01	2.83E+00	2.16E+01	2.72E+00	4.88E-02	6.15E-03	2.08E+00	2.62E-01	1.23E-04	1.55E-05
Option 1b	1.12E+01	1.42E+00	1.32E+01	1.67E+00	3.89E-02	4.91E-03	1.71E+00	2.15E-01	6.24E-05	7.87E-06
Option 1c	1.12E+01	1.42E+00	1.32E+01	1.67E+00	3.89E-02	4.91E-03	1.71E+00	2.15E-01	6.24E-05	7.87E-06
Option 2a	1.12E+01	1.42E+00	1.32E+01	1.67E+00	3.89E-02	4.91E-03	1.71E+00	2.15E-01	6.24E-05	7.87E-06
Option 2b	0.00E+00	0.00E+00	4.90E+00	6.17E-01	2.90E-02	3.66E-03	1.34E+00	1.68E-01	2.04E-06	2.57E-07
Option 2c	1.12E+01	1.42E+00	1.32E+01	1.67E+00	3.89E-02	4.91E-03	1.71E+00	2.15E-01	6.24E-05	7.87E-06
Option 2d	0.00E+00	0.00E+00	4.90E+00	6.17E-01	2.90E-02	3.66E-03	1.34E+00	1.68E-01	2.04E-06	2.57E-07
Regular Resupply Options Horizontal Units)										
Option 1a	**4.70E+01**	**5.93E+00**	**3.50E+01**	**4.41E+00**	**7.98E-02**	**1.01E-02**	**3.54E+00**	**4.46E-01**	**1.34E-04**	**1.69E-05**
Option 1b	4.70E+01	5.93E+00	3.50E+01	4.41E+00	7.98E-02	1.01E-02	3.54E+00	4.46E-01	1.34E-04	1.69E-05
Option 2a	2.46E+01	3.09E+00	1.83E+01	2.31E+00	6.00E-02	7.56E-03	2.79E+00	3.52E-01	1.37E-05	1.72E-06
Option 2b	4.70E+01	5.93E+00	3.50E+01	4.41E+00	7.98E-02	1.01E-02	3.54E+00	4.46E-01	1.34E-04	1.69E-05
Option 2c	2.46E+01	3.09E+00	1.83E+01	2.31E+00	6.00E-02	7.56E-03	2.79E+00	3.52E-01	1.37E-05	1.72E-06
Total Maximum Volume Source Emissions										
Total =	**5.18E+02**	**6.53E+01**	**5.84E+02**	**7.36E+01**	**2.17E+00**	**2.74E-01**	**4.65E+01**	**5.86E+00**	**1.60E-02**	**2.02E-03**

Table B-6 Point Source 1 (Vertical Emission Units) Drilling Season Emissions by Option

	NO_x Total Emissions		CO Total Emissions		SO_2 Total Emissions		PM_{10}/ $PM_{2.5}$ Total Emissions		Pb Total Emissions	
	(tpy)	(g/s)	(tpy)	(g/s)	(tpy)	(g/s)	(tpy)	(g/s)	(tpy)	(g/s)
Drilling Season Emissions										
Option 1	6.53E+01	5.57E+00	1.09E+01	9.27E-01	1.15E-01	9.81E-03	1.27E+00	8.09E-01	7.42E-03	6.33E-04
Option 2	**6.53E+01**	**5.57E+00**	**1.09E+01**	**9.27E-01**	**1.15E-01**	**9.81E-03**	**1.27E+00**	**8.09E-01**	**7.42E-03**	**6.33E-04**

Table B-7 Point Source 2 (Horizontal Emission Units) Drilling Season Emissions by Option

	NO_x Total Emissions		CO Total Emissions		SO_2 Total Emissions		PM_{10}/ $PM_{2.5}$ Total Emissions		Pb Total Emissions	
	(tpy)	(g/s)	(tpy)	(g/s)	(tpy)	(g/s)	(tpy)	(g/s)	(tpy)	(g/s)
Drilling Season Emissions										
Option 1	2.77E+01	2.36E+00	4.58E+01	3.91E+00	8.26E-02	7.05E-03	3.37E+00	2.93E-01	1.94E-03	1.66E-04
Option 2	**2.77E+01**	**2.36E+00**	**4.58E+01**	**3.91E+00**	**8.26E-02**	**7.05E-03**	**3.37E+00**	**2.93E-01**	**1.94E-03**	**1.66E-04**

Table B-8 Volume Source Drilling Season Emissions by Option

	NO_x Total Emissions		CO Total Emissions		SO_2 Total Emissions		PM_{10}/ $PM_{2.5}$ Total Emissions		Pb Total Emissions	
	(tpy)	(g/s)	(tpy)	(g/s)	(tpy)	(g/s)	(tpy)	(g/s)	(tpy)	(g/s)
Drilling Season Emissions (Vertical Units)										
Option 1	1.21E+02	1.04E+01	1.20E+02	1.02E+01	3.88E-01	3.31E-02	8.94E+00	8.05E-01	1.69E-02	1.44E-03
Option 2	**1.31E+02**	**1.12E+01**	**1.26E+02**	**1.08E+01**	**3.97E-01**	**3.39E-02**	**9.29E+00**	**8.36E-01**	**1.71E-02**	**1.46E-03**
Drilling Season Emissions (Horizontal Units)										
Option 1	**9.37E+00**	**7.99E-01**	**5.95E+00**	**5.08E-01**	**7.59E-03**	**6.48E-04**	**2.91E-01**	**2.54E-02**	**1.44E-04**	**1.23E-05**
Option 2	8.62E-01	7.36E-02	4.13E-02	3.52E-03	7.02E-04	6.00E-05	3.37E-02	3.43E-03	1.35E-05	1.16E-06
Total Maximum Volume Source Emissions										
Total =	**1.41E+02**	**1.20E+01**	**1.32E+02**	**1.13E+01**	**4.04E-01**	**3.45E-02**	**9.59E+00**	**8.61E-01**	**1.72E-02**	**1.47E-03**

Appendix C
Modeled COP OCS Source Stack Parameter Development

Modeled COP OCS Source Stack Parameter Development

1.0 Introduction

The entire COP OCS Source and associated support vessels are being simulated in the dispersion model as two point sources and one volume source as follows:

- The drill rig and nearby static support vessels, which include the Dedicated Oil Spill Response Vessel (OSRV) and the Anchor Handling Tug Supply (AHTS) Vessel, are being represented as two point sources. One point source represents the horizontal stacks and the other represents the vertical stacks included in this set of sources.
- All mobile support vessels are being represented by a single 1 kilometer square volume source.

This appendix documents the development of the modeled stack parameters for the representative horizontal and vertical point sources and the release height for the representative volume source. The modeled point source parameters developed in this appendix using a conservative variation of the USEPA M-Value approach are shown in **Table C-1**. The volume source release height developed in this appendix, which is simply the lowest release height from among all stacks represented by the volume source, is 3.2 meters.

Table C-1 Representative Point Source Stack Parameters

Source	Stack Height (m)	Stack Exit Temperature (K)	Stack Exit Velocity (m/s)	Stack Diameter (m)
Vertical Emission Units	13.5	589	13.6	0.203
Horizontal Emission Units	7.3	589	38.8	0.13

2.0 Representative Point Source Parameter Determination

Stack exit parameters for the two point sources were developed using a conservative variation of USEPA's M-value technique[1]. This technique involves calculating an M-Value for each emission unit based on the stack height, exit temperature, and volumetric flow rate. The emissions from all emission units with a particular stack orientation were modeled from the stack with the lowest M-value. For this determination two steps documented below were required. First, temperature and flow rates were determined for each emission unit based on emission unit type and the USEPA method 19 F-factor approach[2]. Second, an M-Value was calculated for each emission unit and the lowest for each group of emission units (i.e., horizontal and vertical)

[1] Screening Procedures for Estimating the Air Quality Impact of Stationary Sources, Revised – EPA-454/R-92-019. United States Environmental Protection Agency Office of Air Radiation – Office of Air Quality Planning and Standards. Research Triangle Park, North Carolina 27711. October 1992.

[2] 40 CFR Part 60 Appendix A–7, Method 19—Determination of sulfur dioxide removal efficiency and particulate, sulfur dioxide and nitrogen oxides emission rates.

were determined. The stack parameters associated with the emission unit with the lowest M-Value were used to represent all emissions for a particular stack orientation.

2.1 Stack Exit Temperature and Flow Rate Determination

Table C-1 through **Table C-3** provide the stack exit temperature and flow rate determined for emission units whose emissions were combined into the two point sources. The stack exit flow rates were calculated using the USEPA method 19 F-factor approach, which computes the exhaust flow on a dry basis at standard conditions. An emission unit heat input rate and a fuel-specific F_d value were used to convert heat input to exhaust gas flow. While the moisture content of each exhaust stream utilizes a value calculated based on the exhaust oxygen content and a stoichiometric relationship based on liquid fuel combustion. The F_d values were derived based on fuel properties provided by the Tesoro Kenai Alaska Refinery for the fuel which will be used on this project. A comprehensive list of constants and values used in the calculations can be found in **Table C-4**.

The heat input (MMBtu/hr) for each emission unit was calculated based on information provided from the manufacturer. For the internal combustion engines, all calculations were based on the kilowatt output of the emissions unit.

2.2 Determination of the Representative Stack – M-Value Analysis

As discussed above, two individual point sources representing vertical and horizontal oriented units, respectively, were used to model all emissions from the Drill Rig, Anchor Handling Tug Supply (AHTS) vessel, and Dedicated Oil Spill Response Vessel (OSRV). All emissions from stacks of a particular orientation were modeled from a representative horizontal and vertical stack. Representative stack parameters for each of the stacks are equivalent to the stack from each group with the lowest M-Value.

For this application, the M-Value for a particular emission unit was set equal to the product of the stack height (meters), exit temperature (Kelvin), and volumetric flow rate (m^3/s). This is a conservative variation on the traditional approach because it does not include the emission rate in the denominator; therefore, it does not account for the emission potential of particular emission units making the analysis independent of emission unit operation. Taking this approach, stack parameters associated with emission units that seldom operate factor equally with those that operate continuously.

The M-Value calculations for each emission unit are presented in **Table C-5**. Based on the calculated M-Values, the representative stacks for vertical and horizontal stack are the logging winch on the drill rig and the emergency generator on the OSRV, respectively. The representative stack parameters are summarized in **Table C-1**.

3.0 Modeled Volume Source Parameters Determination

All mobile support vessel fleet emissions were modeled from a 1 kilometer square volume source. The volume source vertical dimensions were based on the lowest release height from among all the exhaust stacks included on the vessels represented by the single volume source excluding those of the work boats.

Table C-6 lists the release height for all exhaust stacks included on the vessels represented by the single volume source. The lowest release height among all emission units is 3.2 meters which is associated with the Thruster Engines on the Offshore Supply Vessel. This release height was used to develop the vertical volume source parameters.

Table C-1 Jackup Drill Rig Stack Calculations

Unit Type	Equipment	Capacity	Operational Data	Stack Exit Parameters	
				Temperature	Flow Rate[4]
Primary Engines	Main Drilling Engine Wärtsilä 8L26A2	2,480 kW	21.94 $MMBtu/hr_{LHV}$ [1]	600 F[2] 589 K	12,398 ACFM[3] 5.85 m^3/s
	Main Drilling Engine Wärtsilä 8L26A2	2,480 kW	21.94 $MMBtu/hr_{LHV}$ [1]	600 F[2] 589 K	12,398 ACFM[3] 5.85 m^3/s
	Main Drilling Engine Wärtsilä 8L26A2	2,480 kW	21.94 $MMBtu/hr_{LHV}$ [1]	600 F[2] 589 K	12,398 ACFM[3] 5.85 m^3/s
	Main Drilling Engine Wärtsilä 8L26A2	2,480 kW	21.94 $MMBtu/hr_{LHV}$ [1]	600 F[2] 589 K	12,398 ACFM[3] 5.85 m^3/s
Utility/ Emergency Engines	Emergency Back-up Engine Caterpillar Diesel 3508 B	968 kW	9.01 $MMBtu/hr_{LHV}$ [1]	600 F[2] 589 K	4,839 ACFM[3] 2.28 m^3/s
	Cement Engine Caterpillar 15 DITA	403 kW	4.12 $MMBtu/hr_{LHV}$ [1]	600 F[2] 589 K	2,015 ACFM[3] 0.95 m^3/s
	Cement Engine Caterpillar 15 DITA	403 kW	4.12 $MMBtu/hr_{LHV}$ [1]	600 F[2] 589 K	2,015 ACFM[3] 0.95 m^3/s
	Logging Winch Engine Caterpillar C7 Acert Engine	187 kW	1.65 $MMBtu/hr_{LHV}$ [1]	600 F[2] 589 K	935 ACFM[3] 0.44 m^3/s
Air Heaters And Boilers	Air Heater Unknown	3.50 $MMBtu/hr_{LHV}$	3.50 $MMBtu/hr_{LHV}$	450 F[6] 505 K	1,401 ACFM[5] 0.66 m^3/s
	Air Heater Unknown	3.50 $MMBtu/hr_{LHV}$	3.50 $MMBtu/hr_{LHV}$	450 F[6] 505 K	1,401 ACFM[5] 0.66 m^3/s

Notes and Calculations

The following calculations incorporate constants and values from the emission unit specifications (assumed) and the distillate fuel oil properties provided by Tesoro Kenai Alaska Refinery for the fuel that were used. Refer to the Emission Unit and Fuel Specifications Table (**Table C-4**) for a listing and description of values used in these calculations.

1 The Heat input calculation is based on the kilowatt output of the generator attached to the engine.

Example Calculation: (7,500 kW) * (9,387 Btu/kW-hr $_{HHV}$) / (10^6 Btu / MMBtu) * (124,500 Btu/gal $_{LHV}$) / (132,096Btu/gal $_{HHV}$) = 66.36 MMBtu/hr $_{LHV}$

2 600 degrees Fahrenheit is based on professional judgment. For units equipped with SCR, this is the lowest exhaust temperature required for an SCR control device to function properly. For units without SCR, this is cooler than typical operations. Therefore, this value will lead to less dispersion and higher model predicted impacts in all cases.

3 The exhaust flow rate calculation is carried out on a lower heating value basis and is based on the following:

Example Calculation: (66.36 MMBtu/hr $_{LHV}$) * (1 hr / 60 min) * (9,629 dscf/MMBtu $_{LHV}$ F_d) * [(20.9) / (20.9 - 8.0 O_2%)] / [(1 - 7.6/100 Moisture %)] * [(600 F+460) / (68 F+460)] = 37,494 ACFM (actual ft^3/min)

4 Example Calculation: 29,996 ft^3/min * 1 min / 60 s / (35.31467 ft^3 / m^3) = 14.2 m^3/s

5 The exhaust flow rate calculation is carried out on a lower heating value basis and is based on the following:

Example Calculation: (3.50 MMBtu/hr $_{LHV}$) * (1 hr / 60 min) * (9,629 dscf/MMBtu $_{LHV}$ F_d) * [(20.9) / (20.9 - 8.0 O_2%)] / (1 – 9.2/100 Moisture %) * [(450 F+460) / (68 F+460)] = 1,401 ACFM

6 Heater stack exit temperature set to 450 F based on professional judgment.

Table C-2 Anchor Handling Supply Tug (AHTS) Vessel Stack Exit Calculations

Unit Type	Equipment	Capacity	Operational Data	Stack Exit Parameters	
				Temperature[2]	Flow Rate[3, 4]
Primary Engines	Main Engine Caterpillar 3608	2,350 kW	20.79 MMBtu/hr$_{LHV}$ [1]	600 F 589 K	11,747 ACFM 5.54 m^3/s
	Main Engine Caterpillar 3608	2,350 kW	20.79 MMBtu/hr$_{LHV}$ [1]	600 F 589 K	11,747 ACFM 5.54 m^3/s
	Bow Thruster Caterpillar 3508	750 kW	6.64 MMBtu/hr$_{LHV}$ [1]	600 F 589 K	3,749 ACFM 1.77 m^3/s
	Stern Thruster Caterpillar C32	750 kW	6.64 MMBtu/hr$_{LHV}$ [1]	600 F 589 K	3,749 ACFM 1.77 m^3/s
Utility/ Emergency Engines	Tow Winch Engine Caterpillar 3508	750 kW	6.64 MMBtu/hr$_{LHV}$ [1]	600 F 589 K	3,749 ACFM 1.77 m^3/s
	Generator 1 Caterpillar 3412	500 kW	4.42 MMBtu/hr$_{LHV}$ [1]	600 F 589 K	2,500 ACFM 1.18 m^3/s
	Generator 2 Caterpillar 3412	500 kW	4.42 MMBtu/hr$_{LHV}$ [1]	600 F 589 K	2,500 ACFM 1.18 m^3/s
	Emergency Generator Caterpillar 3306	206 kW	1.82 MMBtu/hr$_{LHV}$ [1]	600 F 589 K	1,029 ACFM 0.49 m^3/s

Notes and Calculations

The following calculations incorporate constants and values from the emission unit specifications (assumed) and the distillate fuel oil properties provided by Tesoro Kenai Alaska Refinery for the fuel that were used. Refer to the Emission Unit and Fuel Specifications Table (**Table C-4**) for a listing and description of values used in these calculations.

1 The Heat input calculation is based on the kilowatt output of the generator attached to the engine.

Example Calculation: (7,500 kW) * (9,387 Btu/kW-hr $_{HHV}$) / (10^6 Btu / MMBtu) * (124,500 Btu/gal $_{LHV}$) / (132,096Btu/gal $_{HHV}$) = 66.36 MMBtu/hr $_{LHV}$

2 600 degrees Fahrenheit is based on professional judgment. For units equipped with SCR, this is the lowest exhaust temperature required for an SCR control device to function properly. For units without SCR, this is cooler than typical operations. Therefore, this value will lead to less dispersion and higher model predicted impacts in all cases.

3 The exhaust flow rate calculation is carried out on a lower heating value basis and is based on the following:

Example Calculation: (66.36 MMBtu/hr $_{LHV}$) * (1 hr / 60 min) * (9,629 dscf/MMBtu $_{LHV}$ F_d) * [(20.9) / (20.9 - 8.0 O_2%)] / [(1 - 7.6/100 Moisture %)] * [(600 F+460) / (68 F+460)] = 37,494 ACFM (actual ft^3/min)

4 Example Calculation: 29,996 ft^3/min * 1 min / 60 s / (35.31467 ft^3 / m^3) = 14.2 m^3/s

5 The exhaust flow rate calculation is carried out on a lower heating value basis and is based on the following:

Example Calculation: (3.50 MMBtu/hr $_{LHV}$) * (1 hr / 60 min) * (9,629 dscf/MMBtu $_{LHV}$ F_d) * [(20.9) / (20.9 - 8.0 O_2%)] / (1 – 9.2/100 Moisture %) * [(450 F+460) / (68 F+460)] = 1,401 ACFM

6 Heater stack exit temperature set to 450 F based on professional judgment.

Table C-3 Dedicated Oil Spill Response Vessels (OSRV) Stack Exit Calculations

Unit Type	Equipment	Capacity	Operational Data	Stack Exit Parameters	
				Temperature[2]	Flow Rate[3,4]
Primary Engines	Main Engine Caterpillar 3516C	2,289 kW	20.25 MMBtu/hr$_{LHV}$ [1]	600 F 589 K	11,445 ACFM 5.40 m^3/s
	Main Engine Caterpillar 3516C	2,289 kW	20.25 MMBtu/hr$_{LHV}$ [1]	600 F 589 K	11,445 ACFM 5.40 m^3/s
	Stern Thruster Brunvoll CPP Tunnel	820 kW	7.26 MMBtu/hr$_{LHV}$ [1]	600 F 589 K	4,101 ACFM 1.94 m^3/s
	Bow Thruster Brunvoll CPP Tunnel	820 kW	7.26 MMBtu/hr$_{LHV}$ [1]	600 F 589 K	4,101 ACFM 1.94 m^3/s
	Bow Thruster Brunvoll CPP Drop Down Azimuth	820 kW	7.26 MMBtu/hr$_{LHV}$ [1]	600 F 589 K	4,101 ACFM 1.94 m^3/s
Utility/ Emergency Engines	Generator 1 Caterpillar C-32	710 kW	6.28 MMBtu/hr$_{LHV}$ [1]	600 F 589 K	3,549 ACFM 1.68 m^3/s
	Generator 2 Caterpillar C-32	710 kW	6.28 MMBtu/hr$_{LHV}$ [1]	600 F 589 K	3,549 ACFM 1.68 m^3/s
	Emergency Generator Caterpillar 3306	208 kW	1.84 MMBtu/hr$_{LHV}$ [1]	600 F 589 K	1,040 ACFM 0.49 m^3/s

Notes and Calculations

The following calculations incorporate constants and values from the emission unit specifications (assumed) and the distillate fuel oil properties provided by Tesoro Kenai Alaska Refinery for the fuel that were used. Refer to the Emission Unit and Fuel Specifications Table (**Table C-4**) for a listing and description of values used in these calculations.

1 The Heat input calculation is based on the kilowatt output of the generator attached to the engine.

Example Calculation: (7,500 kW) * (9,387 Btu/kW-hr $_{HHV}$) / (10^6 Btu / MMBtu) * (124,500 Btu/gal $_{LHV}$) / (132,096Btu/gal $_{HHV}$) = 66.36 MMBtu/hr $_{LHV}$

2 600 degrees Fahrenheit is based on professional judgment. For units equipped with SCR, this is the lowest exhaust temperature required for an SCR control device to function properly. For units without SCR, this is cooler than typical operations. Therefore, this value will lead to less dispersion and higher model predicted impacts in all cases.

3 The exhaust flow rate calculation is carried out on a lower heating value basis and is based on the following:

Example Calculation: (66.36 MMBtu/hr $_{LHV}$) * (1 hr / 60 min) * (9,629 dscf/MMBtu $_{LHV}$ F_d) * [(20.9) / (20.9 - 8.0 O_2%)] / [(1 - 7.6/100 Moisture %)] * [(600 F+460) / (68 F+460)] = 37,494 ACFM (actual ft^3/min)

4 Example Calculation: 29,996 ft^3/min * 1 min / 60 s / (35.31467 ft^3 / m^3) = 14.2 m^3/s

5 The exhaust flow rate calculation is carried out on a lower heating value basis and is based on the following:

Example Calculation: (3.50 MMBtu/hr $_{LHV}$) * (1 hr / 60 min) * (9,629 dscf/MMBtu $_{LHV}$ F_d) * [(20.9) / (20.9 - 8.0 O_2%)] / (1 – 9.2/100 Moisture %) * [(450 F+460) / (68 F+460)] = 1,401 ACFM

6 Heater stack exit temperature set to 450 F based on professional judgment.

Table C-4 Emission Unit and Fuel Specifications

Emission Unit Specifications		Units	Comments
BSFC (hp)	7,000	Btu/hp-hr$_{HHV}$	AP-42 Table 3.4-1 "Gaseous Emission Factors for Large Stationary Diesel and all Stationary Dual-Fuel Engines"
BSFC (kW)	9,387	Btu/kW-hr$_{HHV}$	kW to hp conversion
Engine Exhaust %H_20	7.62	%	Calculated using liquid fuel combustion stoichiometry relationships and assumed excess oxygen.
Heater/Boiler Exhaust %H_20	9.20	%	Calculated using liquid fuel combustion stoichiometry relationships and assumed excess oxygen.
Engine Exhaust %O_2	8.0	% dry	Basic assumption based on professional judgment.
Heater/Boiler Exhaust %O_2	5.0	% dry	Basic assumption based on professional judgment.
Heat Conversion	0.03347	MMBtu$_{LHV}$/Bhp	Cleaver-Brooks Boiler Handbook (version 06-08) Section I1-2 (http://www.boilerspec.com/specifire_pdf/welcome.htm) (33,472 Btu $_{LHV}$ /hr)
Fuel Specifications - No. 1 Distillate			
HHV	132,096	Btu/gal	Diesel Fuel Oil No. 1-D S15 Tesoro Kenai Alaska Refinery 11/25/2008
LHV	124,500	Btu/gal	Diesel Fuel Oil No. 1-D S15 Tesoro Kenai Alaska Refinery 11/25/2008
$F_{d\ HHV}$	9,081	dscf/MMBtu	F_d values derived based on fuel properties provided by the Tesoro Kenai Alaska Refinery 11/25/2008
$F_{d\ LHV}$	9,629	dscf/MMBtu	F_d values derived based on fuel properties provided by the Tesoro Kenai Alaska Refinery 11/25/2008
Sulfur Content (ULSD)	0.0015	% wt	
Density	6.752	lb/gal	Diesel Fuel Oil No. 1-D S15 Tesoro Kenai Alaska Refinery 11/25/2008

Table C-5 M-Value Determination for each Stack

Emission Source	Stack Height Above Base Elev. [1] (m)	Exhaust Temp. [2] (K)	Volumetric Flow Rate [3] (ACFM)	Stack Orientation	M-Value [4]	
					Vertical Units	Horizontal Units
Drill Rig Emission Units						
Main Drilling Engine 1	29.00	589	12,398.18	Horizontal	--	211.77
Main Drilling Engine 2	28.00	589	12,398.18	Horizontal	--	204.47
Main Drilling Engine 3	28.00	589	12,398.18	Horizontal.	--	204.47
Main Drilling Engine 4	29.00	589	12,398.18	Horizontal.	--	211.77
Emergency Generator	22.80	589	4,839.29	Horizontal	--	64.99
Cement Engine 1	19.00	589	2,014.70	Horizontal	--	22.55
Cement Engine 2	19.00	589	2,014.70	Horizontal.	--	22.55
Logging Winch	**13.50**	**589**	**934.86**	**Vertical**	**7.43**	**--**
Heater 1	13.50	505	1,401.45	Vertical	9.55	--
Heater 2	13.50	505	1,401.45	Vertical	9.55	--
Anchor Handling Tug Supply (AHTS) Vessel Emission Units						
Main Engine 1	14.76	589	13,548.01	Vertical	117.82	--
Main Engine 2	14.76	589	13,548.01	Vertical	117.82	--
Tow Winch Engine	14.56	589	3,749.45	Vertical	32.16	--
Thruster Engine 1	14.56	589	3,749.45	Vertical	32.16	--
Thruster Engine 2	14.56	589	3,749.45	Vertical	32.16	--
Generator 1	14.56	589	2,499.63	Vertical	21.44	--
Generator 2	14.56	589	2,499.63	Vertical	21.44	--
Emergency Generator	14.56	589	1,028.92	Vertical	8.83	--
Dedicated Oil Spill Response Vessel (OSRV) Emission Units						
Main Engine 1	3.91	589	11,444.83	Vertical	26.37	--
Main Engine 2	3.91	589	11,444.83	Vertical	26.37	--
Thruster Engine 1	3.68	589	4,100.75	Vertical	8.88	--
Thruster Engine 2	3.68	589	4,100.75	Horizontal.	--	8.88
Thruster Engine 3	4.21	589	4,100.75	Horizontal	--	10.17
Generator 1	4.21	589	3,549.48	Vertical	8.80	--
Generator 2	4.21	589	3,549.48	Vertical	8.80	--
Emergency Generator	**7.26**	**589**	**1,040.10**	**Horizontal**	**--**	**4.45**

1 Based on vendor data. For the drill rig emission units, this value is the distance from the platform. For vessels, this height is distance from the surface of the water. Drill rig emission units are based on the height above the platform.

2 Based on stack characteristics detailed above in **Table C-1** through **Table C-3**.

3 Based on F_d calculations detailed above in **Table C-1** through **Table C-3**.

4 M-Value = Stack Height x Stack Exit Temperature x Stack Exit Volumetric Flow. Note: The M-Value has been divided by 10^6 to make it easier to determine the smallest M-Value.

Table C-6 Modeled Volume Source Release Height Determination

Vessel/Emission Unit	Release Height (m)
Anchor Handling Tug Supply (AHTS) Vessel Emission Units	
Main Engine 1	14.76
Main Engine 2	14.76
Tow Winch Engine	14.56
Thruster Engine 1	14.56
Thruster Engine 2	14.56
Generator 1	14.56
Generator 2	14.56
Emergency Generator	14.56
Oil Spill Response Vessel (OSRV) Emission Units	
Main Engine 1	3.91
Main Engine 2	3.91
Thruster Engine 1	3.68
Thruster Engine 2	3.68
Thruster Engine 3	4.21
Generator 1	4.21
Generator 2	4.21
Emergency Generator	7.26
Offshore Supply Vessel (OSV) Emission Units	
Main Engine 1	3.30
Main Engine 2	3.30
Thruster Engine 1	3.30
Thruster Engine 2	**3.20**
Thruster Engine 3	**3.20**
Generator 1	3.30
Generator 2	3.30
Generator 3	3.30
Emergency Generator	3.60

Continued on the Next Page…

Table C-6 Modeled Volume Source Release Height Determination

Vessel/Emission Unit	Release Height (m)
Ware Vessel Emission Units	
Main Engine 1	15.25
Main Engine 2	15.25
Main Engine 3	15.25
Main Engine 4	15.25
Generator 1	15.25
Generator 2	15.25
Generator 3	15.25
Emergency Generator	15.25
Ice Breaker Emission Units	
Main Engine 1	30.50
Main Engine 2	30.50
Main Engine 3	30.50
Main Engine 4	30.50
Harbor Generator	29.58
Emergency Generator	28.91
Boiler 1	30.50
Boiler 2	30.50
Marine Research Vessel Emission Units	
Main Engine	10.40
Generator 1	10.40
Generator 2	10.40
Generator 3	10.40
Spill Storage Tanker Emission Units	
Main Engine 1	29.81
Generator 1	29.81
Generator 2	29.81
Generator 3	29.81
Emergency Generator	29.81
Boiler 1	29.81
Boiler 2	29.81

Appendix D
Regional Background Data Analysis

Regional Background Concentration Development

1.0 Introduction

In an effort to develop representative regional background concentrations to support a cumulative impact analysis in the vicinity of the 193 lease sale, pollutant concentration data were obtained from nearby monitoring sites in northern Alaska. Analyses were performed on these data to determine representative modeling background concentrations at both Point Lay and Wainwright, AK.

Monitoring stations which provided data necessary for this analysis included the Wainwright Permanent Monitoring Station, the Wainwright Near-Term Monitoring Station and the Point Lay Monitoring Station. The Point Lay Station is located at the northeast corner of the community of Point Lay, AK, off of Tuttunniagvik Street just north of Sisrik Avenue. It is maintained and operated by SLR International Corp. (SLR). The Wainwright Permanent Station is located just northeast of Wainwright, AK, about 0.25 miles northeast of the Summer Road/Blair Street intersection while the Wainwright Near-Term station was located about 75 yards southeast of the Tununiq Road/ Airport Road intersection on the eastern edge of Wainwright. Both stations were previously maintained and operated by AECOM Environment (AECOM). Maps showing the location of the three sites can be found in **Figure D-1** through **Figure D-3**. Many meteorological parameters have been collected at these sites, including wind speed and direction. In addition, ambient NO_2, SO_2, CO, O_3, PM_{10} and $PM_{2.5}$ concentration data are available from these sites.

Both the Wainwright Permanent and Point Lay stations were operational through 2010. Complete data sets covering the 2010 drilling season (July-November) were obtained from these two stations. The Wainwright Near-Term station was operational from November 2008 through November 2009. A complete dataset for the 2009 drilling season plus data for November 2008 were obtained from this station. The Point Lay data were provided by USEPA Region 10 and were used as-is. Data for both Wainwright stations were processed and provided by AECOM.

The following sections discuss the development of representative ambient background pollutant concentrations for all measured pollutants and averaging periods for which there is a National Ambient Air Quality Standard (NAAQS). A summary of the maximum regional ambient background pollutant concentrations for all stations is presented in **Table D-1** through **Table D-4**. A discussion of the proposed background concentration in these tables is found in Section 1.1. Section 1.2 provides a discussion on data quality control and near-field/far-field influences.

1.1 Proposed Background Concentrations

A summary of the maximum regional ambient background pollutant concentrations for both stations is presented in **Table D-1**through **Table D-4**[1]. **Table D-1** provides a summary of the proposed background concentrations. **Table D-2** through **Table D-4** provide detailed summaries of data collected at the Point Lay, Wainwright Permanent, and Wainwright Near-Term Stations used to derive the proposed background concentrations.

The proposed background concentrations consist of the highest and second-highest concentrations measured between the Point Lay, Wainwright Permanent, and Wainwright Near-Term monitoring stations. As discussed below, while data most heavily influenced by exceptional events were removed from the

[1] As discussed in Section 1.1.2, lead (Pb) concentrations were not measured directly but were calculated from measured $PM_{2.5}$ concentrations.

datasets, some measured concentrations that were influenced by the following were retained in the datasets and are reflected in the proposed background concentrations:

- exceptional events (i.e., wildfires),
- instrument drift,
- impacts from near-field fugitive sources, and
- impacts from community combustion sources.

Discussions of these influences for the Point Lay and Wainwright Permanent Stations can be found in Section 1.2, while detailed discussions of the Wainwright Near-Term Station data can be found in ConocoPhillips (2010a) and AECOM (2011).

A description of the averaging techniques used to derive the proposed background concentrations can be found in Section 1.1.1. A description of calculated lead concentration can be found in Section 1.1.2, while a description of data quality control is found in Section 1.1.3.

1.1.1 Derivation of the Proposed Background Concentrations

Once data were analyzed and quality controlled, remaining data were processed to find the highest and second highest measured background concentration values for different averaging periods. The results of this analysis can be found in **Table D-1** through **Table D-4**. Key points to consider when looking at these tables are as follows:

- Data collected at the Point Lay Monitoring Station and Wainwright Monitoring Station during the 2010 drilling season (July- November 2010) were used in **Table D-2** and **Table D-3**, respectively. **Table D-4** includes data obtained from the Wainwright Near-Term Station collected during drilling season 2009 plus November 2008.
- Unless otherwise noted, averages for each averaging period were developed as non-overlapping block averages utilizing valid hourly data starting at midnight local standard time. A discussion of the data removed from the background concentration analysis can be found in Section 1.1.3. In order for any block average to be included for this analysis, at least 75 percent of all possible hours within the block were required to be valid.
- The 8-hour rolling O_3 background concentrations represent the maximum 8-hour rolling average of valid measurements during the time period of interest. Eight-hour averages were calculated from overlapping blocks starting at midnight local standard time each day. In order for an averaging block to be included for this analysis, at least 75 percent of all possible hours within the block were required to be valid.
- The quarter average $PM_{2.5}$, PM_{10} and Pb background concentrations represent the average of all valid hourly measurements made during each quarter of a drilling season. Only two quarters are available during a full drilling season for the Point Lay and Wainwright Permanent Stations – one full and one partial. One quarter included July, August, and September. The other quarter included October and November. Since the Wainwright Near-Term station included November 2008 data, November 2008 was included as an additional month in that dataset.
- The three month rolling $PM_{2.5}$, PM_{10} and Pb background concentrations represent a 90-day rolling average. Each rolling average was developed by averaging overlapping blocks of valid hourly data beginning at midnight local standard time. In order for a 90-day period to be utilized in the overall rolling average, at least 75 percent of all possible hours within that 90-day period were required to be valid.
- Lead (Pb) concentrations were derived by applying a conversion factor to the averaged standard $PM_{2.5}$ measurements (see Section 1.1.2 for further details).

1.1.2 Background Pb Calculations

Since Pb was not directly measured at any of the monitoring stations, Pb air quality background concentrations were calculated using $PM_{2.5}$ concentration measurements. $PM_{2.5}$ measurements are the appropriate surrogate for this approach since all project Pb emissions are the result of combustion and will be emitted as a subset of $PM_{2.5}$.

As discussed in USEPA (1997), combustion processes emit Pb in the submicron particle size range due to the elevated temperatures at which these processes take place. As the particles are transported from the source they agglomerate into 0.1 to 2 micron sized particles where they remain stable. Furthermore, USEPA documents that many studies of atmospheric Pb concentrations have confirmed that ambient urban and rural air contain Pb particles predominantly in the 0.2 to 0.3 µm size range. Pb in ambient air is produced as a result of combustion processes. Therefore, Pb in ambient air will be predominately in the submicron size range and will be a component of measured $PM_{2.5}$ concentrations.

The conversion factor used in the Pb calculations was 0.00143 – the fraction of Pb in measured $PM_{2.5}$ concentrations from liquid fuel combustion. This is based on the ratio of the Pb emission factor (9.0×10^{-6} lb/MMBtu) to the $PM_{2.5}$ emission factor (6.28×10^{-3} lb/MMBtu) for liquid fuel-fired boilers published by USEPA in AP42 (USEPA 2010). The ratio is based on boiler emissions since that approach yields a higher value than using the emission factors for liquid fuel fired internal combustion engines.

1.1.3 Quality Control of Data

Data obtained from the Point Lay Monitoring Station were quality controlled by SLR International. Details regarding data quality control procedures, data processing, and sensor calibrations can be found in SLR's quarter A and quarter B data summaries (SLR International 2011a; b). Data obtained from the Wainwright Permanent Monitoring Station and Wainwright Near-Term Monitoring Station were quality controlled by AECOM. Details regarding data quality control procedures, data processing, and sensor calibrations can be found in AECOM's quarterly reports (AECOM 2010a;b, AECOM 2009a;b;c;d, CP 2010).

There were a few data periods which contained very high measured concentrations that can be attributed to exceptional events. Known wildfires on July 8 through 10, July 31, and August 1 and 2, 2010 contributed to unusually high measured $PM_{2.5}$ and PM_{10} concentrations on those dates (AECOM 2010a). As a result, data during these timeframes were not included in the $PM_{2.5}$ and PM_{10} background concentration analyses.

In addition, an abnormally high PM_{10} hourly value on November 30, 2010 was eliminated from the Point Lay data set as it did not match the data given in the Quarterly Data Summary provided by SLR International (SLR 2011). According to SLR (2011), work was being performed on the PM monitor just before the abnormally high value was recorded.

1.2 Influences of Non-Modeled Sources

Plots of the 2010 drilling season NO_2, SO_2, CO, O_3, PM_{10} and $PM_{2.5}$ datasets for the Wainwright Permanent and Point Lay monitoring stations were created to understand the near field/far field impacts of pollutants at both monitoring stations, and can be found in **Figure D-4** through **Figure D-16** . A discussion regarding each measured pollutant is provided in the following subsections.

1.2.1 NO_2 Discussion

The plots of hourly Point Lay and Wainwright NO_2 measurements (**Figure D-4** and **Figure D-5**) indicate low concentrations with intermittent time periods of higher concentrations. The NO_2 pollutant rose plots (**Figure D-6** and **Figure D-7**) show average NO_2 concentrations by wind direction for Wainwright and Point Lay. These plots indicate that the highest concentrations occur during southerly winds for Point Lay,

and northwesterly winds for Wainwright, clearly showing that community influences are included in the data. Known NO_2 sources in these respective wind directions relative to the monitoring sites include a power plant located just to the west-northwest of the Wainwright Station, and a power plant located just south of the Point Lay Station.

Note that the maximum NO_2 1-hour averages at the Wainwright Near-Term Station (**Table D-4**) are caused by near-field mobile or stationary source activity, as documented in AECOM (2011).

1.2.2 CO and SO_2 Discussion

The plots of hourly Point Lay and Wainwright CO and SO_2 measurements (**Figure D-8** and **Figure D-9**) indicate that CO and SO_2 background concentrations at both sites are very low. The stair-step nature of the Point Lay data seems to indicate instrument drift (within acceptable limits) of the Point Lay instruments. According to the SLR Quarter A Data Summary (SLR 2011), the SO_2 instrument was down just prior to the abrupt decrease in concentration at the beginning of August. The instrument was being calibrated just prior to the drop during September, and was being audited just prior to the large drop in CO during October. The Wainwright dataset provided by AECOM had instrument drift adjusted out. It is unknown whether similar adjustments were made to the data collected by SLR International. Background concentrations do include positive instrument drift from near-zero ambient concentration and are therefore biased high compared to actual ambient concentrations.

The highest and second-highest 1-hour SO_2 concentrations found in **Table D-4** at the Wainwright Near-Term Station are likely caused by near-field sources. It is known that the NO_2 dataset was influenced by near-field mobile or stationary source activity within only days of the SO_2 maximums (AECOM 2011).

1.2.3 O_3 Discussion

A 72-hour rolling average plot of measured Point Lay and Wainwright O_3 concentrations is provided in **Figure D-10**. This plot shows a strong correlation between the two sites, indicating that O_3 concentrations are regional in nature and not significantly influenced by near-field sources. Any near-field influences on regional O_3 concentrations are small compared to the background.

1.2.4 $PM_{2.5}$ Discussion

Plots of measured hourly $PM_{2.5}$ concentrations at Wainwright and Point Lay are provided in **Figure D-11**. Even though some of the highest wildfire-contaminated $PM_{2.5}$ concentrations were excluded from this analysis, various wildfire contaminations may still be present in the data utilized. Higher concentrations found during the beginning of July and beginning of August time periods highlight this possibility. Note that Wainwright's highest 24-hour average $PM_{2.5}$ concentration presented in **Table D-3** occurred on August 2, the day of a known wildfire. It is likely that the Wainwright $PM_{2.5}$ background concentrations are influenced by impacts due to wildfires (i.e., exceptional events). Point Lay's maximum 24-hour $PM_{2.5}$ concentrations occurred on July 2 and November 16.

The $PM_{2.5}$ pollutant rose plots (**Figure D-12** and **Figure D-13**) show average $PM_{2.5}$ concentrations by wind direction for both Wainwright and Point Lay. These plots indicate that average concentrations in all directions are very small. The highest concentrations tend to occur during southwest winds. The community of Point Lay is just to the southwest of the Point Lay monitoring station, and the community of Wainwright is just to the southwest of the Wainwright monitoring stations. While both communities have sources of $PM_{2.5}$ and could be contributing to the background, instrument noise may also be a strong contributor as most values are within the noise thresholds of the instrument. The sporadic nature of the plots may also be attributed to instrument noise.

1.2.5 PM_{10} Discussion

Plots of measured hourly PM_{10} concentrations at Wainwright and Point Lay are provided in **Figure D-14**. Even though some the highest wildfire-contaminated PM_{10} concentrations were excluded from this analysis, some wildfire influences may still be present in the data utilized. Higher concentrations found during the beginning of July and beginning August time periods highlight this possibility. Note that Point Lay's highest 24-hour PM_{10} concentration occurred on August 3 and Wainwright's highest 24-hour PM_{10} concentration occurred on August 2, the day after and the day of a known wildfire respectively. It is likely that the PM_{10} background concentrations presented in **Table D-2** and **Table D-3** are influenced by these exceptional events.

PM_{10} pollutant rose plots (**Figure D-15** and **Figure D-16**) show average PM_{10} concentrations by wind direction for both Wainwright and Point Lay. As expected, the highest concentrations occur when the wind is out of the southwest, or from the communities. Fugitive dust from these nearby towns may be contributors to the background concentrations at both sites.

Table D-1 Proposed Background Concentrations

Pollutant	Averaging Period	Proposed Background Concentrations			
		H1H[1]		H2H[2]	
		ppm	µg/m^3	ppm	µg/m^3
Sulfur Dioxide (SO_2)	1-hr	0.009	23.6	0.008	20.9
	3-hr	0.007	18.3	0.005	13.1
	24-hr	0.005	13.1	0.005	13.1
	Drilling Season	0.002	4.7		
Nitrogen Dioxide (NO_2)	1-hr	0.035	65.8	0.034	63.9
	Drilling Season	0.001	1.9		
Carbon Monoxide (CO)	1-hr	0.900	1030.3	0.900	1030.3
	8-hr	0.900	1030.3	0.900	1030.3
$PM_{2.5}$ (Actual)	24-hr		11.0		6.3
	3 month rolling		1.6		1.6
	Quarter		1.5		1.1
	Drilling Season		1.2		
PM_{10} (Standard)	24-hr		60.7		42.8
	3 month rolling		8.1		8.1
	Quarter		8.0		4.8
	Drilling Season		5.8		
Ozone (O_3)	8-hr rolling	0.040	78.5	0.040	78.5
Lead (Pb)	3 month rolling		0.002		0.002
	Quarter		0.002		0.002

1 Highest first-highest (H1H) measured concentration.
2 Highest second-highest (H2H) measured concentration.

Table D-2 Concentration Measurements for the Point Lay Monitoring Station

Pollutant	Averaging Period	Point Lay Station Ambient Measurements[1]			
		H1H[2]		H2H[3]	
		ppm	µg/m^3	ppm	µg/m^3
Sulfur Dioxide (SO_2)	1-hr	0.006	15.7	0.006	15.7
	3-hr	0.005	13.1	0.005	13.1
	24-hr	0.005	13.1	0.005	13.1
	Drilling Season	0.002	4.7		
Nitrogen Dioxide (NO_2)	1-hr	0.033	62.1	0.026	48.9
	Drilling Season	0.000	0.0		
Carbon Monoxide (CO)	1-hr	0.900	1030.3	0.900	1030.3
	8-hr	0.900	1030.3	0.900	1030.3
$PM_{2.5}$ (Actual)	24-hr		6.0		6.0
	3 month rolling		1.6		1.6
	Quarter		1.5		0.4
	Drilling Season		1.0		
PM_{10} (Standard)	24-hr		19.3		16.9
	3 month rolling		5.7		5.7
	Quarter		5.6		4.8
	Drilling Season		5.3		
Ozone (O_3)	8-hr rolling	0.040	78.5	0.040	78.5
Lead (Pb)	3 month rolling		0.002		0.002
	Quarter		0.002		0.001

1 Includes only valid data within the July – November 2010 data range.
2 Highest first-highest (H1H) measured concentration.
3 Highest second-highest (H2H) measured concentration.

Table D-3 Concentration Measurements for the Wainwright Permanent Monitoring Station

Pollutant	Averaging Period	Wainwright Permanent Station Ambient Measurements[1]			
		H1H[2]		H2H[3]	
		ppm	µg/m^3	ppm	µg/m^3
Sulfur Dioxide (SO_2)	1-hr	0.004	10.5	0.004	10.5
	3-hr	0.003	7.9	0.003	7.9
	24-hr	0.002	5.2	0.001	2.6
	Drilling Season	0.000	0.0		
Nitrogen Dioxide (NO_2)	1-hr	0.017	32.0	0.017	32.0
	Drilling Season	0.000	0.0		
Carbon Monoxide (CO)	1-hr	0.700	801.3	0.700	801.3
	8-hr	0.650	744.1	0.638	730.4
$PM_{2.5}$ (Actual)	24-hr		11.0		6.3
	3 month rolling		1.2		1.2
	Quarter		1.4		1.1
	Drilling Season		1.2		
PM_{10} (Standard)	24-hr		60.7		42.8
	3 month rolling		8.1		8.1
	Quarter		8.0		2.7
	Drilling Season		5.8		
Ozone (O_3)	8-hr rolling	0.038	74.5	0.038	74.5
Lead (Pb)	3 month rolling		0.002		0.002
	Quarter		0.002		0.002

1 Includes only valid data within the July – November 2010 data range.
2 Highest first-highest (H1H) measured concentration.
3 Highest second highest (H2H) measured concentration.

Table D-4 Concentration Measurements for the Wainwright Near-Term Monitoring Station

Pollutant	Averaging Period	Wainwright Near-Term Station Ambient Measurements[1]			
		H1H[2]		H2H[3]	
		ppm	µg/m^3	ppm	µg/m^3
Sulfur Dioxide (SO_2)	1-hr	0.009	23.6	0.008	20.9
	3-hr	0.007	18.3	0.005	13.1
	24-hr	0.004	10.5	0.002	5.2
	Drilling Season	0.000	0.0		
Nitrogen Dioxide (NO_2)	1-hr	0.035	65.8	0.034	63.9
	Drilling Season	0.001	1.9		
Carbon Monoxide (CO)	1-hr	0.839	960.5	0.832	952.4
	8-hr	0.826	945.6	0.326	373.2
$PM_{2.5}$ (Actual)	24-hr		not available		not available
	3 month rolling		not available		not available
	Quarter		not available		not available
	Drilling Season		not available		not available
PM_{10} (Standard)	24-hr		not available		not available
	3 month rolling		not available		not available
	Quarter		not available		not available
	Drilling Season		not available		not available
Ozone (O_3)	8-hr rolling	0.036	70.6	0.036	70.6
Lead (Pb)	3 month rolling		not available		not available
	Quarter		not available		not available

1 Includes only valid data within the November 2008 – November 2009 data range.
2 Highest first-highest (H1H) measured concentration.
3 Highest second-highest (H2H) measured concentration.

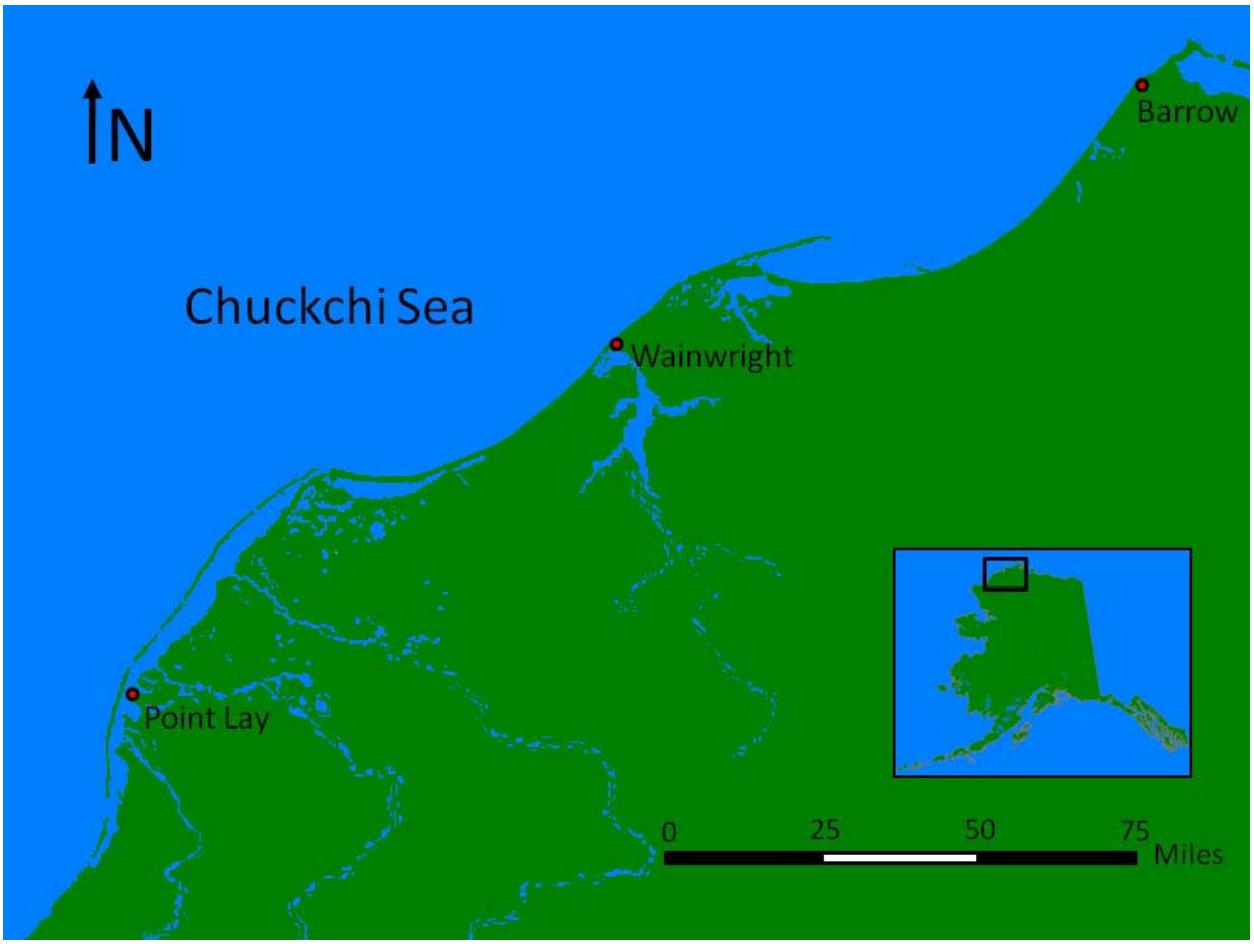


Figure D-1 Monitoring Station Locations
(Source: SLR, 2010a)

Figure D-2 Map of Immediate Area Surrounding the Wainwright Permanent Monitoring Station and the Wainwright Near-Term Monitoring Station
(Sources: AECOM, 2010a and CP 2010)

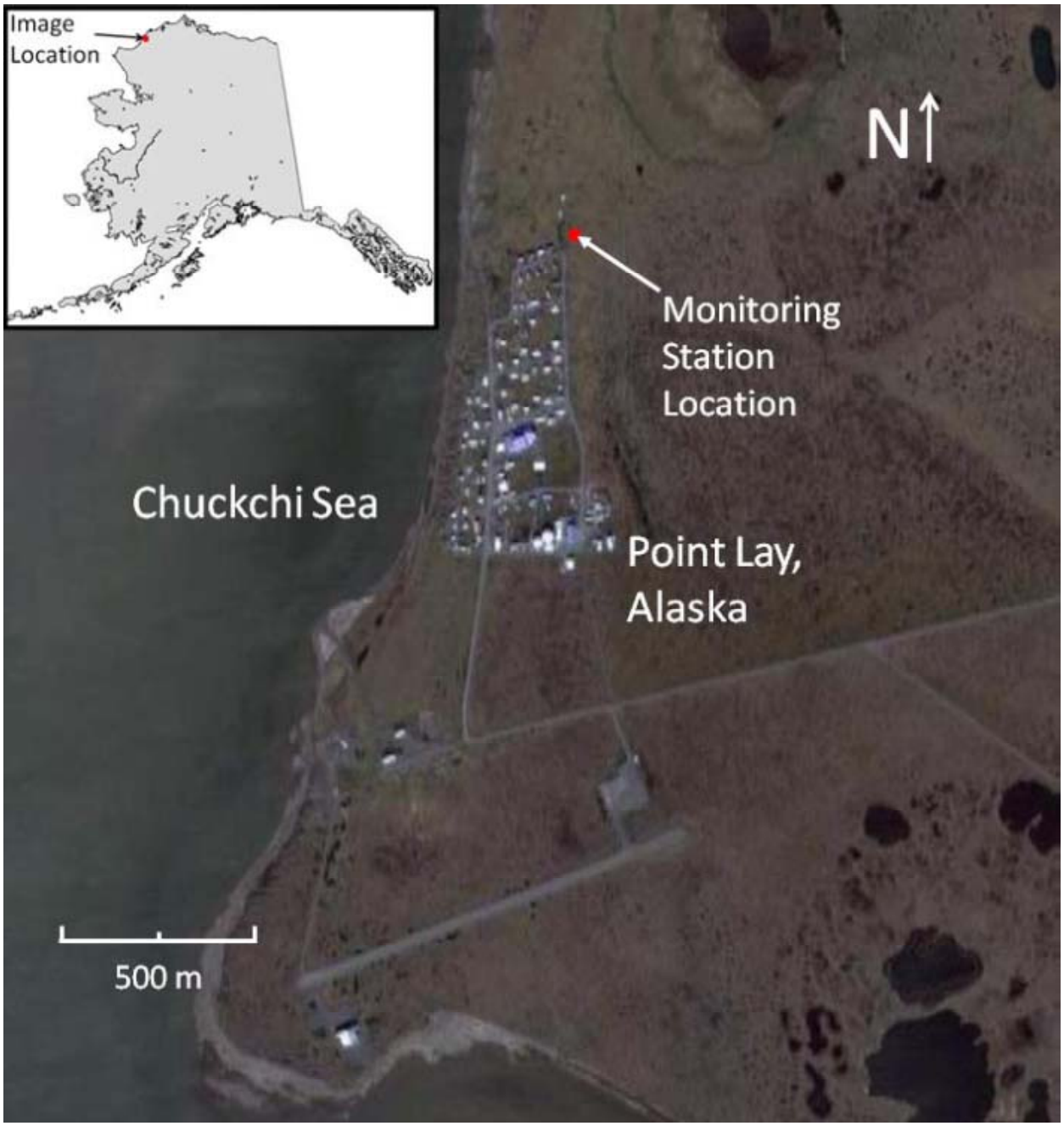


Figure D-3 Map of Immediate Area Surrounding Point Lay Monitoring Station (Source: SLR, 2010a)

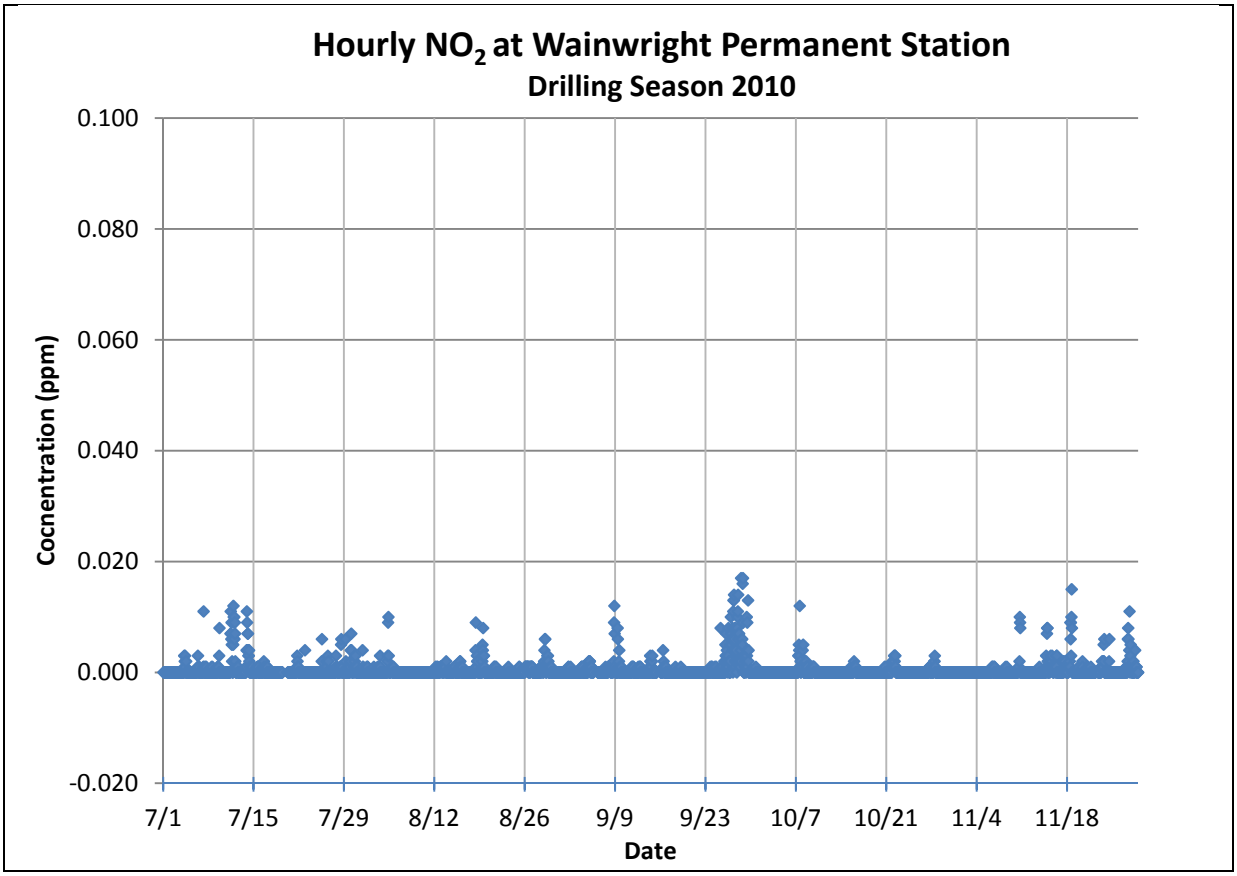


Figure D-4 **1-hour Average Wainwright Permanent Station NO_2 Concentration Measurements for Drilling Period (July – November 2010)**

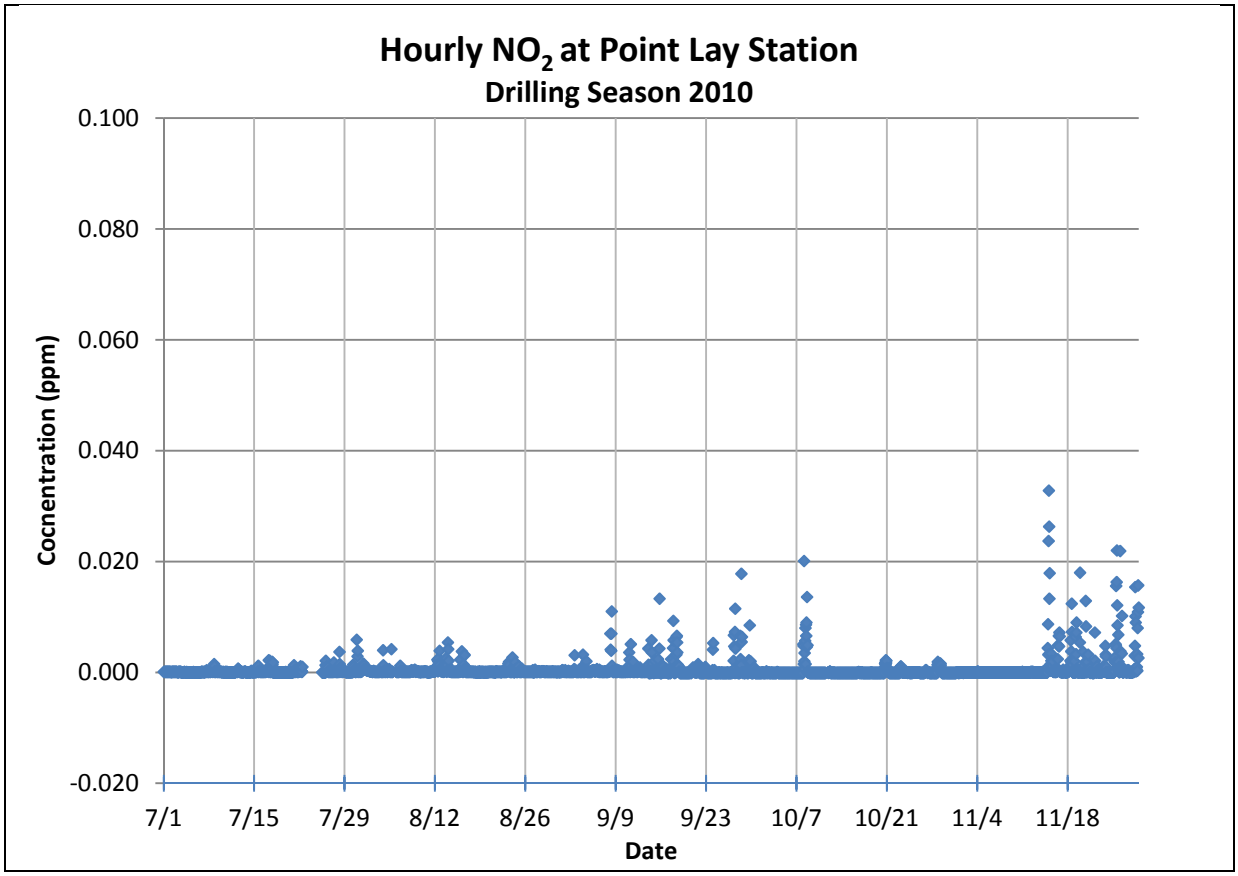


Figure D-5 **1-hour Average Point Lay Station NO_2 Concentration Measurements for Drilling Period (July – November 2010)**

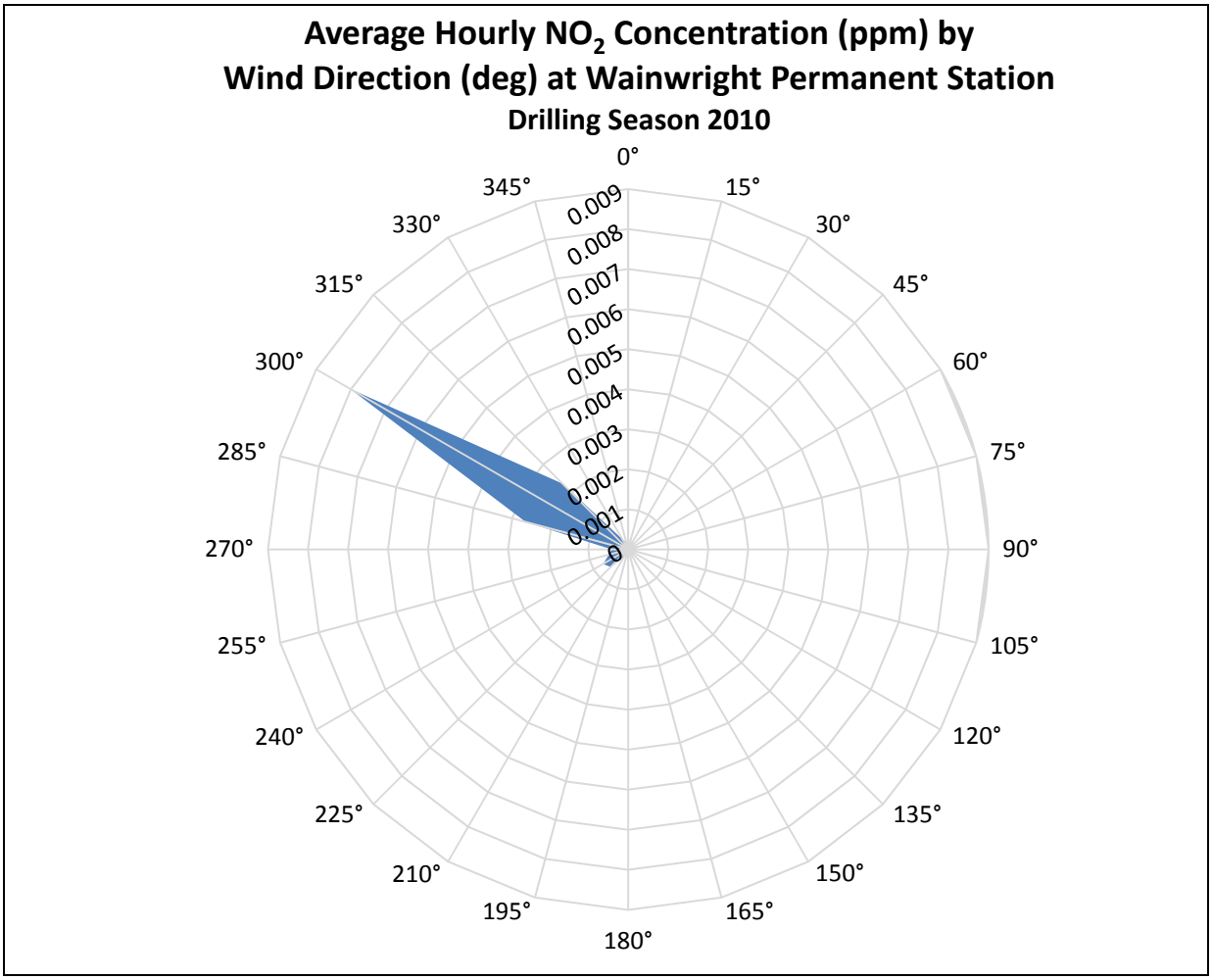


Figure D-6 **Average Hourly NO_2 Pollutant Rose by Wind Direction at Wainwright Permanent Station for Drilling Period (July – November 2010)**

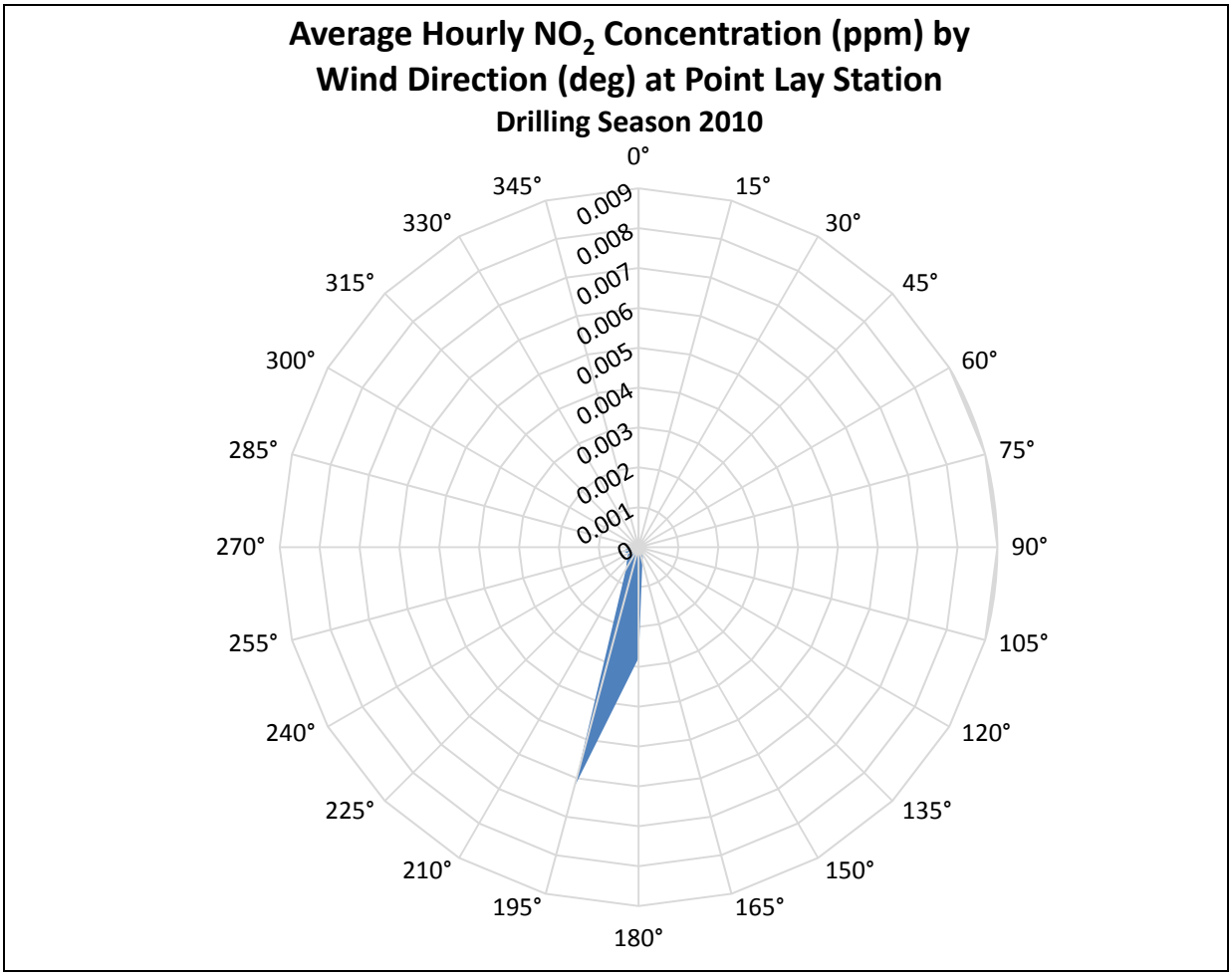


Figure D-7 **Average Hourly NO_2 Pollutant Rose by Wind Direction at Point Lay Station for Drilling Period (July – November 2010)**

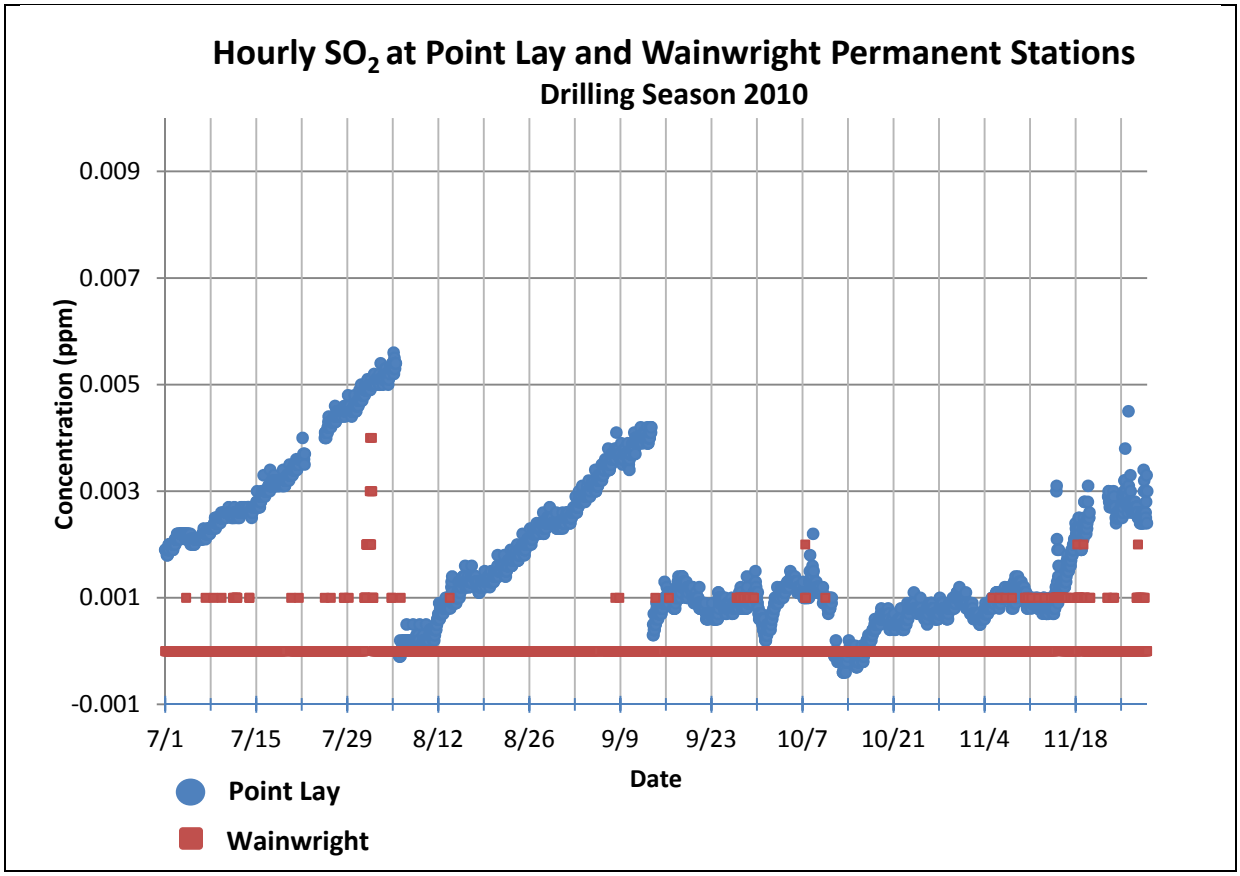


Figure D-8 **1-hour Average Point Lay and Wainwright Permanent Station SO_2 Concentration Measurements for Drilling Period (July – November 2010)**

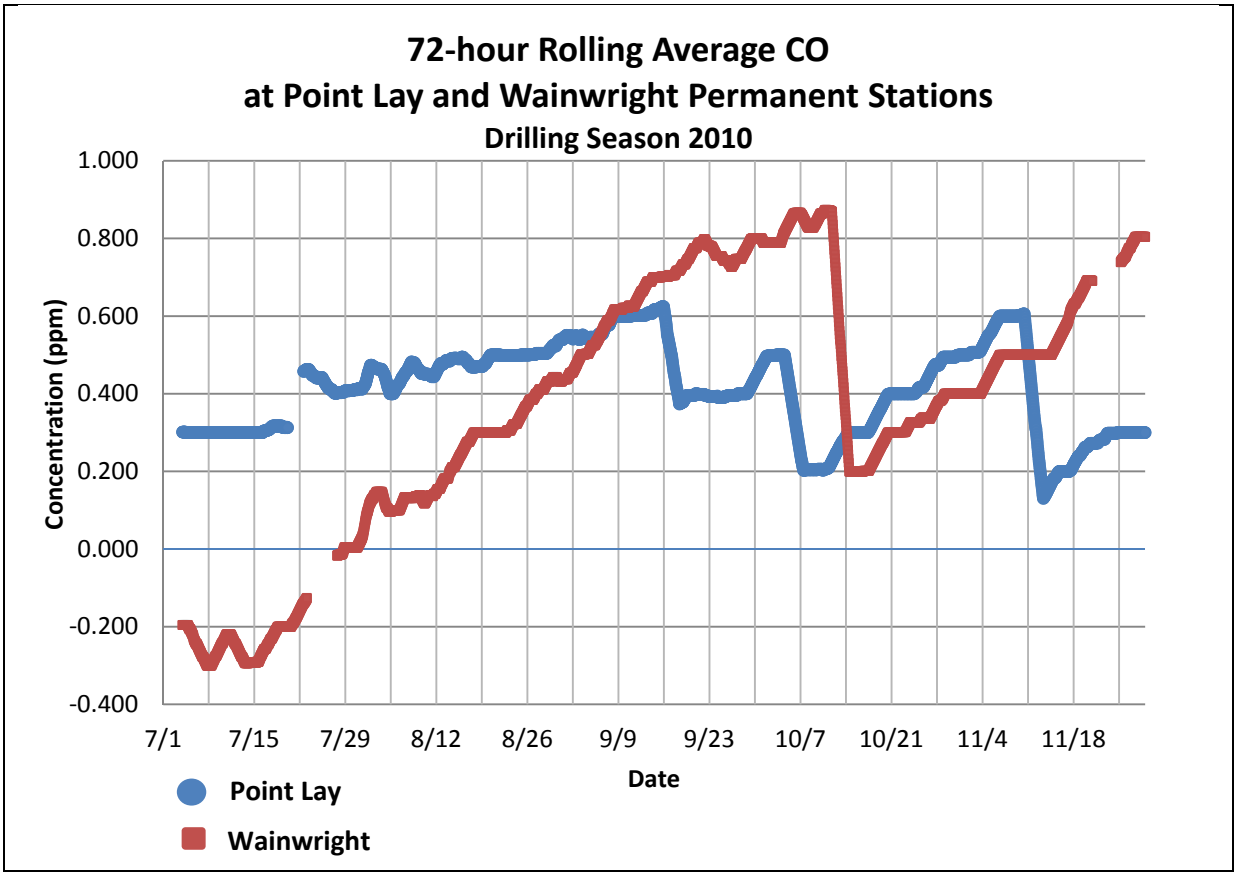


Figure D-9 **72-hour Rolling Average of Point Lay and Wainwright Permanent Station Hourly Measured CO Concentrations for Drilling Period (July – November 2010)**

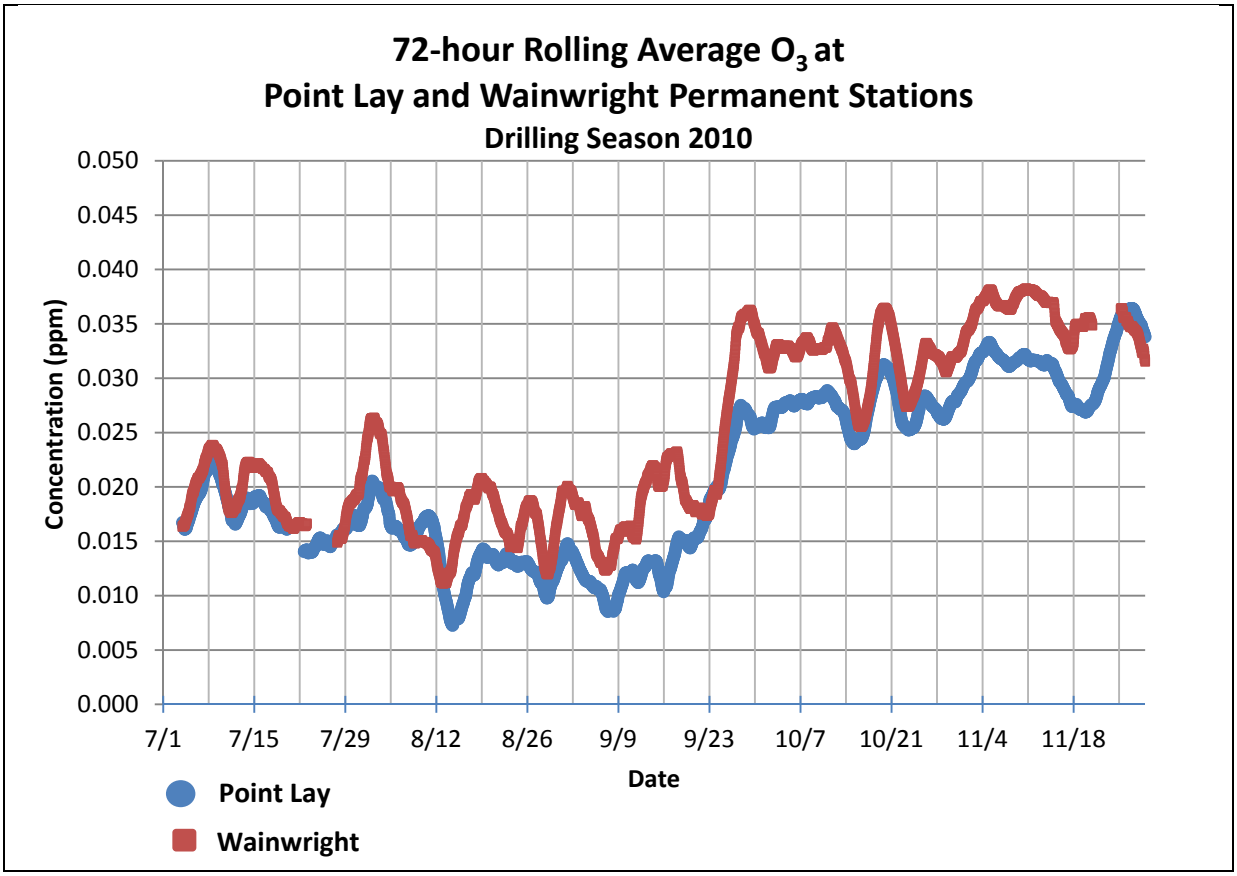


Figure D-10 **72-hour Rolling Average of Point Lay and Wainwright Permanent Station Measured O_3 Concentrations for Drilling Period (July – November 2010)**

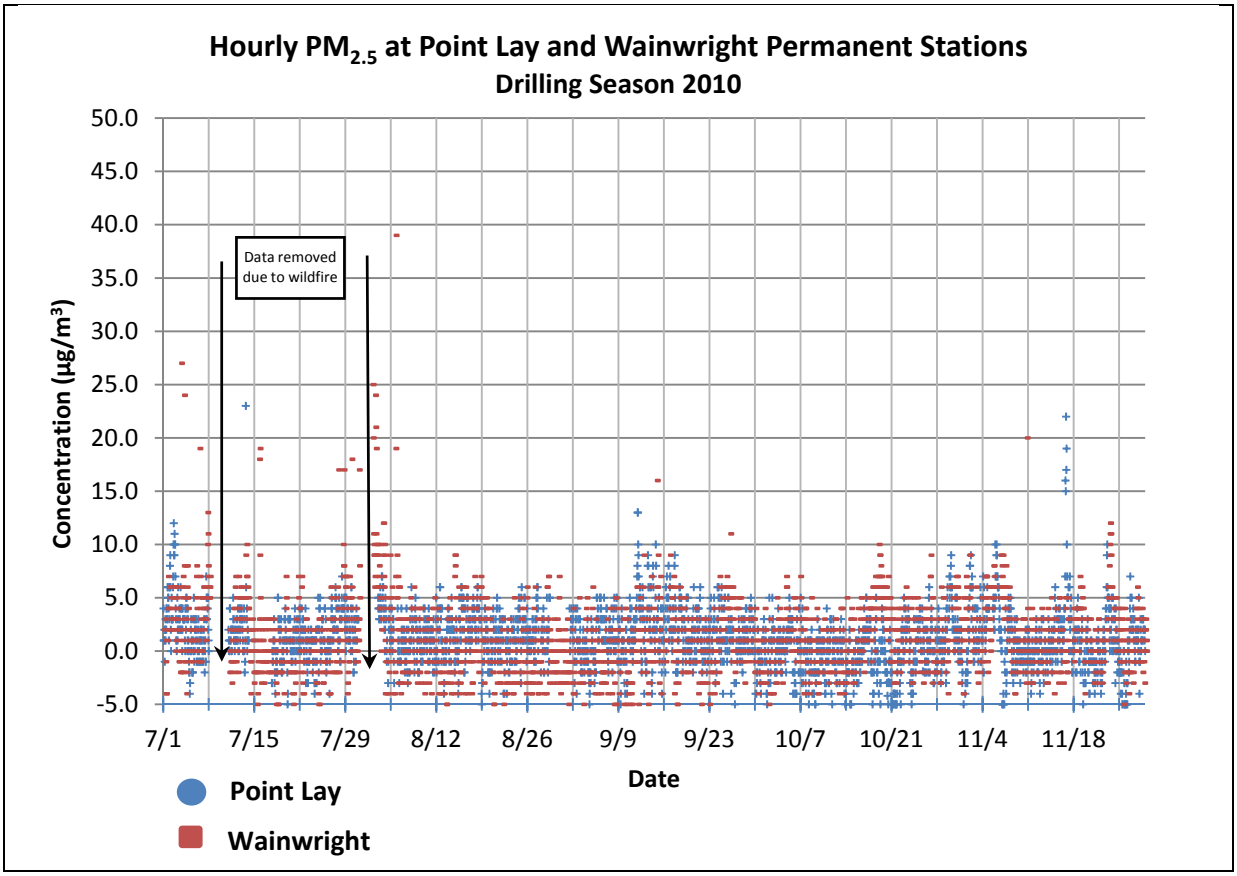


Figure D-11 **1-hour Average Point Lay and Wainwright Permanent Station $PM_{2.5}$ Concentration Measurements for Drilling Period (July – November 2010)**

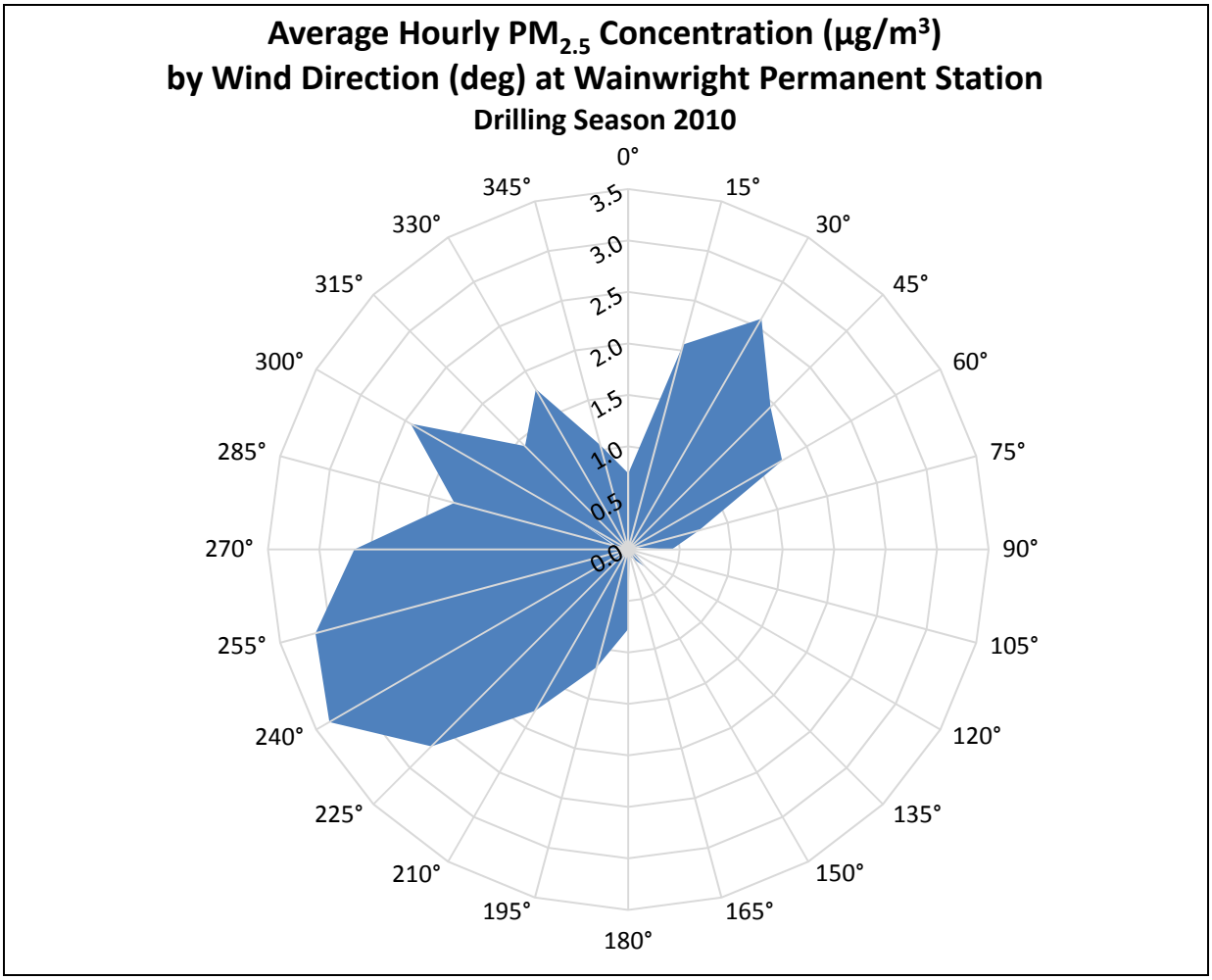


Figure D-12 Average Hourly $PM_{2.5}$ Pollutant Rose by Wind Direction at the Wainwright Permanent Station for Drilling Period (July – November 2010)

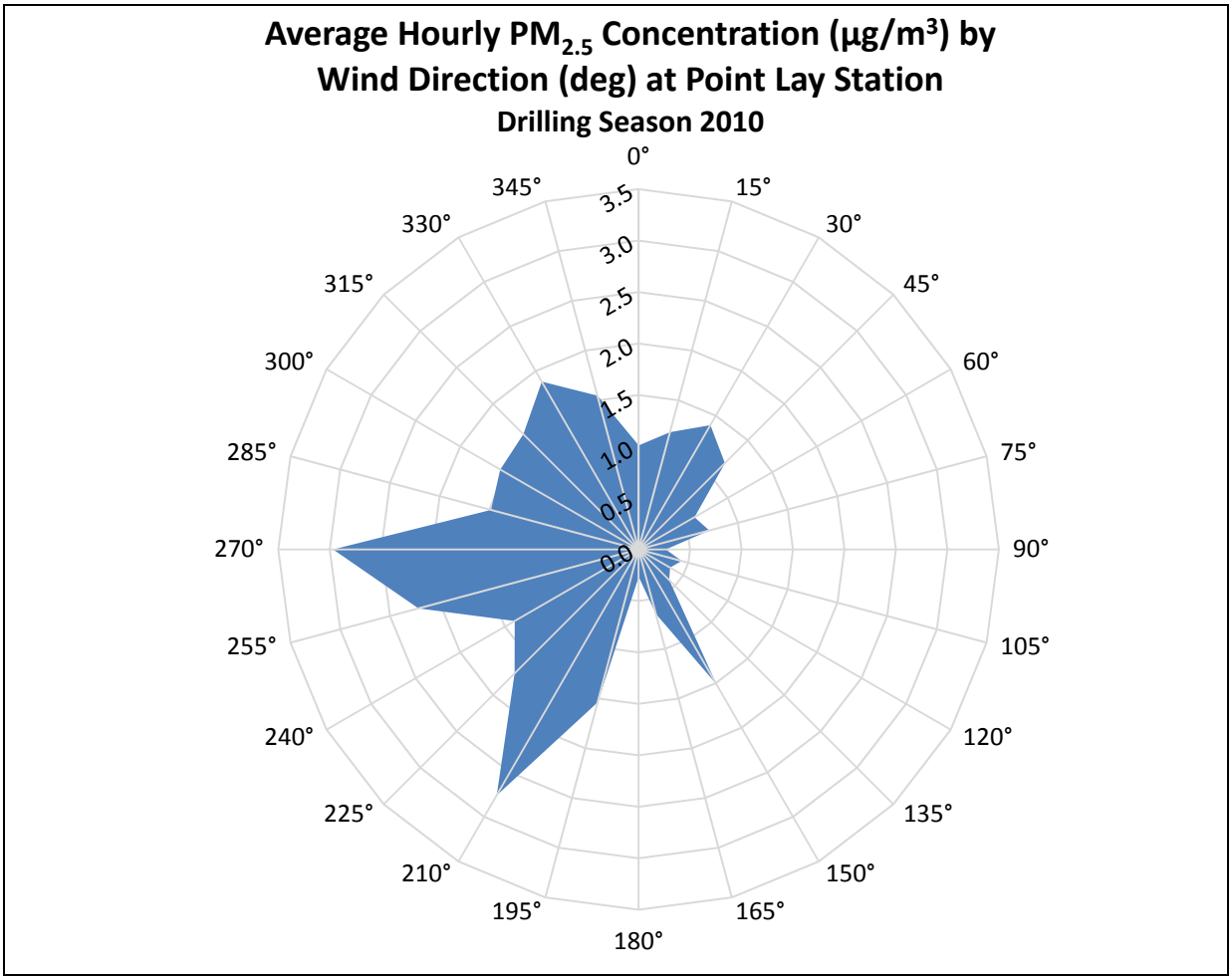


Figure D-13 Average Hourly $PM_{2.5}$ Pollutant Rose by Wind Direction at the Point Lay Station for Drilling Period (July – November 2010)

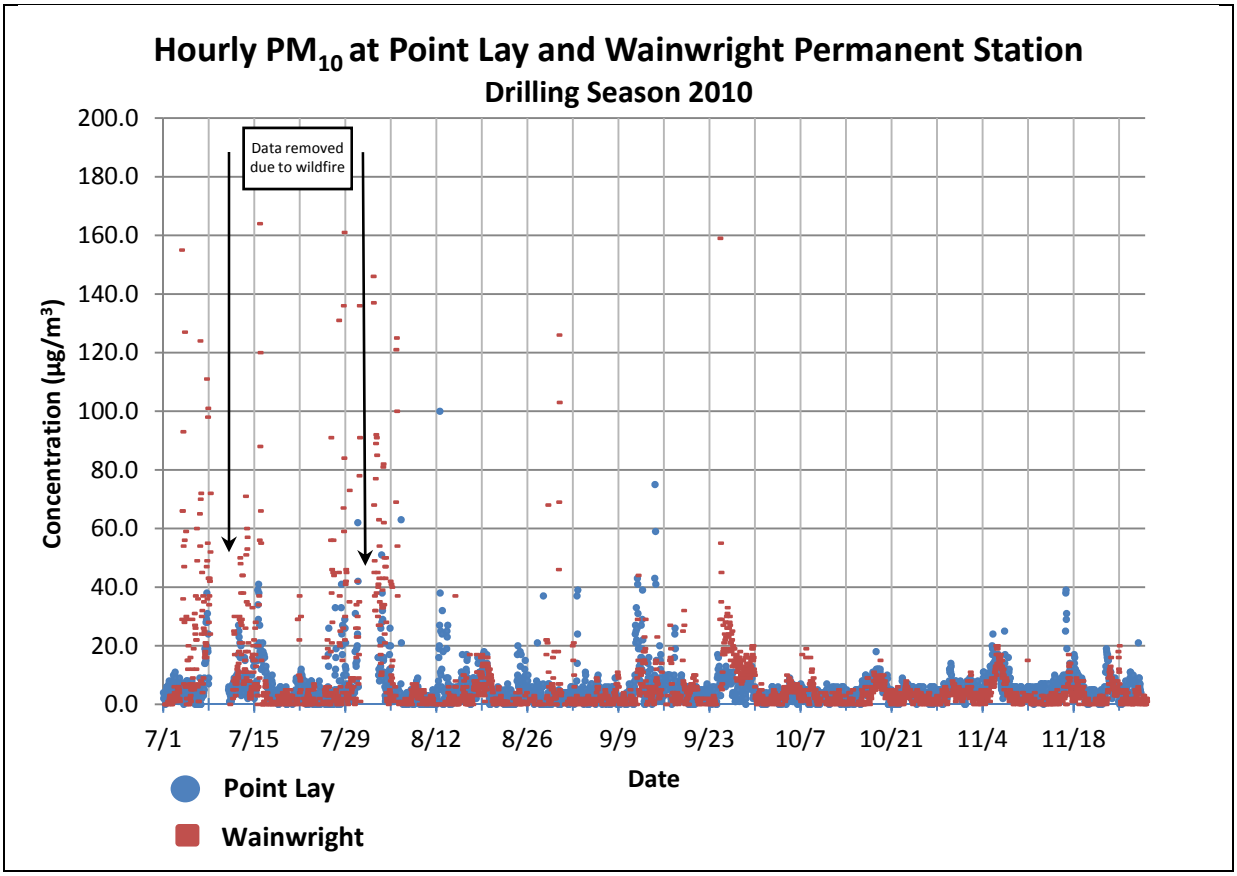


Figure D-14 **1-hour Average Point Lay and Wainwright Permanent Station PM_{10} Concentration Measurements for Drilling Period (July – November 2010)**

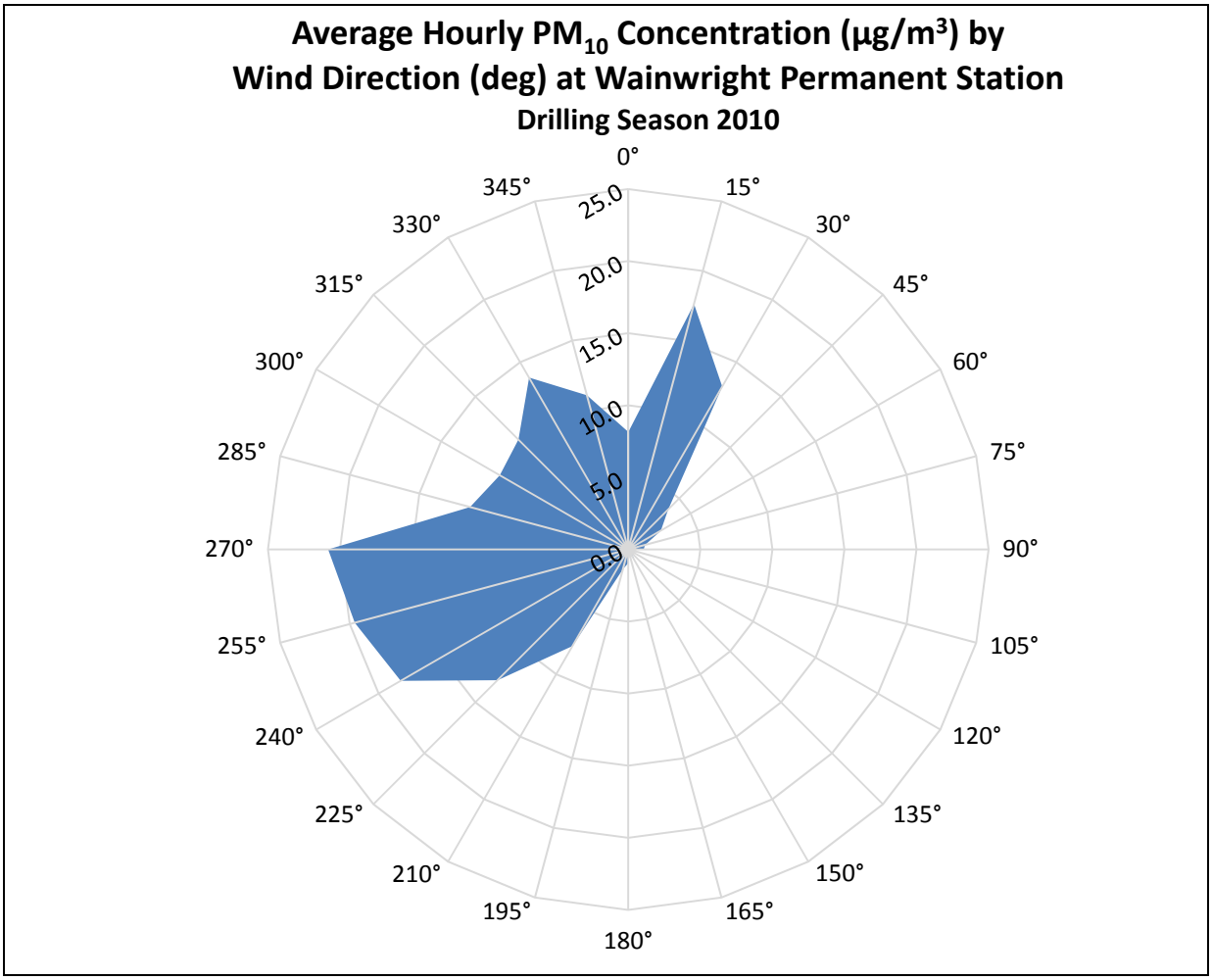


Figure D-15 **Average Hourly PM_{10} Pollutant Rose by Wind Direction at the Wainwright Permanent Station for Drilling Period (July – November 2010)**

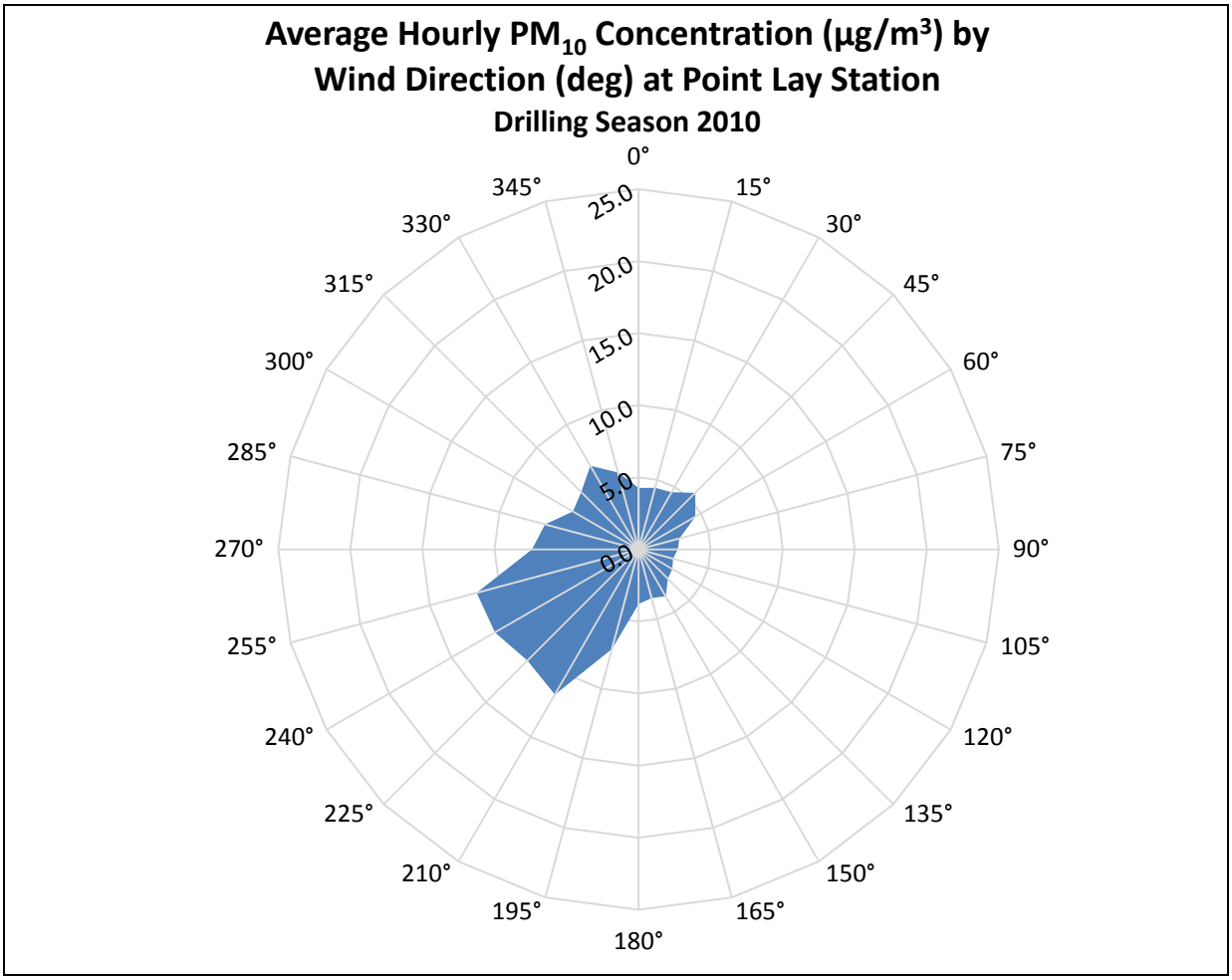


Figure D-16 **Average Hourly PM_{10} Pollutant Rose by Wind Direction at the Point Lay Station for Drilling Period (July – November 2010)**

2.0 References

AECOM 2009a. Wainwright Near-Term Ambient Air Quality Monitoring Program First Quarter Data Report, November 2008 through January 2009. AECOM Environment, Fort Collins, CO. March 2009. Submitted to USEPA Region 10 March 27, 2009.

_____. 2009b. Wainwright Near-Term Ambient Air Quality Monitoring Program Third Quarter Data Report, May through July 2009. AECOM Environment, Fort Collins, CO. August 2009. Submitted to USEPA Region 10 September 10, 2009.

_____. 2009c. Wainwright Near-Term Ambient Air Quality Monitoring Program Fourth Quarter Data Report, August and October 2009. AECOM Environment, Fort Collins, CO. August 2009. Submitted to ConocoPhillips Alaska, Inc. December 2009.

_____. 2009d. Wainwright Near-Term Ambient Air Quality Monitoring Program Monthly Preliminary Data Summary Final. November and December 2009. AECOM Environment, Fort Collins, CO. Submitted to ConocoPhillips Alaska, Inc. January 2010.

AECOM 2010a. Wainwright Permanent Ambient Air Quality Monitoring Program Third Quarter Data Report; July through September 2010. AECOM Environment, Fort Collins, CO. Submitted to US EPA Region 10 November 29, 2010.

_____. 2010b. Wainwright Permanent Ambient Air Quality Monitoring Program Fourth Quarter Data Report; October through December 2010. AECOM Environment, Fort Collins, CO. Submitted to USEPA Region 10. March 16, 2011.

AECOM. 2011. ConocoPhillips OCS Air Permit Application Air Quality Impact Analysis Revised Ambient Background Concentrations. AECOM Environment, Fort Collins, CO. Submitted to ConocoPhillips, Anchorage, AK. February 2011.

SLR International Corp. 2011a. Quarter A Data Summary for the Point Lay Comprehensive Ambient Air and Meteorological Monitoring Program. Prepared for Shell Offshore, Inc. June 2011

_____. 2011b. Quarter B Data Summary for the Point Lay Comprehensive Ambient Air and Meteorological Monitoring Program. Prepared for Shell Offshore, Inc. June 2011

ConocoPhillips Company (CoP). 2010a. ConocoPhillips Wainwright Near-Term Ambient Air Quality Monitoring Program Annual Data Report. November 2008 through November 2009. Submitted to USEPA Region 10. April 19, 2010.

United States Environmental Protection Agency (USEPA). 1997. Guidance for Siting Ambient Air Monitors Around Stationary Lead Sources. USEPA Office of Air Quality Planning and Standards. Research Triangle Park, NC 27711. EPA-4541R-92-009. August 1997.

_____. 2010. AP42 -Fuel Oil Combustion from External Combustion Sources Table 1.3-10 “Emission Factors for Trace Elements from Distillate Fuel Oil Combustion Sources” and Table 1.3-7 “Cumulative Particle Size Distribution and Size-Specific Emission Factors from Uncontrolled Commercial Coilers Burning Residual or Distillate Oil”. May 2010.

Appendix E
Shell OCS Source Offsite Inventory Development

Shell OCS Source Offsite Inventory Development

1.0 Introduction

The purpose of this section is to document the development of the Shell OCS Source inventory included in modeling supporting cumulative impact analyses conducted for the ConocoPhillips Company (COP) Chukchi Sea exploratory drilling project. The offsite inventory was prepared using the Shell Chukchi Permit Application (Shell 2011), supplemental documentation produced by Region 10 in support of the Shell Chukchi air quality permit (Region 10 Shell TSD)(USEPA 2011b) and the modeling files submitted by Shell in support of their permit application for their drilling operations in the Chukchi Sea (Shell Model I/O)(USEPA 2011a).

To maintain consistency with the approach in modeling COP project emissions, the Shell OCS Source was simplified by:

- Collocating the sources representing the Shell drillship and mobile support vessel fleet and modeling them without downwash eliminating the need to make the simulation wind direction dependent;
- Not conducting hour-by-hour modeling; therefore, all emission units were assumed to operate continuously during the drilling season;
- Modeling a single worst-case scenario rather than three scenarios (MLC Case, Drilling Case and Cement/Logging Case)
- Modeling only two sources: one point source representing the drillship and static vessels located near the drillship and one volume source representing the mobile support vessels; and
- Modeling the entire annual Potential to Emit (PTE) in a 4 month period.

These revisions are discussed further below.

2.0 Development of Modeled Emission Rates

2.1 Short Term Emission Rates

The Shell Model I/O were analyzed and processed to develop emission rates to use in the simplified modeling approach. To develop the modeled emission rate for the single point source, the maximum point source emission rates across all operating scenarios from the Shell Model I/O were summed together to develop the emission rate for the single modeled point source.

To develop the modeled emission rate for the single volume source, the area source emission rates documented by Shell were converted to actual emission rates by multiplying the AREMIS rate used in the Shell Model I/O with the area reported in the Shell Chukchi Permit Application. This resulted in the actual emission rate for each source. The actual emission rate for each source across all operating scenarios were summed together to develop the emission rate for the single modeled volume source.

In all cases the emission rates from the Shell Model I/O were compared with the maximum emission rates reported in the Shell Chukchi Permit Application (reference Attachment A - Daily Maximum Emissions for each Source Group table page 16) to ensure consistency and to confirm that the maximum emission rates were used to develop the Shell modeling for this application.

While comparing the Shell Model I/O to emission rates documented in the Shell Chukchi Permit Application, it was discovered that the SO_2 emission rates documented in the Shell Model I/O were higher than what was documented in the Shell Chukchi Permit Application. As a result of this difference, the higher (modeled) SO_2 emission rates were used to create the modeled Shell OCS Source inventory for this application. The documented maximum emissions rates across all three Shell operating scenarios (MLC Case, Drilling Case and Cementing/Logging Case) are summarized in **Table E-1**. **Table E-3** presents the modeled short-term emission rates developed for each of two simplified Shell sources.

2.2 Annual Emission Rates

To develop the annual emission rates, the permitted tons per year emission rates were converted to grams per second emission rates for modeling assuming a 123 day year. **Table E-2** shows the Annual Maximum Emissions for each source group documented in the Shell Chukchi Permit Application Table 2-6. The modeled annual emission rates were calculated using a 123 day drilling season consistent with the modeling done for the ConocoPhillips OCS Source which only included the months of July, August, September and October. **Table E-3** presents the modeled long-term emission rate for each of two simplified Shell sources.

2.3 Lead Emission Rates

Shell was not required to calculate lead emissions as part of their application. Therefore, representative lead emission rates were derived from the documented $PM_{2.5}$ emission rates. The fraction of lead in measured $PM_{2.5}$ concentrations from liquid fuel combustion is 0.00143 based on the ratio of the lead emission factor (9.0E-06 lb/MMBtu) to the $PM_{2.5}$ emission factor (6.28 E-03 lb/MMBtu) for liquid fuel-fired boilers (USEPA 2010). The ratio is based on boiler emission factors since that approach yields a higher ratio than using the emission factors for liquid fuel fired internal combustion engines. **Table E-3** presents the modeled lead emission rate for each of two simplified Shell sources.

3.0 Source Simulation

Emissions from Shell exploration activities were modeled in a conservative, simplified manner similar to the approach used for COP sources. A single merged point source was developed to represent the drillship and nearby static vessels, and a single volume source was used to represent all mobile support vessel sources. The point source and the volume sources were collocated.

3.1 Modeled Point Source Exit Parameterization

For modeling conducted in support of the Shell Chukchi Sea Permit Application, emission units on the drillship and nearby static vessels were simulated as a set of refined point sources. This approach was simplified for this application by combining the emissions from the sources representing the Shell OCS Source point sources and modeling them from a single worst-case stack. This was done not only to simplify the simulation, but to be consistent with the ConocoPhillips OCS Source analysis and to maximize impacts at the point of compliance.

Source parameters for the single worst-case stack were developed using a conservative variation of USEPA's M-value technique (USEPA 1992). For this application, the M-value for a particular emission unit was set equal to the product of the stack height (meters), exit temperature (Kelvin), and volumetric flow rate (m^3/s). This is a more conservative approach to calculating the standard M-value because it does not include the emission rate in the denominator; therefore, it does not account for the emission potential of particular emission unit making the analysis independent of emission unit operation. Taking this approach, stack parameters associated with emission units that seldom operate factor equally with those that operate continuously. Following this approach, an M-value was determined for each emission unit. The emissions from all emission units were

modeled from the stack with the lowest M-value. The M-value analysis for this set of sources is presented in **Table E-4**. The stack with the lowest M-value which was used to represent all others was the drillship incinerator.

Though selecting a representative stack based on the M-value approach is typically associated with a near-field analysis, it is equally applicable to a far-field analysis since it minimizes initial dispersion (i.e., favors the stack with the lowest volumetric flow rate and temperature) and keeps the plume centerline close to the surface of the water (i.e., favors the stack with the lowest release height). For a long range transport analysis without terrain and deposition, this will maximize model predicted impacts in the following ways:

- Minimizing initial dispersion minimizes final dispersion maximizing plume concentrations and downwind impacts.
- Since the highest plume concentrations are nearest the plume centerline, keeping the plume centerline closer to the water maximizes sea surface concentrations. This assertion is only true given that CALPUFF is being run without chemistry or deposition; therefore, no pollutant mass will be lost in transport processes particularly for plumes close to the surface of the water.

3.2 Volume Sources

All of the area (AREAPOLY) sources modeled by Shell in their compliance demonstration, which represent the Shell OCS Source mobile support vessels, were combined and modeled as a single volume source for this analysis. Shell's modeled area source parameters are shown in **Table E-5**. The area source with the lowest release height, the OSR Work Boat, was chosen to represent the dimensions of the single modeled volume source. The following procedure was used to size the volume source in order to simplify, but yet closely approximate, the approach used by Shell:

1. Release Height: The release height of the volume source was set equal to the release height of the representative AREAPOLY source, in this case the OSR Work Boat which has a release height of 3.0 meters.

2. Initial Lateral Dimension: Following the AERMOD User's Guide (USEPA 2004) for a single volume source the initial lateral dimension was set to the length of a side divided by 4.3. In this case, the length of a side was set equal to the square root of an area, which has an area equivalent to the area of the representative AREAPOLY source. Therefore, the length of a side was calculated to be 2,000 m for an initial lateral dimension of 465 m.

3. Initial Vertical Dimension: Following the AERMOD User's Guide (USEPA 2004) for a single elevated volume source not on or adjacent to a building the initial vertical dimension will set to the vertical dimension of the source divided by 4.3. In this case, the vertical dimension of the source will be equivalent to the lowest release height modeled for the particular area source being simulated for an initial vertical dimension of 0.70 m.

The final source parameters for the simplified Shell sources are provided in **Table E-6**.

4.0 References

Shell Offshore Inc. (Shell) 2011. AREMOD Air Quality Impact Analysis of NO_2, SO_2, $PM_{2.5}$, PM_{10}, CO and NH_3 – Discoverer Drillship; Supplement to March 18 and April 29, 2011, AERMOD Impact Reports, May 19, 2011.

United States Environmental Protection Agency (USEPA) 2011a. Email from Andy Hawkins (USEPA Region 4) to Thomas Damiana (AECOM) titled “Shell Offsite Input Files” dated October 13, 2011.

USEPA 2011b. Technical Support Document Review of Shell’s Supplemental Ambient Air Quality Impact Analysis for the Discoverer OCS Permit Applications in the Beaufort and Chukchi Seas. USEPA Region 10. June 24, 2011.

USEPA 2010. AP-42 - Fuel Oil Combustion from External Combustion Sources Table 1.3-10 “Emission Factors for Trace Elements from Distillate Fuel Oil Combustion Sources” and Table 1.3-7 “Cumulative Particle Size Distribution and Size Specific Emission Factors from Uncontrolled Commercial Boilers Burning Residual or Distillate Oil”, May 2010.

USEPA 2004. User’s Guide for the AMS/EPA Regulatory Model –AERMOD. U.S. Environmental Protection Agency Office of Air Quality Planning and Standards Emissions Monitoring and Analysis Division Research Triangle Park, North Carolina. EPA-454/B-03-001. September 2004.

USEPA 1992. Screening Procedures for Estimating the Air Quality Impact of Stationary Sources, Revised. October 1992.

Table E-1 Shell Modeled Short-Term Emission Rates by Emission Unit

Source Group	NO_x (g/s)	$PM_{2.5}$ (g/s)	PM_{10} (g/s)	CO (g/s)	SO_2 [4] (g/s)	VOC (lb/day)
Discoverer						
Generation	0.585	0.149	0.149	0.209	5.29E-02	5.13
MLC Compressor	0.896	0.022	0.022	0.416	1.01E-02	170.58
HPU Engines	0.415	0.003	0.003	0.073	4.68E-03	78.97
Cranes_PT	0.156	0.001	0.001	0.003	6.84E-04	0.37
Cranes_SB	0.156	0.001	0.001	0.003	6.84E-04	0.37
Cementing and Logging	0.826	0.020	0.020	0.046	2.38E-03	5.01
Heaters & Boilers	0.402	0.047	0.047	0.155	2.13E-02	0.54
Seldom-used units	0.066	0.005	0.005	0.014	1.59E-04	1.00
Emergency Generator	2.485	0.175	0.175	0.535	5.99E-03	3.13
Incinerator	0.082	0.115	0.134	0.508	4.09E-02	0.41
Primary Ice Management						
Propulsion & Generation	8.279	1.294	1.294	3.742	2.72E-01	113.22
Heaters & Boilers	0.189	0.031	0.031	0.047		0.61
Seldom-used units	0.044	0.003	0.003	0.009		0.67
Incinerator	0.049	0.088	0.129	2.910		7.70
Model ID ICEMGMT1: ICEMGMT/AH/AREAPOLY [1, 2]	9.82E-07	1.62E-07	1.67E-07	7.70E-07	3.12E-08	NA
Secondary Ice Management						
Propulsion & Generation	8.533	1.333	1.333	3.858	2.71E-01	116.70
Heaters & Boilers	0.076	0.012	0.012	0.019		0.25
Seldom-used units	0.044	0.003	0.003	0.009		0.67
Incinerator	0.049	0.088	0.129	2.911		7.70
Model ID ICEMGMT2: ICEMGMT/AH/AREAPOLY [1, 2]	9.98E-07	1.65E-07	1.70E-07	7.80E-07	3.11E-08	NA
Resupply Ship (Transit Mode)						
Propulsion & Generation	1.109	0.030	0.030	0.239	2.67E-03	55.9
Resupply - transit -1 way, 2km, 5% of distance	1.109	0.030	0.030	0.239		
Model ID: RESUP_T: Resupply AREAPOLY [1, 3]	2.77E-07	7.39E-09	1.70E-07	7.80E-07	6.86E-10	NA
Resupply Ship (DP Mode)						
Propulsion & Generation	14.791	0.394	0.394	3.186	3.56E-02	223.60
Offshore Management/Skimmer Vessel						
Propulsion & Generation	6.261	0.112	0.112	1.663	4.06E-02	33.54
Seldom-used units	0.044	0.003	0.003	0.009		0.67
Incinerator	0.039	0.072	0.105	2.362		6.25
Model ID: OSR_SKIM: Offshore mgmt vessel AREAPOLY [1, 3]	1.59E-06	4.67E-08	5.50E-08	1.01E-06	1.02E-08	NA
OSR Vessel						
Propulsion & Generation	8.497	0.016	0.016	0.046	4.80E-02	11.77
Seldom-used units	0.044	0.003	0.003	0.009		0.67
Incinerator	0.039	0.072	0.105	2.362		6.25
Model ID: OSR_MAIN: OSR vessel AREAPOLY [1, 3]	2.15E-06	2.27E-08	3.10E-08	6.05E-07	1.20E-08	NA

Continued on the Next Page…

Table E-1 Shell Modeled Short-Term Emission Rates by Emission Unit

Source Group	NO_x (g/s)	$PM_{2.5}$ (g/s)	PM_{10} (g/s)	CO (g/s)	SO_2 [4] (g/s)	VOC (lb/day)
OSR Work Boats						
Work Boats	1.668	0.117	0.117	0.359	4.02E-03	25.22
Model ID: OSR_WORK: OSR work boats AREAPOLY [1, 3]	4.17E-07	2.93E-08	2.93E-08	8.99E-08	1.01E-09	NA

1 AREAPOLY units = $g/s/m^2$

2 IceMGMT/AH AREAPOLY = 8,717,690 m^2

3 Resupply/Offshore/OSR AREAPOLY = 3,998,135 m^2

4 SO_2 values are from the modeling files and represent the sum of each activity.

Table E-2 Shell Modeled Long-Term Emission Rates by Emission Unit

	NOx (tpy)	$PM_{2.5}$ (tpy)	PM_{10} (tpy)	CO (tpy)	SO_2 (tpy)	VOC (tpy)
Point Sources						
Discoverer						
Generation	5.8	1.5	1.5	2.1	7.90E-02	0.3
MLC Compressor	1.7	0.0	0.0	0.8	2.89E-03	1.7
HPU Engines	0.8	0.0	0.0	0.1	1.34E-03	0.8
Cranes	2.8	0.0	0.0	0.1	1.81E-03	0.0
Cementing and Logging	4.1	0.1	0.1	0.2	1.76E-03	0.1
Heaters & Boilers	4.6	0.5	0.5	1.8	3.66E-02	0.0
Seldom-used units	0.8	0.0	0.1	0.2	2.73E-04	0.1
Emergency Generator	0.1	0.0	0.0	0.0	2.85E-05	0.0
Incinerator	0.2	0.3	0.3	1.2	1.00E-01	0.1
Re-supply Ship (DP Mode)						
Propulsion & Generation	33.8	0.9	0.9	7.3	1.22E-02	2.7
Total Point Source Emissions	**54.6**	**3.4**	**3.5**	**13.8**	**2.36E-01**	**5.8**
Area Sources						
Primary Ice Management						
Propulsion & Generation	36.0	5.6	5.6	16.3	1.52E-01	2.6
Heaters & Boilers	0.8	0.1	0.1	0.2	8.72E-03	0.0
Seldom-used units	0.2	0.0	0.0	0.0	6.91E-05	0.0
Incinerator	0.2	0.4	0.6	12.6	1.10E-01	4.2
Secondary Ice Management						
Propulsion & Generation	37.1	5.8	5.8	16.8	1.60E-01	2.7
Heaters & Boilers	0.3	0.1	0.1	0.1	3.49E-03	0.0
Seldom-used units	0.2	0.0	0.0	0.0	6.91E-05	0.0
Incinerator	0.2	0.4	0.6	12.6	1.10E-01	4.2
Resupply Ship (Transit Mode)						
Propulsion & Generation	16.9	0.5	0.5	3.6	6.11E-03	1.3
Offshore Management/Skimmer Vessel						
Propulsion & Generation	71.6	1.3	1.3	19.0	3.56E-02	2.0
Seldom-used units	0.5	0.0	0.0	0.1	1.82E-04	0.0
Incinerator	0.5	0.8	1.2	27.0	2.30E-01	9.0
OSR Vessel						
Propulsion & Generation	97.1	0.2	0.2	0.5	4.83E-02	0.7
Seldom-used units	0.5	0.0	0.0	0.1	1.82E-04	0.0
Incinerator	0.5	0.8	1.2	27.0	2.30E-01	9.0
OSR Work Boats						
Work Boats	19.1	1.3	1.3	4.1	6.89E-03	1.5
Total Area Emissions	**281.5**	**17.4**	**18.5**	**140.2**	**1.10E+00**	**37.4**

Table E-3 Shell Emission Rates for COP Cumulative Impact Analysis

Source Group	Short-Term (ST) and Long-Term (LT) Emission Rates (g/s)									
	NO_x		$PM_{2.5}$		PM_{10}		CO	SO_2		Pb
	ST	LT[1]	ST	LT[1]	ST	LT[1]	ST	ST	LT[1]	3-Month
Point Source										
Drillship and Nearby Static Vessels	2.09E+01	4.66E+00	9.32E-01	2.88E-01	9.51E-01	2.96E-01	5.15E+00	1.75E-01	2.01E-02	1.33E-03
Volume Source										
Mobile Support Vessel Fleet	3.50E+01	2.40E+01	3.28+E00	1.48E+00	3.43E+00	1.58E+00	2.06E+01	6.38E-01	9.40E-02	4.69E-03

[1] The long-term (LT) emission rate calculations are based on 123 days; that include July, August, September and October for a total of 2,952 hours.

Table E-4 Shell's Modeled Point Source Parameters and M-Value Analysis

Point Source Description	Modeled Source ID	Release Height Above Water (m)	Exit Temperature (K)	Exit Velocity (m/s)	Stack Diameter (m)	Volumetric Flow (m^3/s)	Stack M-Value
Generation	MAINENGS	17.40	710	32.9	0.32	158.76	1.96E+06
Emergency Generator	EMERGEN	17.40	710	32.9	0.32	158.76	1.96E+06
MLC compressor	MLCENGS	13.11	700	40.0	0.21	83.13	7.63E+05
HPU Engines	HPUENGS	10.67	700	40.0	0.18	61.07	4.56E+05
Crane (Port)	CRANE_PT	18.29	672	20.1	0.25	59.20	7.28E+05
Crane (Starboard)	CRANE_SB	18.29	672	20.1	0.25	59.20	7.28E+05
Cementing and Logging	CEM_LOG	10.67	800	46.6	0.18	71.15	6.07E+05
Heaters and Boilers	HEATBOIL	17.40	478	7.3	0.46	72.79	6.05E+05
Seldom used units	SELDOM	10.67	700	40.0	0.18	61.07	4.56E+05
Incinerator [1]	**INCIN_D**	**7.01**	**623**	**10.0**	**0.46**	**99.71**	**4.35E+05**
Resupply DP mode	RESUP_DP	18.29	650	14.6	0.60	247.68	2.94E+06

[1] Point source with the lowest M-Value used as the representative stack for this application.

Table E-5 Shell's Modeled Area Source Parameters

Source Description	Modeled Source ID's	Release Height [1] (m)	Initial Vertical Dimension (m)	Area (m^2)	Length of One Side (m)
Primary Ice Management	ICEMGMT1	24.38	0	8,717,690	2,952.57
Secondary Ice Management/Anchor	ICEMGMT2	24.38	0	8,717,690	2,952.57
OSR Vessel	OSR_MAIN	6.10	0	3,998,135	1,999.53
Offshore Management/Skimmer	OSR_SKIM	6.10	0	3,998,135	1,999.53
OSR Work Boats [2]	**OSR_WORK**	**3.00**	**0**	**3,998,135**	**1,999.53**
Resupply Ship – Transport Mode	RESUP_T	17.10	0	3,998,135	1,999.53

1 According to the technical approaches described in the Shell Chukchi Permit Application and represented in the Shell Model I/O, the AERAPOLY release height varied hourly according to the meteorological condition. The release height listed represents the lowest release height from among all those modeled for a particular AREAPOLY source.

2 AREAPOLY with the lowest release height used as the representative AREAPOLY for this application.

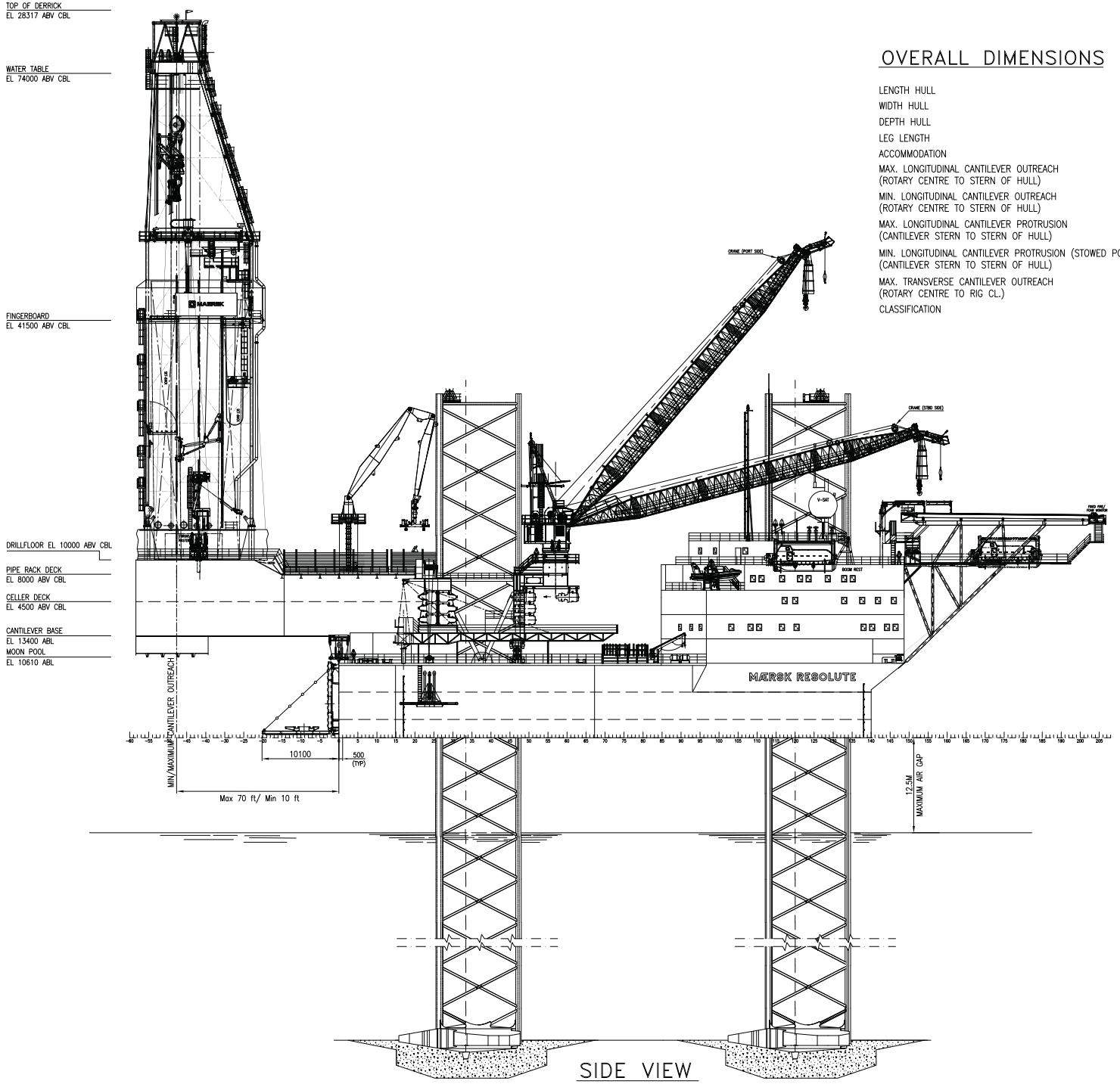
Table E-6 Simplified Shell Source Parameters for COP Cumulative Impact Analysis

Point Source Stack Parameters				
	Height (m)	**Temp (K)**	**Velocity (m/s)**	**Diameter (m)**
Drillship and Nearby Support Vessels	7.01	623	10	0.46

Volume Source Parameters			
	Release Height (m)	**Initial Lateral Dimension (m)**	**Initial Vertical Dimension (m)**
Mobile Support Vessel Fleet	3.0	465	0.70

Appendix F
COP OCS Source Drill Rig and Support Vessel Layouts

Representative Jackup Drill Rig



SIDE VIEW

OVERALL DIMENSIONS

LENGTH HULL	70.0 m
WIDTH HULL	68.0 m
DEPTH HULL	9.5 m AT SIDE, 9.8 m AT ℄
LEG LENGTH	146.3 m
ACCOMMODATION	120 pers.
MAX. LONGITUDINAL CANTILEVER OUTREACH (ROTARY CENTRE TO STERN OF HULL)	21.33 m (70 ft)
MIN. LONGITUDINAL CANTILEVER OUTREACH (ROTARY CENTRE TO STERN OF HULL)	3.048 m (10 ft)
MAX. LONGITUDINAL CANTILEVER PROTRUSION (CANTILEVER STERN TO STERN OF HULL)	26.7 m (87.6 ft)
MIN. LONGITUDINAL CANTILEVER PROTRUSION (STOWED POSITION) (CANTILEVER STERN TO STERN OF HULL)	1.5 m (4.9 ft)
MAX. TRANSVERSE CANTILEVER OUTREACH (ROTARY CENTRE TO RIG CL.)	6.8 m / 22.3 ft PS & 7.2 m / 23.6 ft SB &
CLASSIFICATION	ABS +A1 SELF ELEVATING DRILLING UNIT

ALTERATIONS

NO	DESCRIPTION	AUTHORITY	BY	DATE	PCM CHECK

REFERENCE PLANS

NO	TITLE	PLAN NO	PLAN BY

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REVISION													
DATE													
REVISION													
DATE													

APPROVED BY:		DATE:
OWNER	MAERSK	19 JUL 05
	MAERSK	16 AUG 05
	MAERSK	13 DEC 06
	MAERSK	23 JUL 07
CLASS	ABS	04 AUG 05
	ABS	26 SEP 05

Keppel FELS
Keppel FELS Limited
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MAERSK CONTRACTORS

DATE :	15 JUNE 2005	SCALE :	1 : 250
DESIGNED BY :	MSC	HULL/JOB No. :	B274
DRAWN :	LEE CHING	COST CODE No. :	–
CHECKED :	PRABHAT KUMAR	APPROVED :	ANIS HUSSAIN / PATRICK KUO

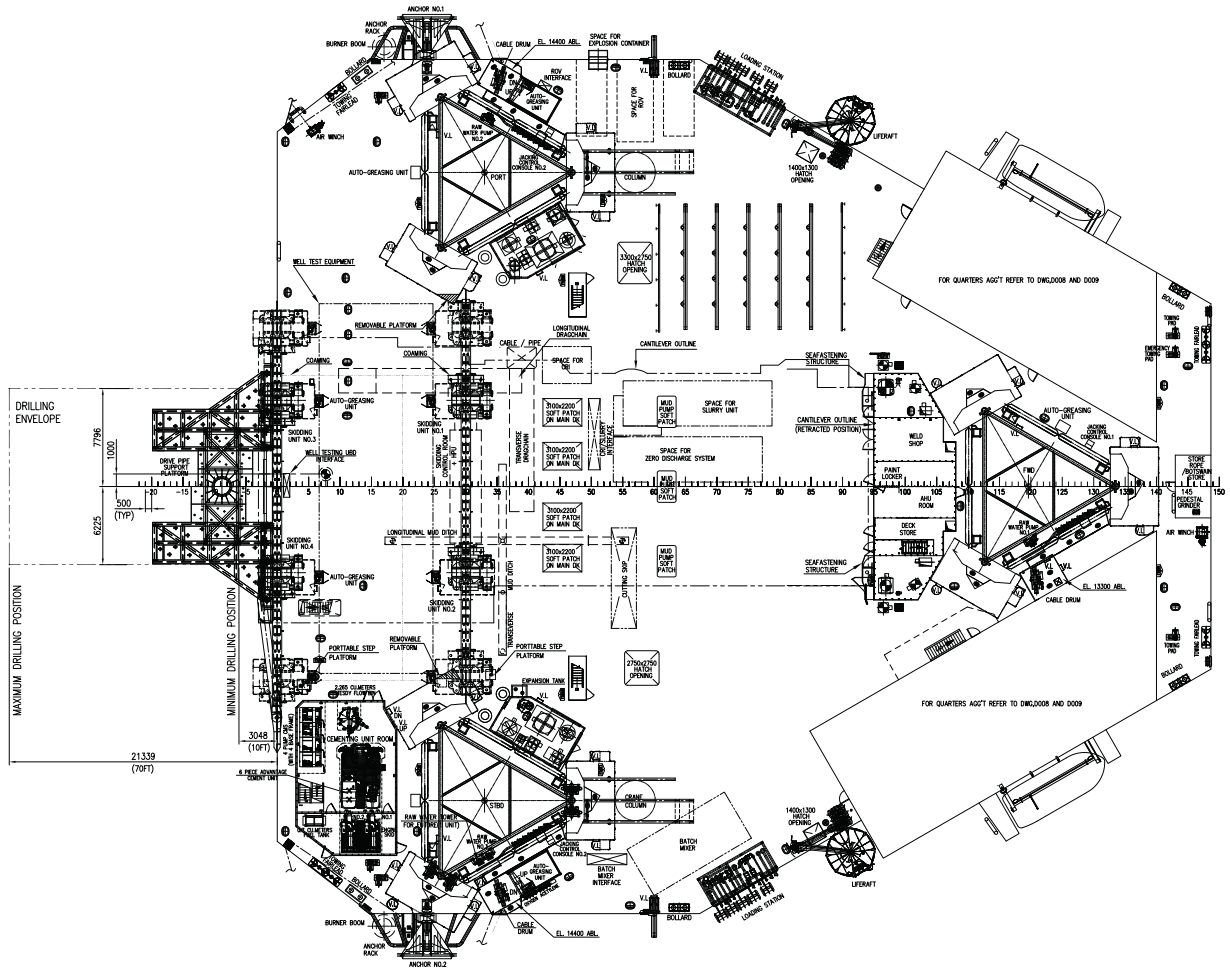
JOB :
MAERSK RESOLUTE
HIGH EFFICIENCY JACK-UP

TITLE :
GENERAL ARRANGEMENT
SIDE VIEW

SHT 1 OF 1 SHTS

K-FELS DRAWING No :	D001 (AS BUILT)	ALT. NO. 0
OWNER DRAWING No :	RSU.02.1001.000.101	

A1 (841mm X 594mm)



PLAN VIEW AT MAIN DECK

ALTERATIONS

NO	DESCRIPTION	AUTHORITY	BY	DATE	PCN CHECK

REFERENCE PLANS

NO	TITLE	PLAN NO	PLAN BY
1.	MACHINERY ARRANGEMENT – CANTILEVER SKIDDING SYSTEM.	M102-10	KFELS

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REVISION RECORD

REVISION							
DATE							
REVISION							
DATE							

APPROVED BY:		DATE:
OWNER		19 JUL 05
	MAERSK	16 AUG 05
	MAERSK	13 DEC 06
	MAERSK	23 JUL 07
CLASS	ABS	04 AUG 05
	ABS	26 SEP 05

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MAERSK CONTRACTORS

DATE :	15 JUNE 2005	SCALE :	1 : 200
DESIGNED BY :	MSC	HULL/JOB No. :	B274
DRAWN :	LEE CHING	COST CODE No. :	–
CHECKED :	PRABHAT KUMAR	APPROVED :	ANIS HUSSAIN / PATRICK KUO

JOB :

MAERSK RESOLUTE
HIGH EFFICIENCY JACK-UP

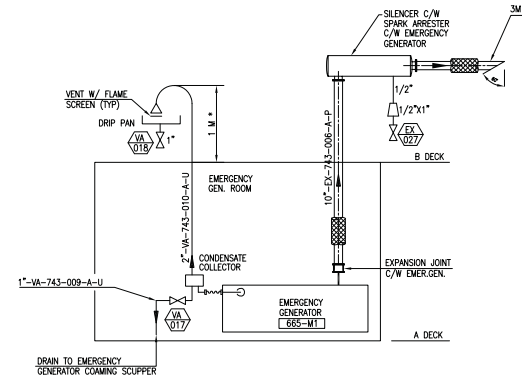
TITLE :

GENERAL ARRANGEMENT
MAIN DECK

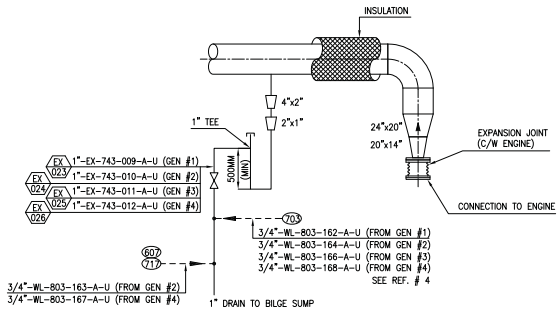
SHT 1 OF 1 SHTS

K-FELS DRAWING No :	D005 (AS BUILT)	ALT. NO. 0
OWNER DRAWING No :	RSU.02.1005.000.101	

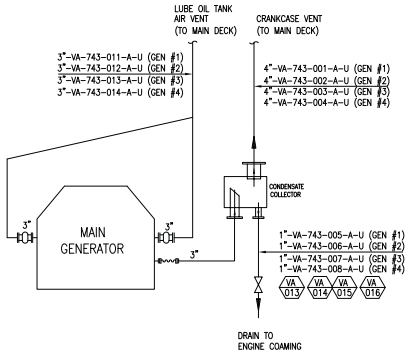
A1 (841mm X 594mm)



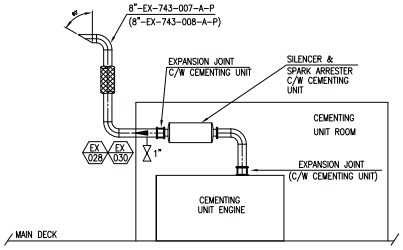
DETAIL 18D EMERGENCY GENERATOR EXHAUST



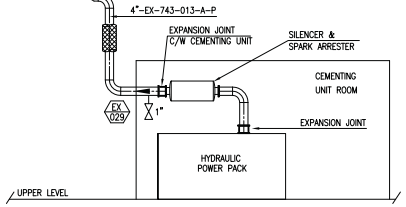
DETAIL 16D TYP MAIN GENERATOR EXHAUST



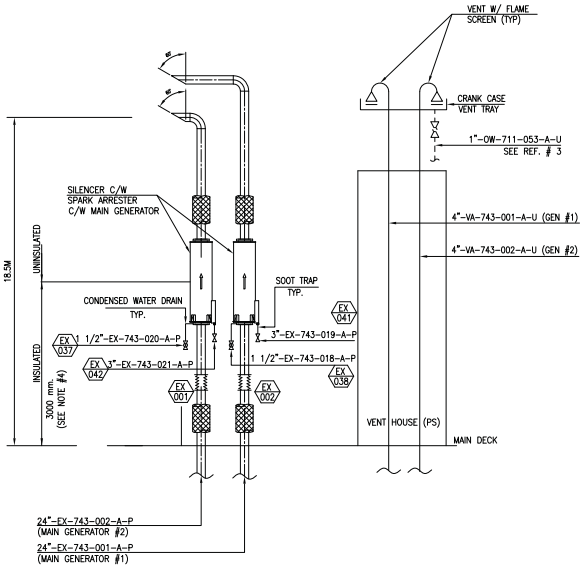
DETAIL 14D TYP MAIN GENERATOR CRANKCASE VENT



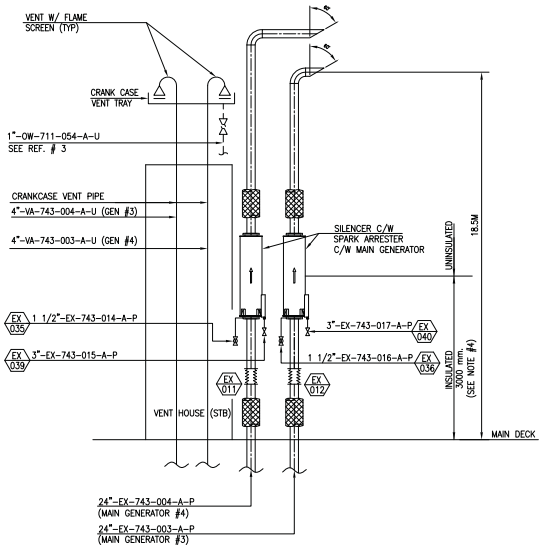
SECTION 18C 9A CEMENTING UNIT EXHAUST



SECTION 18B 10A HYDRAULIC POWER PACK EXHAUST



DETAIL 17A 11D MAIN GENERATOR EXHAUST ON MAIN DECK (PS)



DETAIL 15A 11B MAIN GENERATOR EXHAUST ON MAIN DECK (STB)

ALTERATIONS

NO	DESCRIPTION	AUTHORITY	BY	DATE	PCM CHECK

REFERENCE PLANS

NO	TITLE	PLAN NO	PLAN BY
	SEE SHEET 1		

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REVISION						
DATE						
REVISION						
DATE						

APPROVED BY: OWNER: MAERSK CONTRACTORS — DATE: 25.10.05

ABS: ABS PACIFIC — 13.12.05

Keppel FELS
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MAERSK CONTRACTORS

DATE :	30 AUGUST 2005	SCALE :	NTS
DESIGNED BY :	KFELS	HULL/JOB No. :	B274
DRAWN :	J.BONGO	COST CODE No. :	
CHECKED :	HAN ZHONG JUN	APPROVED :	ALAN LEE

JOB :

MAERSK RESOLUTE
HIGH EFFICIENCY JACK-UP

TITLE :

PIPING DIAGRAM
ENGINE EXHAUST SYSTEM

SHT 3 OF 3 SHTS

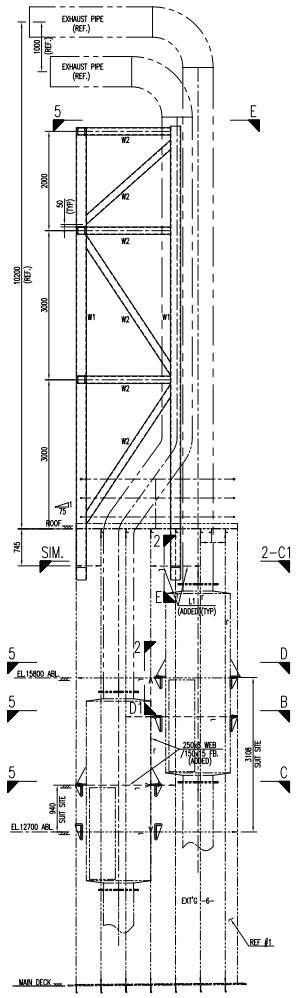
K-FELS DRAWING No : P117 (AS BUILT)

OWNER DRAWING No : RSU.05.0017.000.743

ALT. NO. 0

A1 (841mm X 594mm)

PLOT SCALE : 1 CAPTULE : P117.DWG



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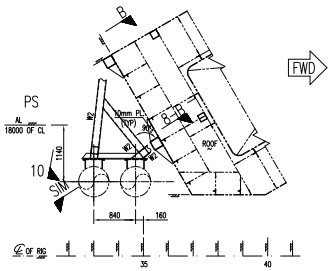

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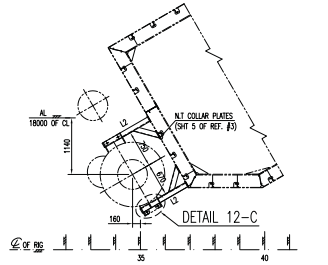

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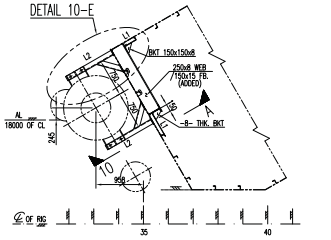

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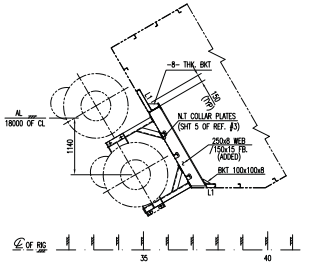

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INFORMATION NOT SHOW SEE SECTI 5-D
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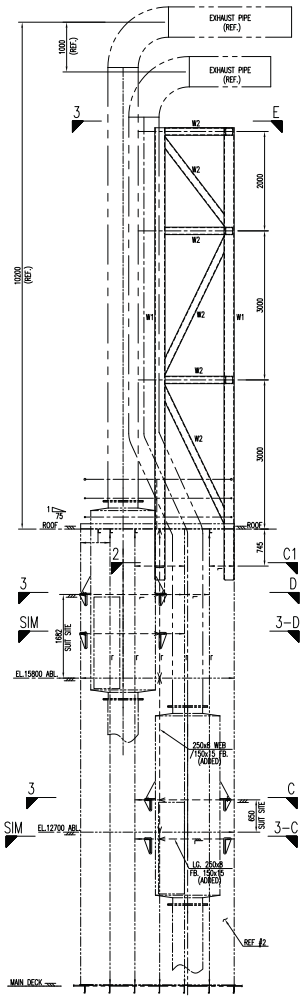

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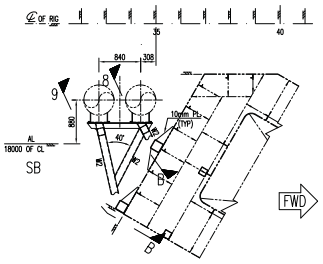

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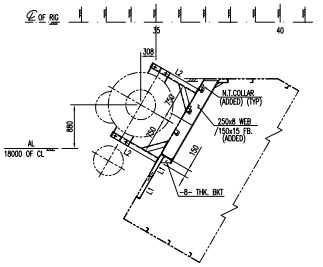

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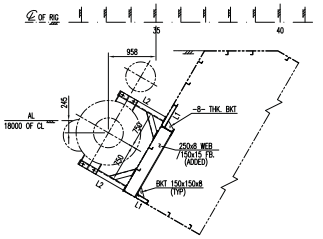

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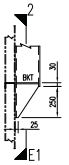

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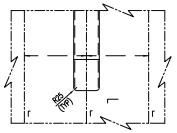

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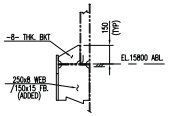

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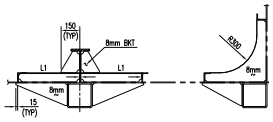


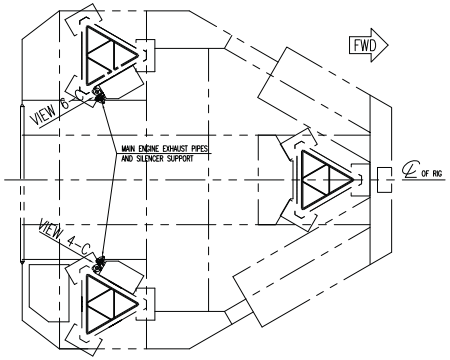
SECTION 2-C1
SCALE = 1 : 20

GENERAL NOTES:

1. ALL MATERIAL GRADE A, UNLESS NOTED OTHERWISE.
2. STIFFENER SPACING 500 mm UNLESS NOTED OTHERWISE.
3. EQUIPMENT FOUNDATION TO BE FLAT AND LEVEL.
4. ALL BOLT AND STUD HOLES TO BE TEMPLATE FROM EQUIPMENT.
5. ALL WELDING TO BE CONTINUOUS FILLET WELD U.N.O.
6. ALL FILLET WELD TO BE LEG LENGTH.

MATERIAL SUBSTITUTION LIST

NO:	ORIGINAL	SUBSTITUTION
W1	SHS 200x200x10	-
W2	SHS 150x150x8	-
L1	L75x50x6	-
L2	L200x100x12	-
P1	5" SCH.80 PIPE	-



KEY PLAN

ALTERATIONS

NO	DESCRIPTION	AUTHORITY	BY	DATE	PCM / DECK

REFERENCE PLANS

NO	TITLE	PLAN NO	PLAN BY
1	VENT HOUSE STRUCTURE AND DETAILS(PORT)	H307-01	K-FELS
2	VENT HOUSE STRUCTURE AND DETAILS(STB'D)	H307-02	K-FELS
3	HULL CONSTRUCTION STD FOR MAIN HULL & LQ STRUCTURE	H501-01	K-FELS
4	HULL STANDARD FITTING DETAILS	H502-01	K-FELS
5	PIPING ARRG'T - ABOVE MAIN DECK (7P, FR 0-50, AFT/ PORT BLOCK)	P202-7PE	K-FELS
6	PIPING ARRG'T - ABOVE MAIN DECK (7S, FR 0-50, AFT/ STBD BLOCK)	P208-7SE	K-FELS
7	MACHINERY ARRANGEMENT - MAIN DECK	M102-01	K-FELS

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REVISION RECORD

REVISION							
DATE							
REVISION							
DATE							

APPROVED BY:		DATE:
OWNER	APPROVED WITH COMMENTS	23/06/06
	APPROVED WITH COMMENTS	20/09/06
	APPROVED	20/07/07
ABS	APPROVED WITH COMMENTS	10/07/06

KeppelFELS
Keppel FELS Limited
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MAERSK CONTRACTORS

DATE :	18 MAY 2006	SCALE :	AS SHOWN
DESIGNED BY :	K-FELS	HULL/JOB No. :	B274
DRAWN :	Wong GM	COST CODE No. :	
CHECKED :	Reagin / GNS	APPROVED :	HO / CHERN

JOB :
MAERSK RESOLUTE
HIGH EFFICIENCY JACK-UP

TITLE :
MAIN ENGINE EXHAUST PIPES AND SILENCER SUPPORT AT MAIN DECK

SHT 1 OF 2 SHTS

K-FELS DRAWING No :	H327-01 (AS BUILT)	ALT. NO. 0
OWNER DRAWING No :	RSU.01.3139.000.263	

A1 (841mm X 594mm)

PLOT SCALE : 1:1
PLOTTED : H327-01.DWG

Representative Offshore Supply Vessel (OSV)

HOS ARROWHEAD
250 EDF CLASS "NEW BREED" OFFSHORE SUPPLY VESSEL

250 EDF Class

DIMENSIONS AND REGULATORY INFORMATION

Length:	250 Ft 76.2 m	**Beam:** 54Ft	16.5m	**Draft Max:**	14.7 Ft	4.5 m	
Tonnage /Gross:	1997 GRT	**Net:** 658		**Draft Min:**	8 Ft	2.4 m	
Certification:	USCG Subchapter "I/L", Oceans-SOLAS, SIP			**O.N.:**	TBD	**CALL SIGN:**	TBD
Classification:	ABS +A1 OSV, +AMS, +ACC, +DPS-2, Loadline			**IMO:**	TBD	**ABS ID:**	TBD

PERFORMANCE

Speed / Consumption:

Max Speed:	14 Kts	250 GPH	946.3 ℓ PH
Cruise Speed:	10 Kts	90 GPH	340.7 ℓ PH

Bollard Pull:

Max Pull: 55.0 ST 49.9 MT

CAPACITIES & DELIVERY RATES

Deadweight: Estimated	2850 LT	2,896 MT	**Deck Dim:**	185 Ft x 45 Ft	56 m x 14 m
Deck Cargo:	1,800 LT	1,829 MT	**Deck Area:**	8,325 Ft2	773 m2
Deck Load Rating:	1,024 #/Ft2	5 T/m2			
Rig Water:	309,741 USG	1,172 m3	**Discharge Rate:**	660 GPM	150 m3/hr
Potable Water:	30,852 USG	117 m3	**Discharge Rate:**	660 GPM	150 m3/hr
Rig Fuel Normal:	153,122 USG	580 m3	**Discharge Rate:**	660 GPM	150 m3/hr
Rig Fuel Max:	454,994 USG	1,722 m3	**Pump Type:**	Positive Displacement	
Liquid Mud/Brine:	8,270 Bbls	1,315 m3	**Discharge Rate:**	814 GPM	185 m3/hr
Dry Bulk:	6,240 Ft.3	177 m3	**System Pressure:**	80 psi	6 bar
Cooler:	400 Ft.3	11 m3	**Freezer:**	400 Ft.3	11 m3
Off Ship Firefighting:	One (1) Monitor		**Flow Rate:**	3,000 GPM	681 m3/hr

ELECTRONICS

GMDSS "A3", VHF Radios, Handheld VHF Radios, Navtex, EPIRB, Public Phone System w/loudhailer, X-band Radars, SARTs, DGPS w/AIS, Mag Compass, Gyro Compass, Depth Sounder, Windbird, Joystick Control, Auto Pilot, DSDL, AIS, SSAS, L-3 NMS 6000, Cyscan, C-Nav, MAMS/VMS, CCTV Cameras

ACCOMMODATIONS

11 air conditioned/heated staterooms certified for 24 person berthing.

SPECIAL FEATURES

FIFI , Deck Crane

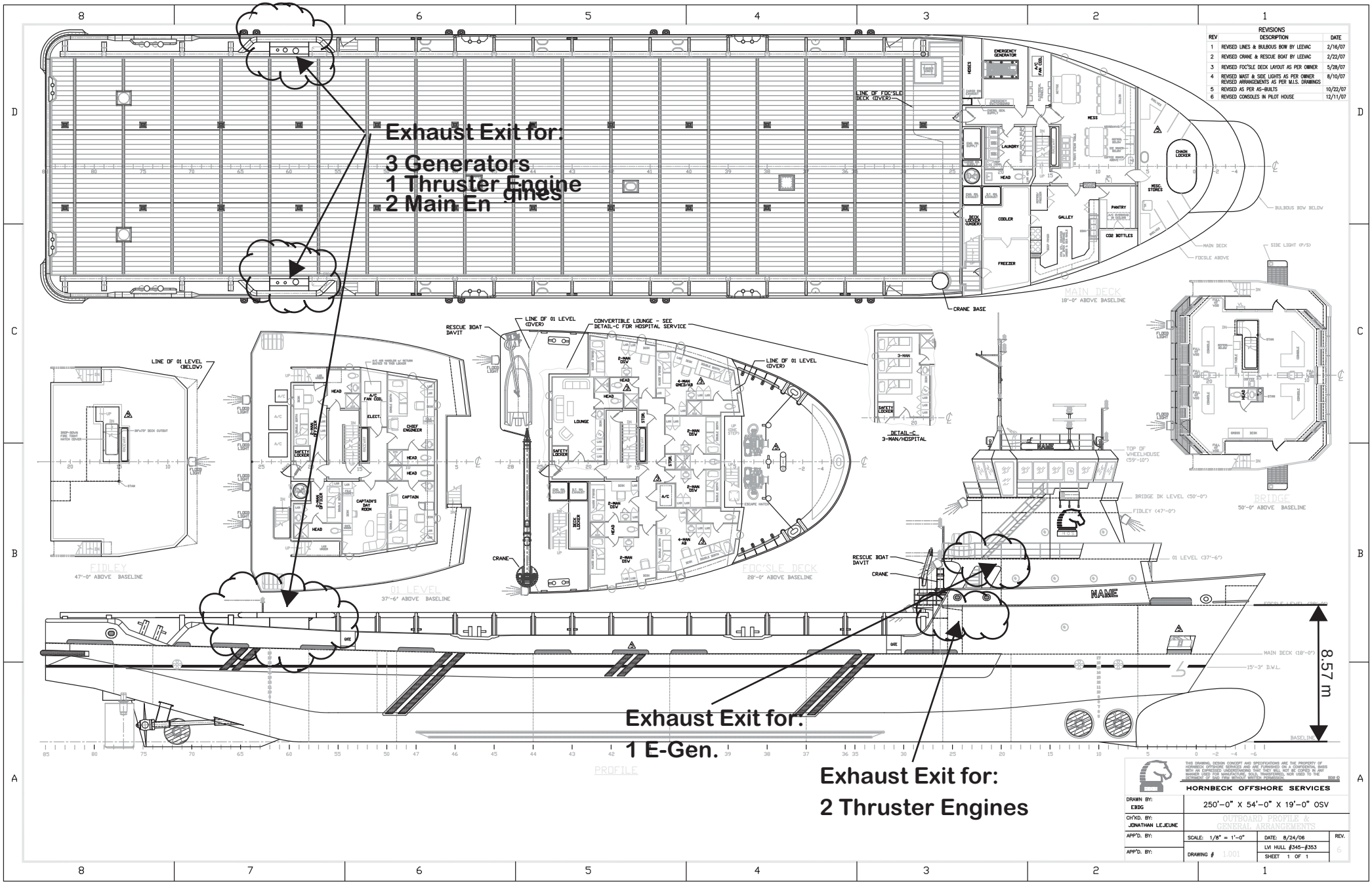
103 Northpark Boulevard, Suite 300
Covington, Louisiana 70433
727-3606

HORNBECK OFFSHORE SERVICES, LLC
Service with Energy

Phone: (985) 727-2000
Fax: (985)

Rev. 2

Date: 04/22/08


Exhaust Exit for:
3 Generators
1 Thruster Engine
2 Main Engines
Exhaust Exit for:
1 E-Gen.
Exhaust Exit for:
2 Thruster Engines
REVISIONS
REV DESCRIPTION DATE
1 REVISED LINES & BULBOUS BOW BY LEEVAC 2/16/07
2 REVISED CRANE & RESCUE BOAT BY LEEVAC 2/22/07
3 REVISED FOC'SLE DECK LAYOUT AS PER OWNER 5/28/07
4 REVISED MAST & SIDE LIGHTS AS PER OWNER REVISED ARRANGEMENTS AS PER M.I.S. DRAWINGS 8/10/07
5 REVISED AS PER AS-BUILTS 10/22/07
6 REVISED CONSOLES IN PILOT HOUSE 12/11/07
MAIN DECK
18'-0" ABOVE BASELINE
FIDLEY
47'-0" ABOVE BASELINE
01 LEVEL
37'-6" ABOVE BASELINE
FOC'SLE DECK
28'-0" ABOVE BASELINE
BRIDGE
50'-0" ABOVE BASELINE
PROFILE
8.57 m
NAME
HORNBECK OFFSHORE SERVICES
DRAWN BY: EBDG
CH'KD. BY: JONATHAN LEJEUNE
APP'D. BY:
APP'D. BY:
250'-0" X 54'-0" X 19'-0" OSV
OUTBOARD PROFILE & GENERAL ARRANGEMENTS
SCALE: 1/8" = 1'-0"
DATE: 8/24/06
REV. 6
DRAWING # 1.001
LVI HULL #345-#353
SHEET 1 OF 1

Representative Ware Vessel

HOS STRONGLINE

370 CLASS MPSV
ROV / Well Test Vessel

370 Class MPSV

DIMENSIONS AND REGULATORY INFORMATION

Length : 381 Ft.- 0 in. 116.0 m **Beam:** 72 Ft. 22.0 m **Draft:** Max: 19.5 Ft. 5.9 m
Tonnage: **GRT:** > 6,000 (est) Min: 6.0 Ft. 1.8 m
Certification **USCG Subchapter "I ", "D" (Grades A and Lower), "O", Oceans, SOLAS, SIP** **O.N.:** 988333 **Call Sign: TBD**
Classification **ABS +A1, +AMS, Chem Tanker / Oil Tanker, +DPS-2, ACC, Loadline** **IMO:** 9040534 **ABS ID:** 9203431

PERFORMANCE

Speed/Consumption:

Cruise:	9.5 Kts	170 GPH	643.5 LPH	DP:	70%	120 GPH	454.2 LPH

SPECIAL FEATURES

Stores Cranes: 3 x 70', Telescoping Boom
Loading / Discharge Stations: P/S Amidships and via Hose Reels Located on Foredeck
Helideck: 72 ft dia 22 mtr dia
ROV Hangar: Suitable for 2 x Triton XLS ROV's
Min Lift at Radius: 5 tons @ 70 ft
Watermaker: 5,000 GPD
Roll Damping: Flume Tank
Power Generation: 600 / 60 / 3 and 480 / 60 / 3

CAPACITIES & DELIVERY RATES

Deadweight (est):	7,955 LT	8,082 MT	**Deck Dim:**	193 ft x 67 ft	58.8 m x 20.4 m
Deck Cargo (est):	5,000 LT	5,080 MT	**Deck Area:**	12,930 Ft.^{2}	1,200 m^2
Potable Water:	22,784 USG	86 m^3	**Deck Load Rating:**	1,024 # / Ft.^{2}	5 T / m^2
Ships Fuel:	97,521 USG	369 m^3	**Discharge Rate:**	1,320 GPM	300 m3/hr
Rig Water:	35,800 Bbls	5,691 m^3	**Discharge Rate:**	1,320 GPM	300 m3/hr
Rig Fuel:	31,870 Bbls	5,060 m^3	**Discharge Rate:**	3,000 GPM	681 m3/hr
Liquid Mud / Brine:	31,870 Bbls	5,060 m^3	**Discharge Rate:**	4,286 Bbls/hr	681 m3/hr
Cargo Oil:	26,092 Bbls	4,148 m^3	**Pump Type:**	3 x Positive Displacement	
Bulk Mud Sys Press:	80 psi	5.5 bar			
Cooler:	2,000 Ft.^{3}	56.0 m^3	**Freezer:**	2,000 Ft.^{3}	56.0 m^3

ELECTRONICS

VHF Radios, Handheld VHF Radios, Navtex, EPIRB, Public Phone System w/loudhailer, X-band Radar, S-band Radar, SARTs, DGPS, Mag Compass, Depth Sounder, Windbird, Joystick Control, Auto Pilot, Nautronix JSDP 6000 DP System, Cyscan Laser Reference System, MAMS/VMS, Remote Cargo System Operation, CCTV Cameras

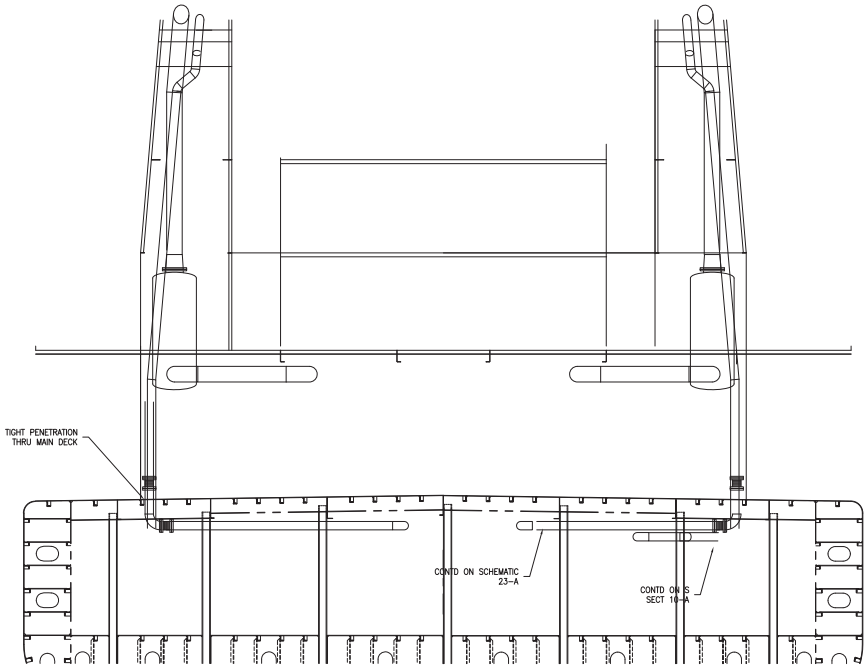
ACCOMMODATIONS

50 air conditioned / heated staterooms for 103 person berthing
Mess Area for 48 person seating, Lounge, and Client Office

HORNBECK OFFSHORE SERVICES, LLC
Service with Energy

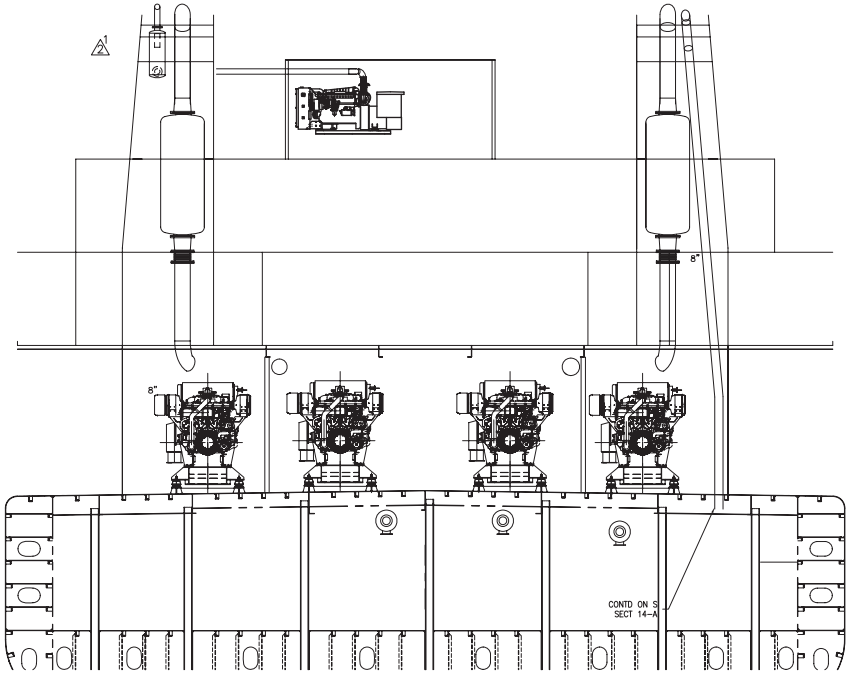
103 Northpark Boulevard, Suite 300
Covington, Louisiana 70433
Task 1359
Drawing Ref. 1.001 Rev. 1

Phone: (985) 727-2000
Fax: (985) 727-3606
Date: 26 June 2008
Rev. 5



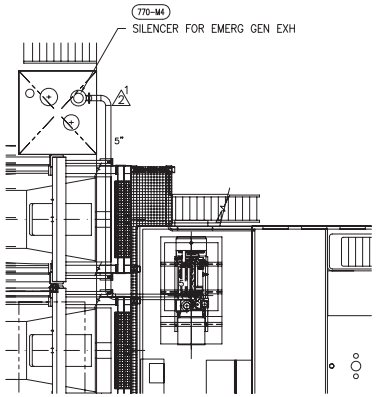
SECTION 14-A

LKG FWD AT FR 59



SECTION 10-A

LKG FWD AT FR 58



PLAN 12-A

BRIDGE DECK

TABLE 13B	LEGEND
	FLEXIBLE JOINT

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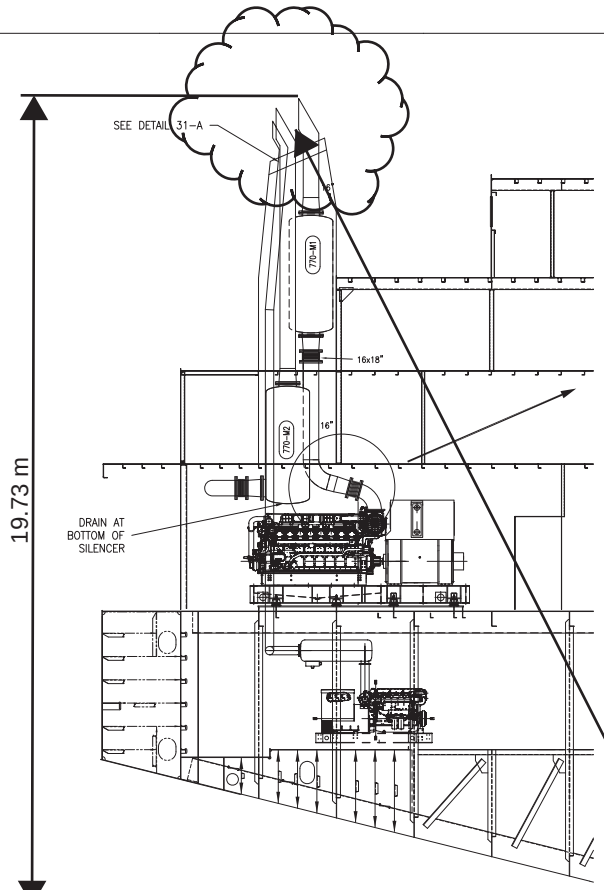
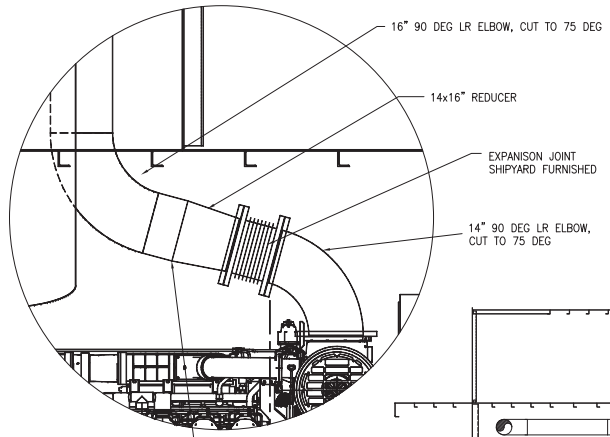
HORNBECK OFFSHORE SERVICES

DRAWN BY: WAJ	DATE: 6/29/06	DNC of Mobile, Inc. 113 S. Dearborn St., Mobile, Al. 36602 Phone: 251-432-8722 Fax: 251-432-8779 www.dncofmobile.com
CHKD. BY: LMS	DATE:	
APPD. BY:	DATE:	MULTIPURPOSE SUPPLY VESSEL 373'-4" X 72'-0" X 25'-0" EXHAUST PIPING DIAGRAMATIC
CONTRACT NO:		
HOS TASK NO: 1258		SIZE D · HULL NO ESI 014&015 · DWG NO 7.702 · REV 2
		SCALE: NOT TO SCALE · JOB NO: 1340 · SHEET 2 OF 5

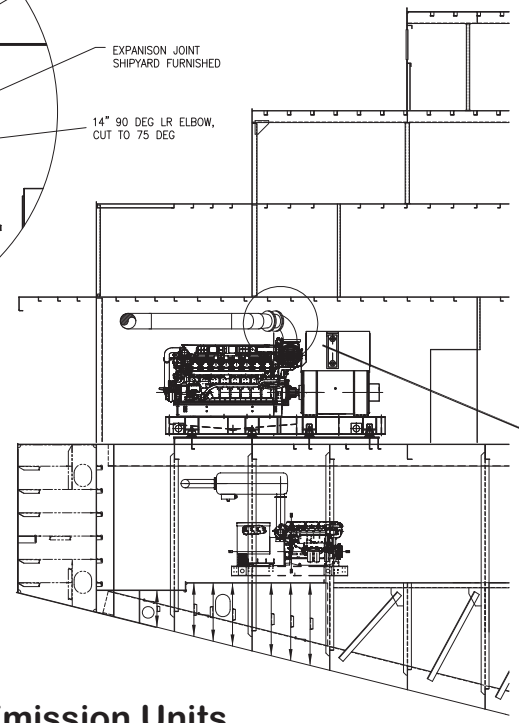


ELEVATION 31-B

STBD STACK SHOWN
ENGINES SHOWN FOR REF

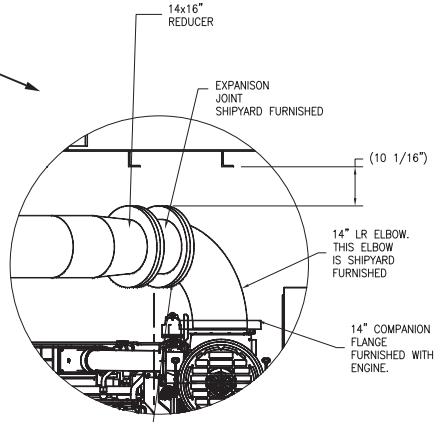


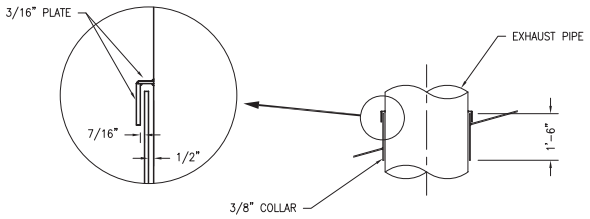
Exhaust Exit for all Emission Units



ELEVATION 27-B

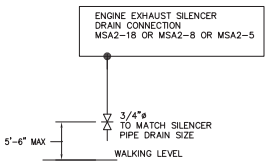
STBD STACK SHOWN
ENGINES SHOWN FOR REF





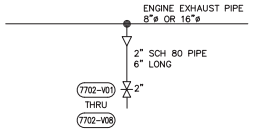
DETAIL 31-A

TYP RAIN CAP DETAIL
SCALE: 1/2"=1'-0"



SCHEMATIC 29-A

TYP SILENCER DRAIN
8 REQUIRED



SCHEMATIC 28-A

TYP WATER TRAP
8 REQUIRED

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HORNBECK OFFSHORE SERVICES

DRAWN BY: WAJ	DATE: 6/29/06	DNC of Mobile, Inc. 113 S. Dearborn St., Mobile, Al. 36602 Phone: 251-432-8722 Fax: 251-432-8779 www.dncofmobile.com
CHKD. BY: LMS	DATE:	MULTIPURPOSE SUPPLY VESSEL 373'-4" X 72'-0" X 25'-0"
APPD. BY:	DATE:	EHAUST PIPING DIAGRAMATIC
CONTRACT NO:		
HOS TASK NO: 1258		SIZE D · HULL NO ESI 014&015 · DWG NO 7.702 · REV 2
		SCALE: NOT TO SCALE · JOB NO: 1340 · SHEET 4 OF 4

Representative Anchor Handling Tug Supply Vessel

8,000 BHP – AHTS SEACOR RELIANT

SEACOR Marine

MAIN PARTICULARS

LENGTH OVERALL	246 ft.	75 m
LENGTH BP	230 ft.	70 m
BEAM	56 ft.	17 m
DEPTH	21 ft.	6 m
LIGHT DRAFT	7 ft.	2 m
LOADED DRAFT	17.5 ft.	5 m
SUMMER FREEBOARD	3.5 ft.	1 m
LIGHTSHIP	1,972 LT.	2,008 MT.

CAPACITIES

DRILL WATER	354,018 USG	1,340 m^3
POTABLE WATER	24,031 USG	91 m^3
FUEL	204,460 USG	774 m^3
LIQUID MUD	6,063 BBLS	964 m^3
DRY BULK	8,100 $ft.^3$	229 m^3
BRINE	254,646 USG	964 m^3
MAX RIG CHAIN	4,400 ft.	1,341 m
DEADWEIGHT	2,947 LT.	3,001 MT.

CARGO DECK

TONNAGE	1,350 LT.	1,375 MT.
LENGTH	150 ft.	46 m
WIDTH	46.5 ft.	14 m
CLEAR AREA	6,975 $ft.^2$	648 m^2

TONNAGE

GRT	2,137 tons
NRT	714 tons

TOWING & ANCHOR HANDLING

WINCH MODEL	Ulstein Brattvaag BFMG 63	
BOLLARD PULL	120 LT.	122 MT.
CHAIN STOPPER(S)	1 Triplex H-350 350 LT. – 356 MT.	
STERN ROLLER	16 ft. x 8 ft. - 350 LT.5 M. x 2 M. - 356 MT.	

PERFORMANCE

MAXIMUM SPEED	14 knots	
CRUISING SPEED	12 knots	
MAXIMUM FUEL CONSUMPTION	334 USG/Hr	30 m^3/24 Hrs
CRUISING FUEL CONSUMPTION	200 USG/Hr	18 m^3/24 Hrs

DISCHARGE RATES

DRILL WATER	1,200 USG/min @ 200 ft.	273 m^3/Hr @ 61 m
POTABLE WATER	1,200 USG/min @ 200 ft.	273 m^3/Hr @ 61 m
FUEL	1,200 USG/min @ 200 ft.	273 m^3/Hr @ 61 m
LIQUID MUD	1,300 USG/min @ 175 ft.	295 m^3/Hr @ 53 m
DRY BULK	735 $ft.^3$/Hr @ 80 PSI	21 m^3/Hr @ 6 bar
BRINE	1,700 USG/min @ 175 ft.	386 m^3/Hr @ 53 m

ACCOMMODATIONS

CABINS/BERTHS	12/29
OFFICERS	5 Cabins - 9 Bunks
CREW	2 Cabins - 6 Bunks, 5 Cabins - 14 Bunks
LOUNGE	7
MESS	12

ELECTRONICS & CONTROLS

JOYSTICK	SIM RAD 1x1
DEPTH SOUNDER	1 Furuno CV-600L Color Depth Sounder
DGPS	Trimble NT 300 D
DYNAMIC POSITIONING	Konsberg Simrad SDP 11
GPS	1 JRC, 1 Furuno
GYRO	1 Yokogawa
SSB	1 SSE3 Necoder
RADAR(S)	2 JRC
RADIO SYSTEM	2 VHF, NAVTEX, GMDSS
INTERNET E-MAIL	Globe WIreless

SPECIAL EQUIPMENT

CRANE	North American 5 LT @ 30 ft. -- 5 MT @ 9 M
SURVIVAL CRAFT	1 x 20 m & 2 x 25 m Inflatable Rafts
RESCUE BOAT	1 x 5m

DOCUMENTATION

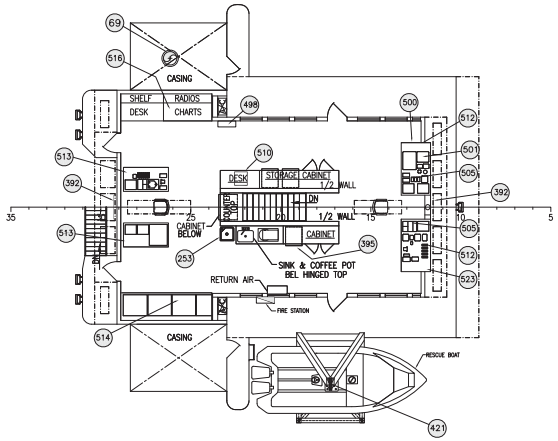
CLASS	8,000 BHP AHTS/DP-1
FLAG	United States
SOLAS	Full
USCG	A1, AMS DPS-1, SH-DLA
YEAR BUILT	1998
OFFICIAL NUMBER	1082755
RADIO CALL SIGN	WCZ2533
BUILDER	North American Shipbuilding

This specification is preliminary and subject to change without notice. Exact tank capacities, deadweight, deck cargo capacity and other figures that have been calculated and may change when the actual vessel is delivered.

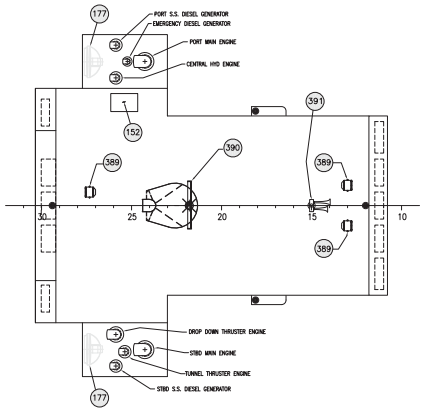
8,000 BHP – AHTS SEACOR RELIANT

ALTERATIONS

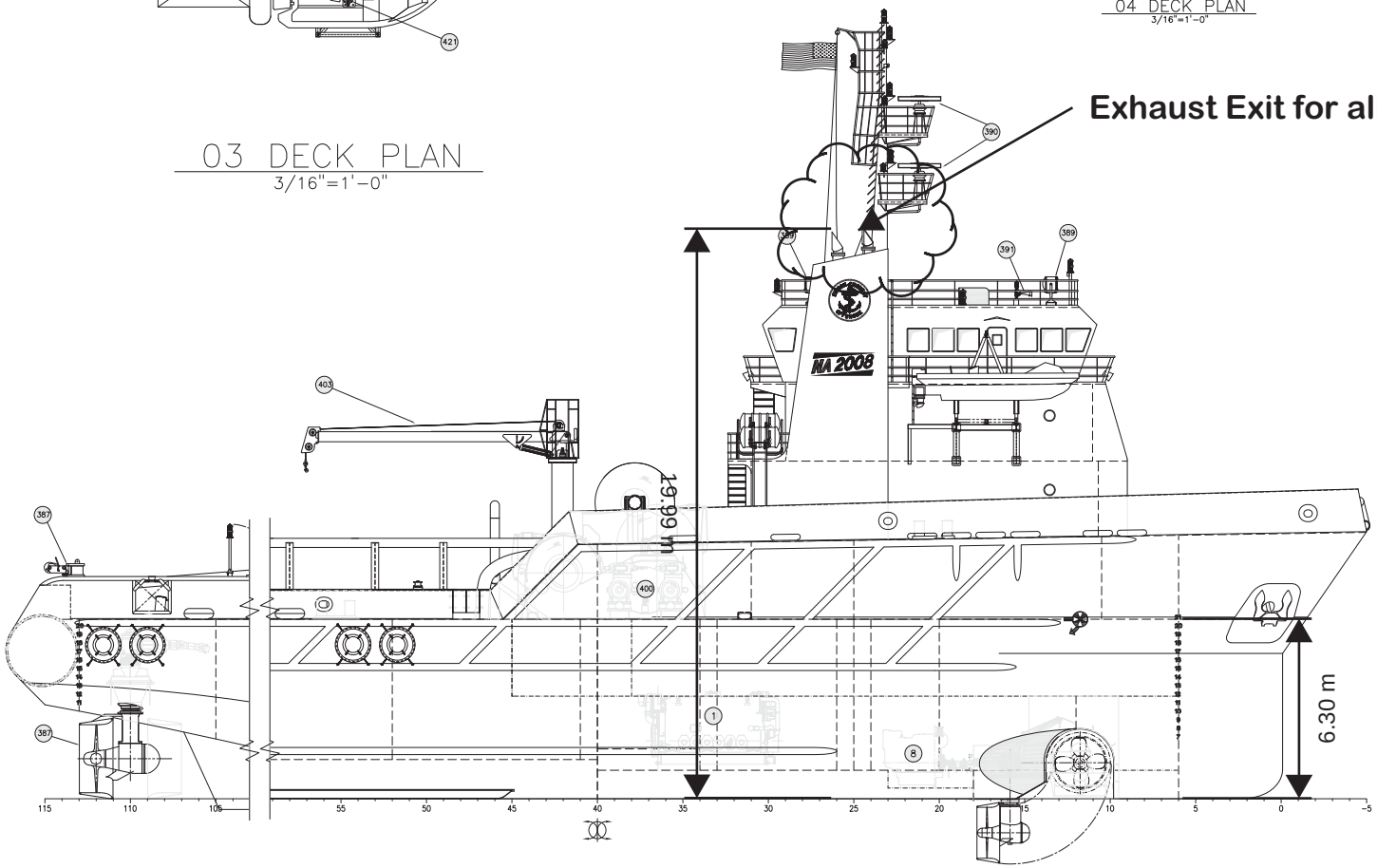
NO	SHT-ZONE	DESCRIPTION	BY	DATE	APPD	DATE
A	THRU-OUT	1. PILOT HOUSE HEAD WAS REMOVED AND CHART TABLE MOVED IN ITS PLACE.	AO	4/6/98		
	THRU-OUT	2. MOVED CERTAIN EQUIPMENT TO MATCH MACHINERY ARRANGEMENT ON HULL 174 AND ADDED 4 AFT COMPARTMENT BLOWERS AND ITEM 523.	AO	7/31/98	FJP	8/17/98
	THRU-OUT	3. REVISED PER FIELD CHECK	RGL	3/1/00		



03 DECK PLAN
3/16"=1'-0"



04 DECK PLAN
3/16"=1'-0"



OUTBOARD PROFILE
3/16"=1'-0"

SHEET INDEX

Sht. No.	Alt. No.	Description
1	A3	MACHINERY LIST
2	A3	MACHINERY ARRANGEMENT
3	A3	MACHINERY ARRANGEMENT
4	A3	MACHINERY ARRANGEMENT

PLAN DISTRIBUTION

Alteration	-	A1	A2	A3
Date	3	4	6	
	30	9	98	
	98	98	99	
Owner				
Charterer				
ABS		1		
USCG		1		
Planning	1	1	1	
Production			2	
Panel-line				
NC				
Emile/Timmy	1/1/1	1/1/1		
Greg/Robert	1	1	1/1/1	

REFERENCES

No.	Title	Dwg. No.

RESERVATIONS

No.	Zone	Description	Prepared By	Date	Prepared By	Date

NORTH AMERICAN SHIPBUILDING
800 INDUSTRIAL PARK ROAD
P.O. DRAWER 800
LAROSE, LA 70373

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Customer: EDISON CHOUEST OFFSHORE ROWAN

Vessel Description: 244'x56'x21' HANDLING HANDLING TUG SUPPLY VESSEL

Dwg Title: MACHINERY ARRANGEMENT

Dwg Ref: 244 56 AHTS

Dwg No: D10

Dwg By: AO Date: 3/23/98
Chkd By: AO Date: 3/23/98
Appd By: FJP Date: 3/23/98
Cust Appd: Date:

Sht No 4 of 4
Hull No 201 SS
Scale AS NOTED
Job No 4322
Alt. A3

TOLERANCES: (unless otherwise noted)
Decimal: X. = ± .06; X.X = ± .03; X.XX = ± .005
Fractions: Linear = ± 1/16"; Diameter = ± 1/16"; Radius = ± 1/32"
Angular: Degrees = ± 1/2 deg; Minutes = ± 5 min.
Geometric symbols in accordance with ANSI Y14.5M

Weight 0.00 Ltns
VCG ft
LCG ft

Plotted 02/01/2000 Drawn By: RL

D12_201

Representative Oil Spill Response Vessel

HOS CORAL

285 Offshore Supply Vessel

DIMENSIONS AND REGULATORY INFORMATION

Length:	285 ft 0 in (86.9 m)	**Beam:**	64 ft 0 in (19.5 m)	**Draft Max:**	19 ft 4 in (5.89 m)
Gross:	3,299 GT	**Net :**	989 NT	**Draft Min:**	10 ft 0 in (3.05 m)
IMO:	9518622	**O.N.:**	1214383		**Flag:** U.S.
Certifications:	Oceans-SOLAS, SIP, USCG Subchapter L				
Classifications:	(E), +A1, +AMS, +DPS-2, American Bureau of Shipping, Loadline, OSV				

PERFORMANCE

Max Speed:	12.0 kts	256 gal/hr (969 l/hr)
Cruise Speed:	11.0 kts	152 gal/hr (575 l/hr)

CAPACITIES AND DELIVERY RATES

Deadweight:	5,609 LT (5,699 MT)	**Deck Area:**	204ft x 54ft	(11,016ft²)
			62m x 16m	(1,023m²)
Deck Cargo:	3,000 LT (3,048 MT)	**Deck Load Rating:**	1,024 lbs/ft² (5 MT/m²)	
Dry Bulk:	12,980 ft³ (367 m³)	**System Pressure:**	80 psi (5.5 bar)	
Brine:	15,212 bbl (2,418 m³)	**Discharge Rate:**	800 GPM (182 m³/hr)	
Liquid Mud:	15,212 bbl (2,418 m³)	**Discharge Rate:**	800 GPM (182 m³/hr)	
Potable Water:	28,440 gal (108 m³)			
Rig Fuel:	336,230 gal (1,273 m³)	**Discharge Rate:**	800 GPM (182 m³/hr)	
Rig Water:	535,040 gal (2,025 m³)	**Discharge Rate:**	800 GPM (182 m³/hr)	
Cooler Area:	460 ft³ (13 m³)	**Freezer Area:**	460 ft³ (13 m³)	

ELECTRONICS

AIS, Auto Pilot, C-Nav, CCTV Cameras, Cyscan, Depth Sounder, DGPS w/AIS, DSDL, EPIRB, GMDSS "A3", Gyro Compass, Joystick Control, Kongsberg DP, Mag Compass, MAMS/VMS, Navtex, Public Phone System w/loudhailer, SARTs, SSAS, VHF Radio, VHF Radio (Handheld), Windbird, X-band Radar, Radar (S-band)

ACCOMMODATIONS

13 air conditioned/heated staterooms certified for 24 person berthing.

SPECIAL FEATURES

Crane: 20t @ 10'

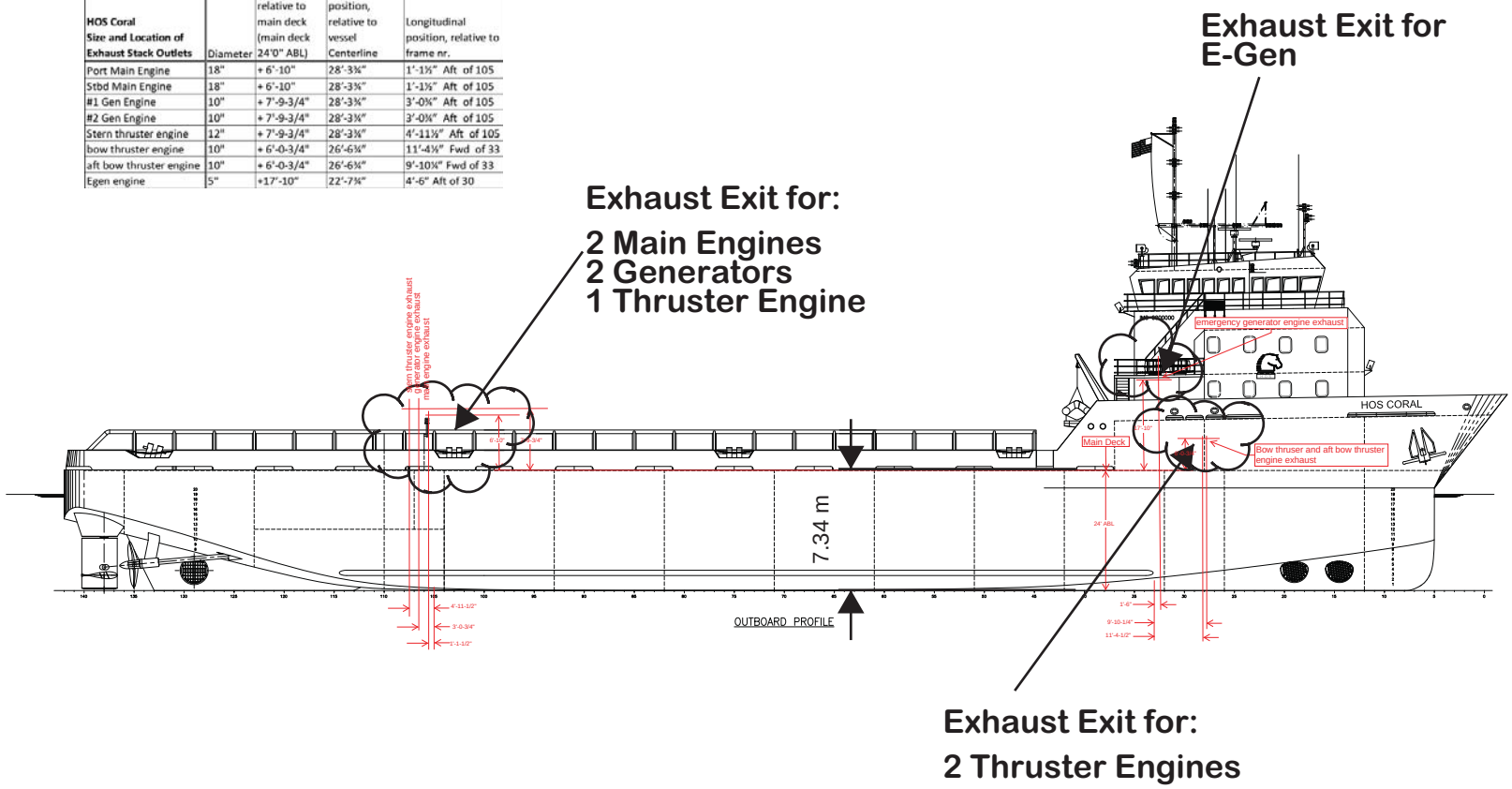
103 Northpark Blvd. Suite 300
Covington, Louisiana 70433
Rev. 4

HORNBECK OFFSHORE
Service with Energy
http://www.hornbeckoffshore.com

Phone: (985)727-2000
Fax: (985)727-3606
Date: 06/04/2010

REVISIONS		
DATE	DESCRIPTION	BY.

HOS Coral Size and Location of Exhaust Stack Outlets	Diameter	Elevation, relative to main deck (main deck 24'0" ABL)	Athwartships position, relative to vessel Centerline	Longitudinal position, relative to frame nr.
Port Main Engine	18"	+ 6'-10"	28'-3¼"	1'-1½" Aft of 105
Stbd Main Engine	18"	+ 6'-10"	28'-3¼"	1'-1½" Aft of 105
#1 Gen Engine	10"	+ 7'-9-3/4"	28'-3¼"	3'-0¾" Aft of 105
#2 Gen Engine	10"	+ 7'-9-3/4"	28'-3¼"	3'-0¾" Aft of 105
Stern thruster engine	12"	+ 7'-9-3/4"	28'-3¼"	4'-11½" Aft of 105
bow thruster engine	10"	+ 6'-0-3/4"	26'-6¼"	11'-4½" Fwd of 33
aft bow thruster engine	10"	+ 6'-0-3/4"	26'-6¼"	9'-10¼" Fwd of 33
Egen engine	5"	+17'-10"	22'-7¾"	4'-6" Aft of 30



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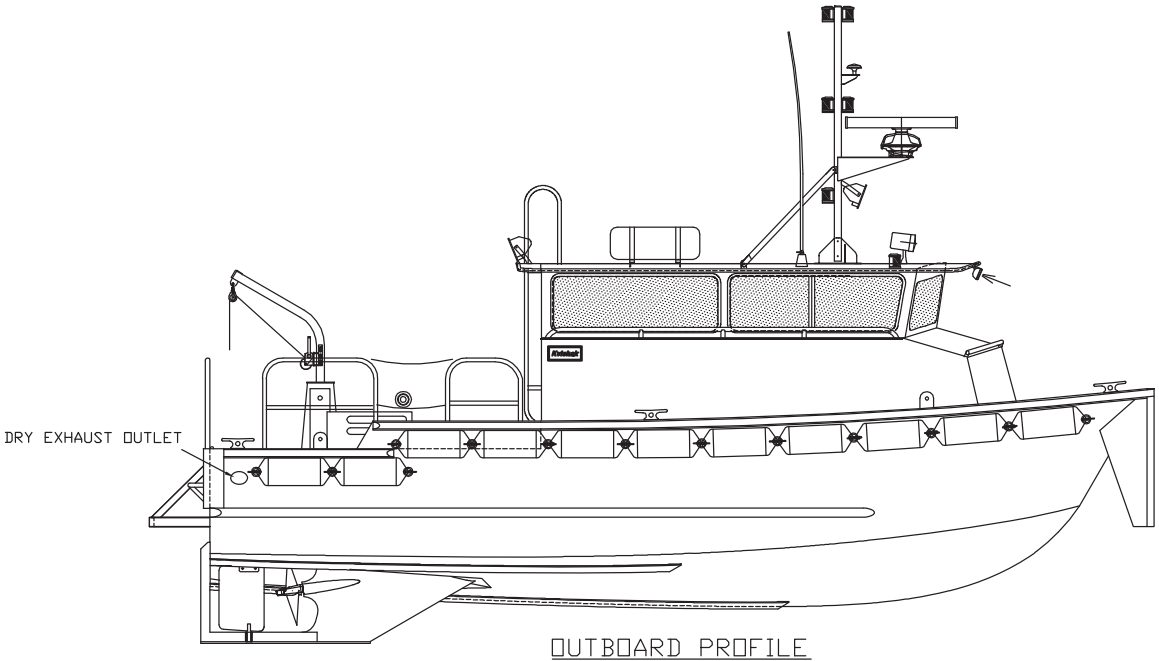
HORNBECK OFFSHORE SERVICES

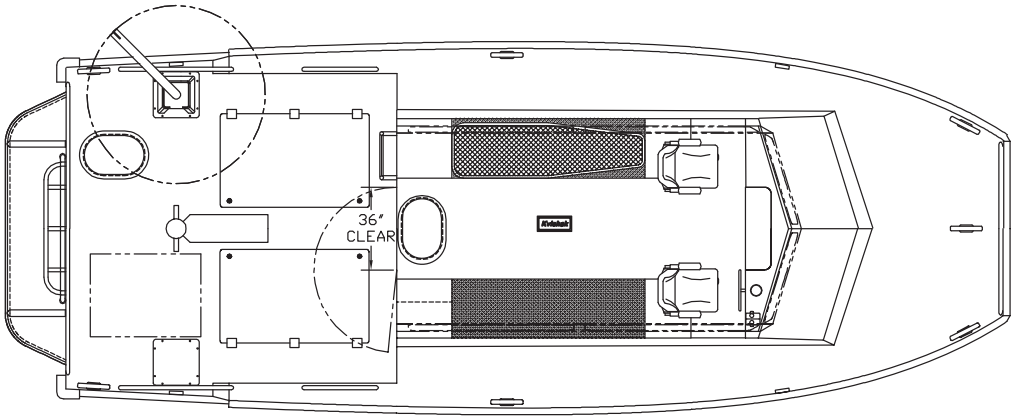
DRAWN BY: TM	285'–0" X 64'–0" X 24'–0" W		
CH'KD. BY: RS	OUTBOARD PROFILE		
APP'D. BY:	SCALE: 1/8"=1'–0"	DATE: 12/05/07	REV.
APP'D. BY:	DRAWING # 1.001	HULL #1990	–
		SHEET 1 OF 1	

Representative Work Boat

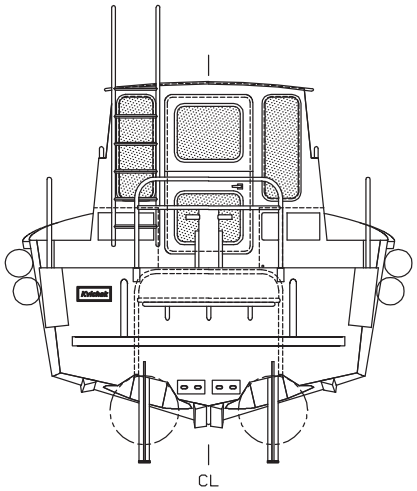
34' OSRV



OUTBOARD PROFILE



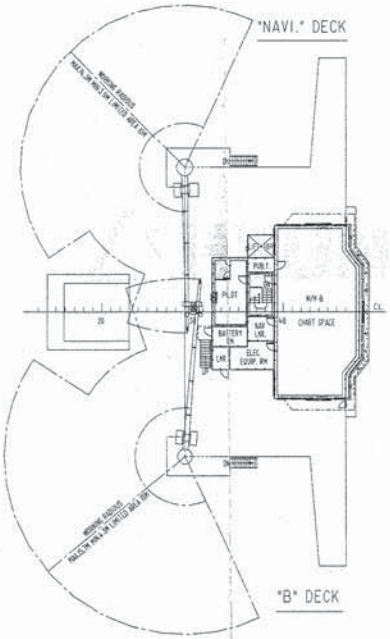
DECK PLAN

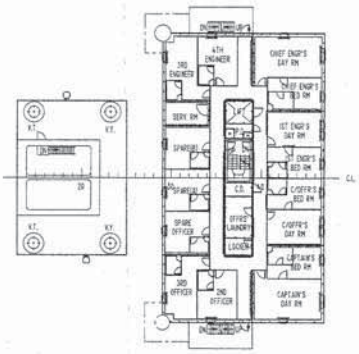


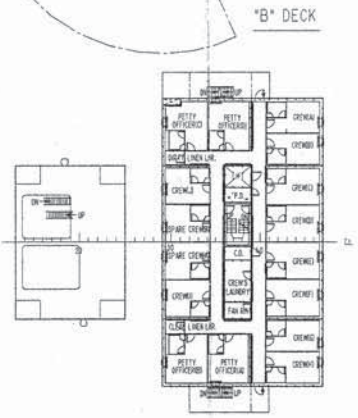
STERN ELEVATION

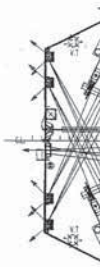
Kvichak

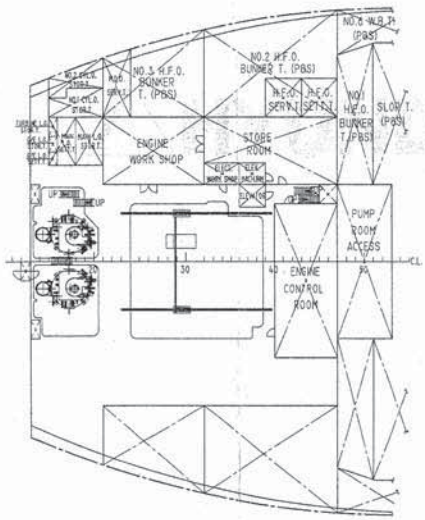
Representative Spill Storage Tanker

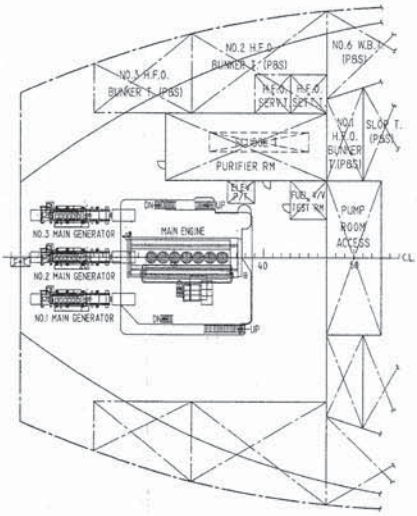












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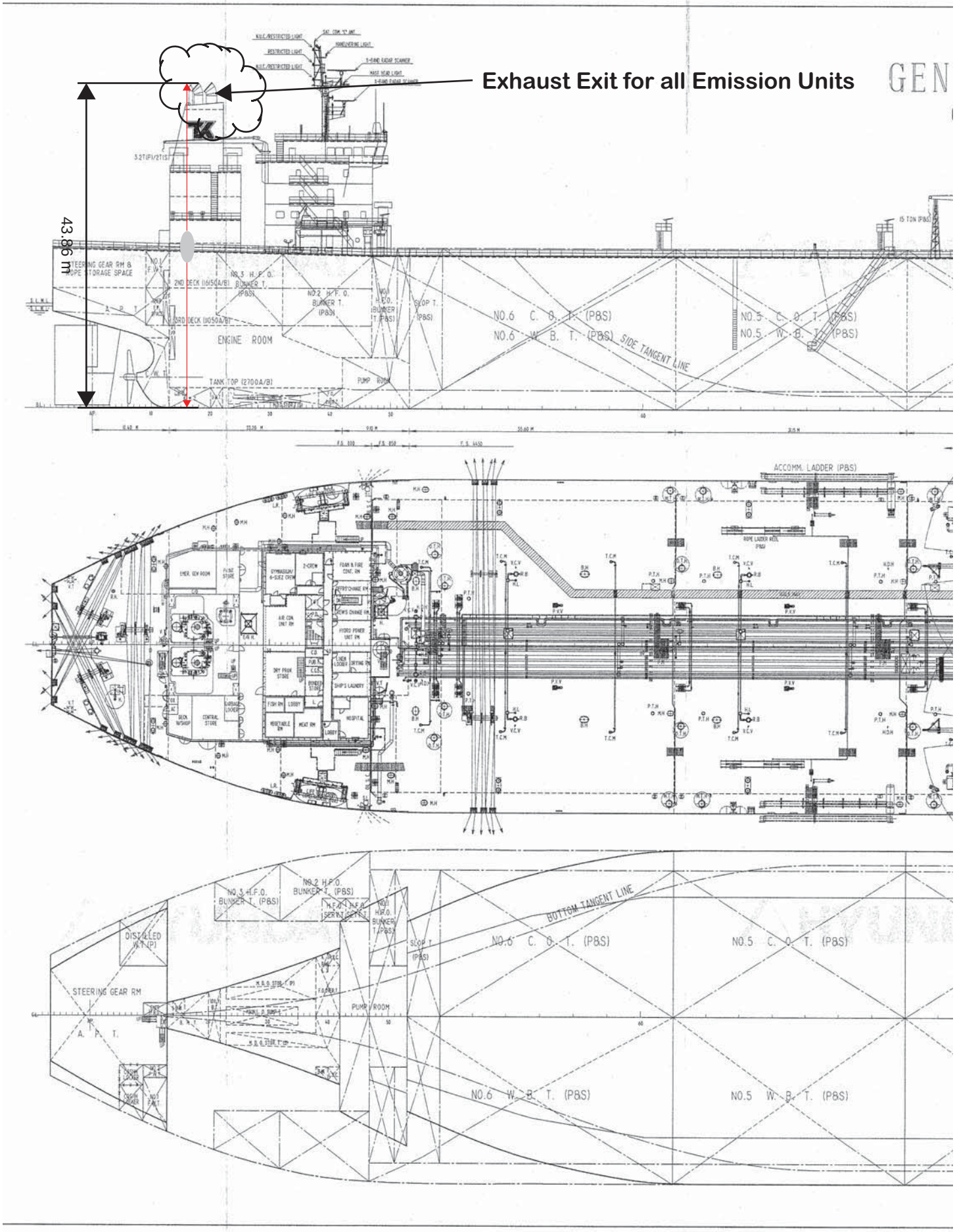
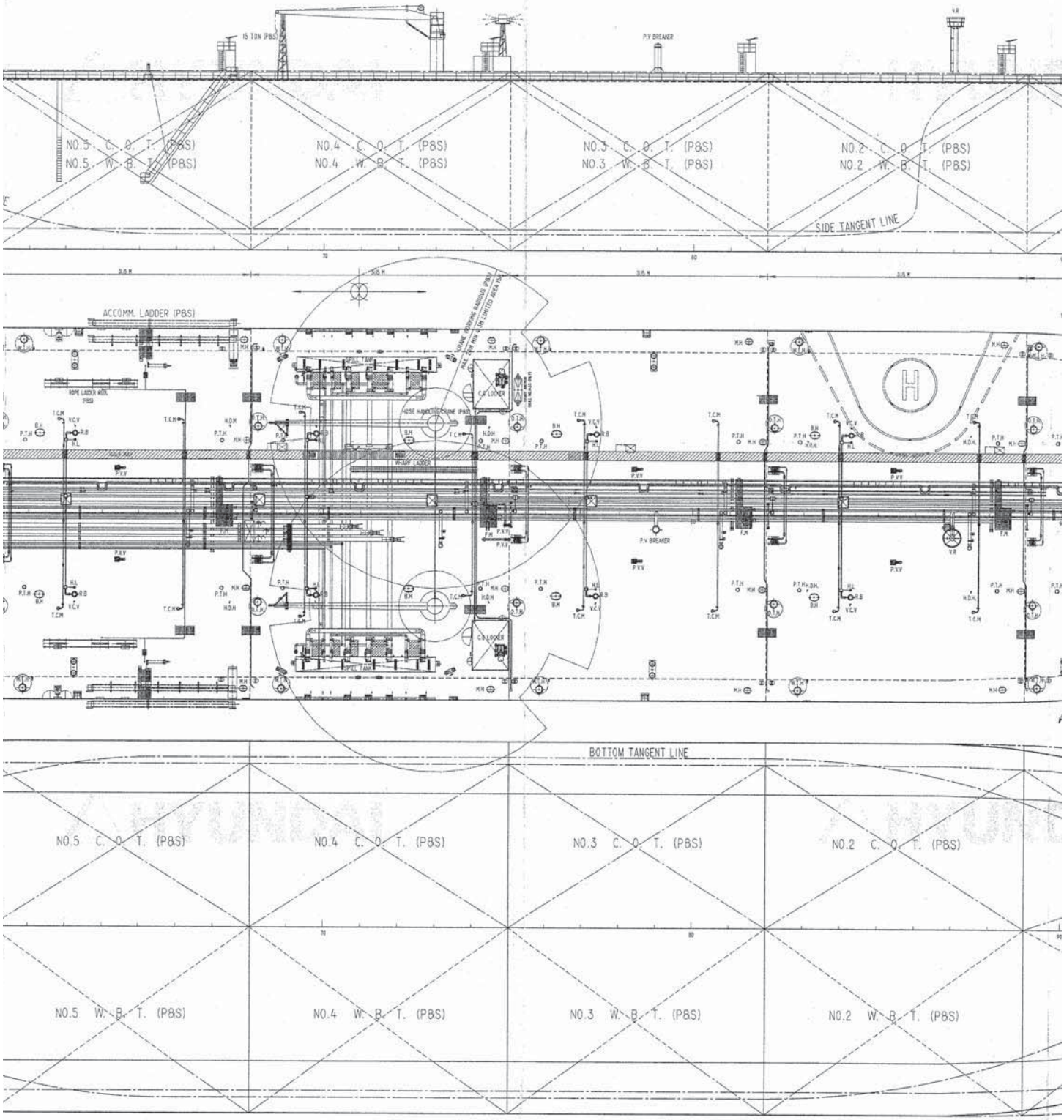
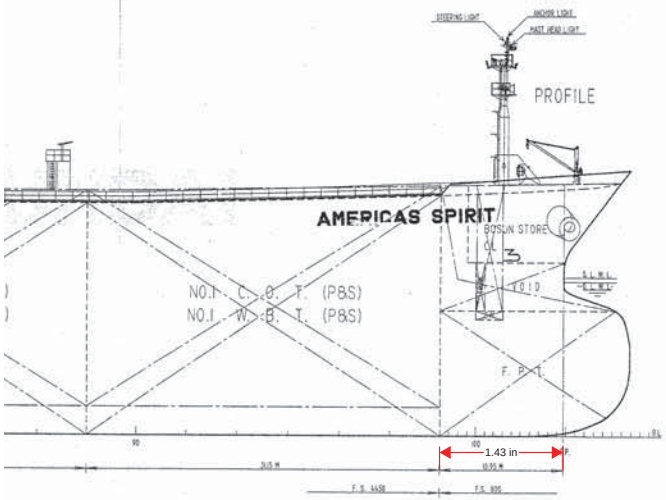
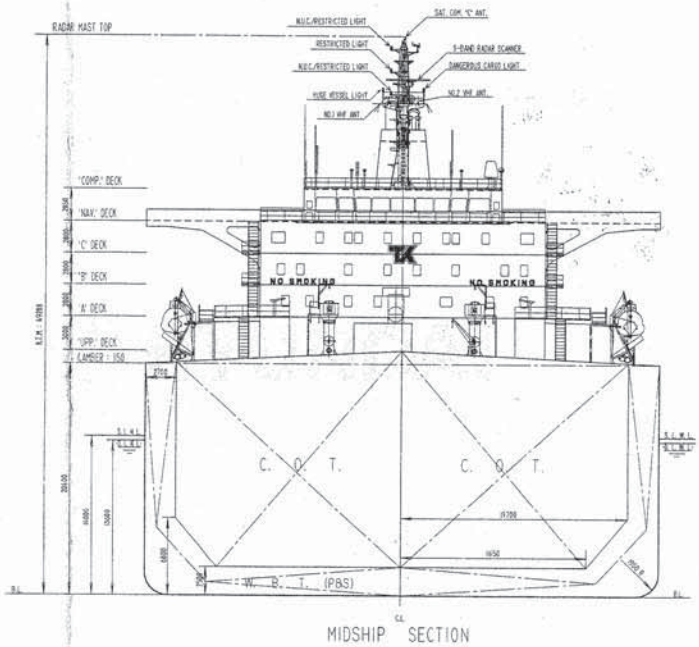

Exhaust Exit for all Emission Units
43.86 m
GEN
STEERING GEAR RM & ROPE STORAGE SPACE
2ND DECK (1650A/B)
3RD DECK (1050A/B)
ENGINE ROOM
TANK TOP (2700A/B)
PUMP ROOM
NO.3 H.F.O. BUNKER T. (P&S)
NO.2 H.F.O. BUNKER T. (P&S)
NO.1 H.F.O. BUNKER T. (P&S)
SLOP T. (P&S)
NO.6 C. O. T. (P&S)
NO.6 W. B. T. (P&S)
SIDE TANGENT LINE
NO.5 C. O. T. (P&S)
NO.5 W. B. T. (P&S)
15 TON (P&S)
ACCOMM. LADDER (P&S)
ROPE LADDER WELL (P&S)
BOTTOM TANGENT LINE
DISTILLED W.T. (P)
STEERING GEAR RM
A. P. T.

GENERAL ARRANGEMENT

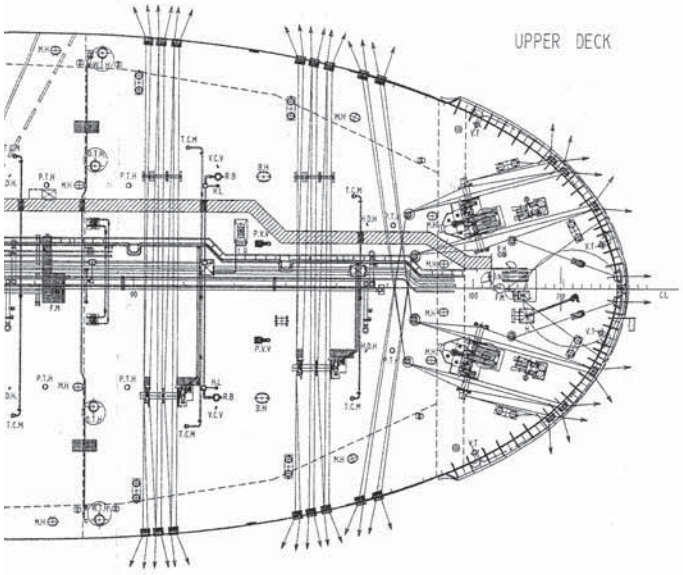
(112,000 DWT CLASS CRUDE OIL CARRIER)



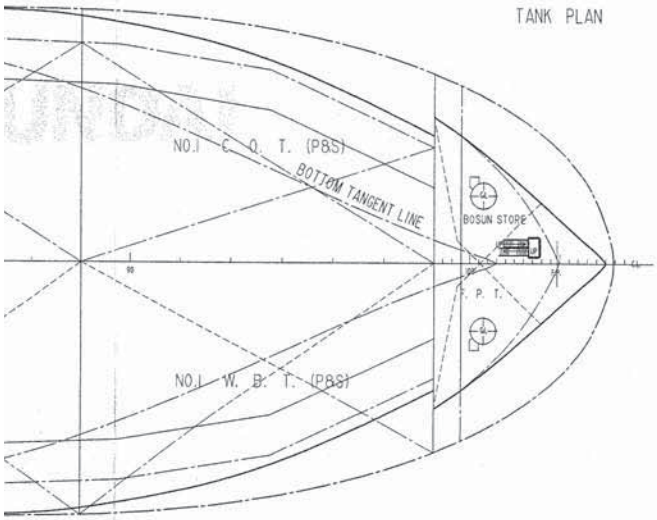




MIDSHIP SECTION



UPPER DECK



TANK PLAN

LENGTH	O.	A.	256.17	M
LENGTH	B.	P.	245.0	M
BREADTH	MLD.		44.8	M
DEPTH	MLD.		20.4	M
DRAUGHT	MLD.(DESIGN)		13.6	M
DRAUGHT	MLD.(SCANTLING)		14.0	M

FREEBOARD FOR TYPE 'A' SHIP

CLASS & NOTATION : DNV, +1A1, TANKER FOR OIL ESP, NAUTICUS (Newbuilding), EO, VCS-2, SPM

MAIN ENGINE : HYUNDAI-B&W 7S60MC
NOMINAL RATING : 18,460 BHP X 105.0 RPM
M C R : 18,460 BHP X 105.0 RPM
N C R : 17,510 BHP X 101.4 RPM

SHIP DESIGN OFFICE HYUNDAI HEAVY INDUSTRIES CO., LTD. ISSUED 2003. 8. 18 ULSAN SHIPYARD KOREA

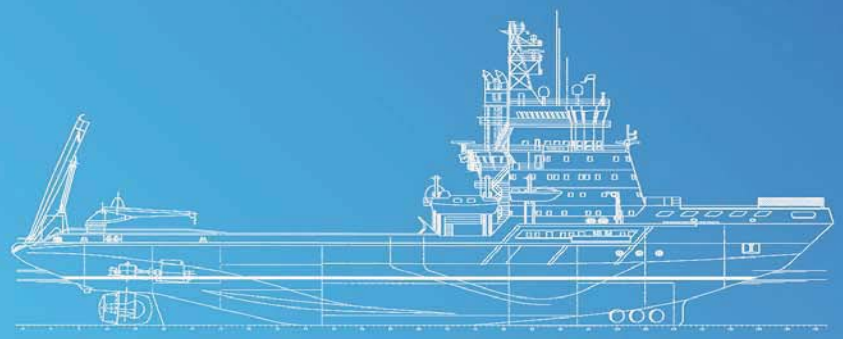
FINISHED PLAN

SEC.NO. C001	SHIP DESIGN OFFICE HULL DESIGN DEP'T NO.2	112,000 DWT CLASS CRUDE OIL CARRIER
TEL.NO. 3546	HULL NO. 1433	SHIP NAME AMERICAS SPIRIT
DATE 2002. 07. 22.	APPROVED D. C. Ryun	NAME OF DRAWING GENERAL ARRANGEMENT
	CHECKED S. G. Kim	
	DRAWN OH JUNG SIK	SCALE 1 / 300 — DRAWING NO. 1C - 7000 - 201
HYUNDAI HEAVY INDUSTRIES CO.,LTD ULSAN SHIPYARD KOREA		CONSOLIDATED NO. FC - 3

BOX 1

Representative Ice Breaker

FINSTASHIP
FIRMLY AT SEA



MSV NORDICA SHORT VESSEL DESCRIPTION

The Nordica is a multifunctional vessel based on a modified icebreaker design with diese lelectric propulsion. The vessel is specially designed for a wide range of offshore related work.

The vessel is designed to carry out offshore installation tasks and can be equipped for laying pipes, cables and umbilicals. The optional 160T SWL crane is well suited for deploy ing trenching machines and ploughs. Her large bollard pull and strong winches make the Nordica ideal for ploughing operations and towing.

With the main components such as winches and cranes already installed, a change of function can be achieved rapidly. Nordica meets all the stringent rules and regulations for offshore work.

ICEBREAKING

The Nordica is a part of Finstaship s icebreaker fleet, one of the most powerful in the world. Icebreaking services include ice management, assistance, towing, securing vessel traffic safety, and traffic control for vessels proceeding in icy conditions.

Nordica s icebreaking capability is excellent. The 15 MW dieselgenerators produce power for two Aqua master azimuth-thrusters to make the vessel easily manoeuvrable. The Nordica is excellent for DP work, all kinds of marine operations and in harsh icy conditions for towing merchant vessels.

VESSEL DETAILS

IMO No.	9056985
Call Sign	OJAE
MMSI	230 275 000
Type of Vessel	Ice Breaker & Multipurpose Support
Flag State	Finland
Port of Registry	Helsinki
Owners	Finstaship
Built	1994
Lightweight	7.935 T
Deadweight (approx.)	4.800 T
Displacement	12.800 T
LOA	116,0 m
LWL	96.7 m
Breadth Moulded	26.0 m
Depth Moulded	12,5 m
Draught (Scantling)	8.4 m

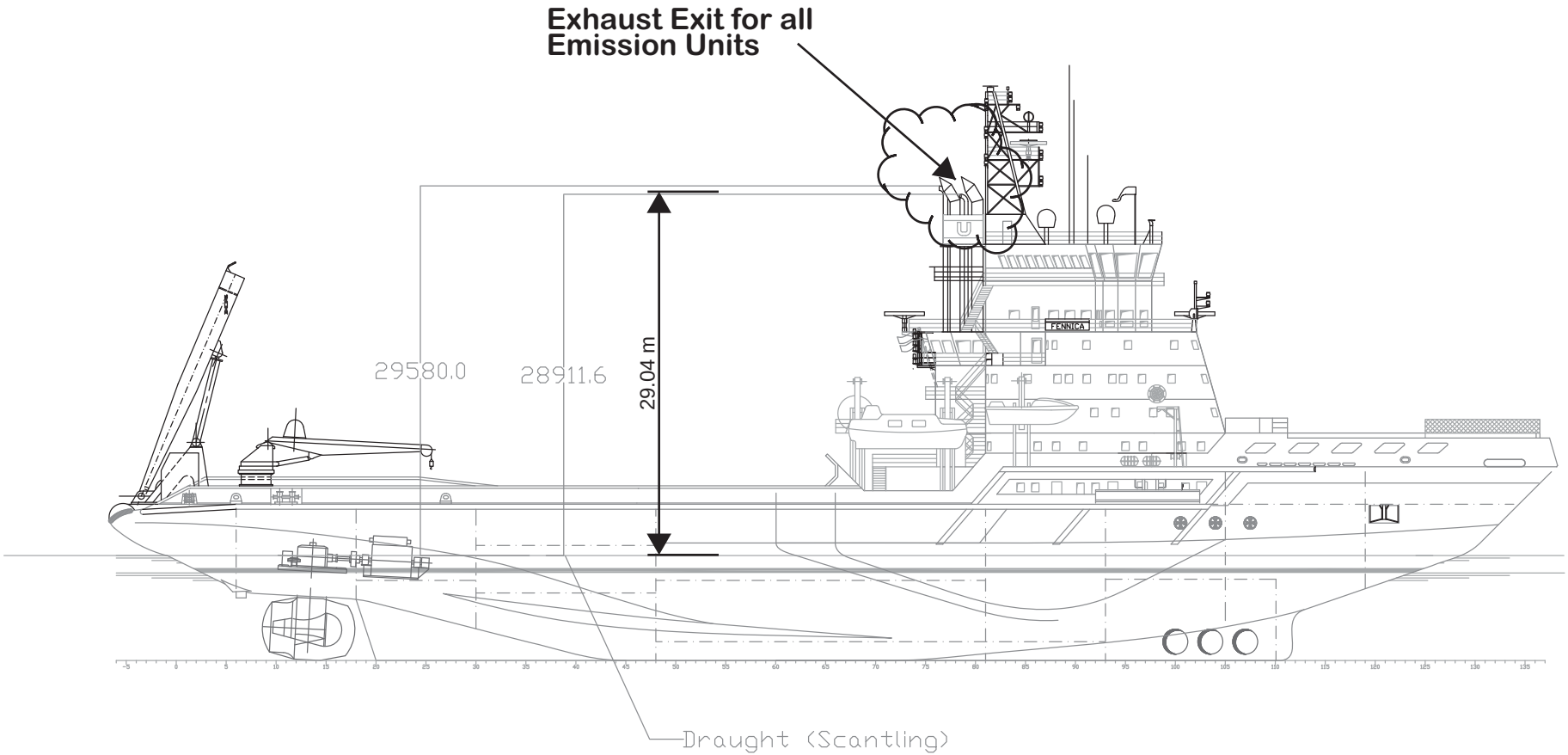
CLASSIFICATION

DNV	+1A1 EOEO Icebreaker POLAR-10 tug Supply Vessel SFSF or HELDK EPR EO DYNPOS AUTR

CAPACITIES AND CONSUMABLES

Fuel Oil (Dual Fuel)	1690 m^3 HFO 817 m^3 DO
Lubricating Oil	85 m^3
Fresh Water	400 m^3
Water Ballast	2200 m^3
F.W. Making Capability	25 T / day
Consumables, 8.4 m Draught:	
Type of Fuel (Dual Fuel)	HFO / DO
Fuel Consumption, 13 knots	abt. 42 T / day
Fuel Consumption, 11 knots	abt. 30 T / day
Fuel Consumption, DP	abt. 15 T / day
Duration, 13 knots	abt. 45 days
Duration, 11 knots	abt. 67 days

Duration times on DP depend on distance and speed of transit, to location.


Exhaust Exit for all
Emission Units
29580.0
28911.6
29.04 m
FENNICA
Draught (Scantling)

Representative Marine Research Vessel

NORSEMAN
108 ft. Research Vessel

DIMENSIONS AND REGULATORY INFORMATION

Length:	108 ft.	**Beam:**	28 ft.	**Draft:**	13 ft.
Gross Tons:	197	**Deck Levels:**	3		

Documentation: United States
Sewage Treatment System: Type II MSD Coast Guard Approved

PERFORMANCE & PROPULSION

Speed: 10 Knots
Endurance: 90+ Days
Range: 10,000 Miles

MACHINERY

Electrical Power: 110 Volt AC
208 Volt AC 3 Phase
480 Volt AC 3 Phase

CAPACITY

Fuel Capacity 40,000 gal.
Fresh Water Holding: 4,500 gal.
Fresh Water Making: 1,200 gal., per day
Walk in Freezer: 400 cu ft.
Walk in Cooler: 300 cu ft.
Open Deck Area: 1,400 sq ft.

ACCOMMODATIONS

Berths: 5 researcher cabins capable of sleeping 12 (can be configured to accommodate 18 to 20 depending on needs), plus separate quarters for 8 crew
Bathrooms: 7 units each with a toilet, shower, and vanity
Dinning: Separate guest and crew messes

SPECIAL FEATURES

Hydraulic Boom Crane: 20,000 Lbs. SWL @ 20' 10,000 lbs.
Stern Mounted A-Frame: SWL 5,000 lbs.
Hydraulic Deck Winch: 2,000 lbs., line pull 1,000 ft., 3/8 wire
Anchor Winch: 75 Fathoms ground gear
Skiff Launching Ability: Up to 27' rigid

ELECTRONICS AND COMMUNICATIONS

Radar: Furuno 1510D, Furuno Navnet VX2 Radar and Plotter; GPS: Furuno GP-32, Northstar 952X; AIS: Furuno FA-150; Depth Sounders: Furuno FCV-292 Color Sounder, Furuno FE 881 II Recording Sounder; **Communications:** Furuno FS400 Single Side Band, Furuno FS4001 Single Side Band, Stephens SEA 222 Single Side Band, Two VHF Radios, Iridium Satellite phone, One Icom, three Portable Handheld VHFs

P.O. Box 9322, Seattle, WA 98109 * ph: 206-403-3630
Web: www.norsemanmaritime.com * e-mail: info@norsemanmaritme.com

OUR Ships

Click Images to Enlarge

R/V Norseman and *R/V Norseman II*

At-sea research requires months of planning and coordination. Funding has to be identified, carefully budgeted and spent well. The work plan has to maximize one of marine research's scarcest resources-sea time. When you finally arrive at the dock with your equipment and research team, a ship has to be waiting that you can trust and depend on. *Norseman Maritime Charters* offers two ships that meet the most exacting standards-- standards you can depend on.

Click to View Accommodations

Click Image to Enlarge

Built for the demands of the North Pacific and Bering Sea winter crab fisheries, the 108' ***R/V Norseman***was designed by noted naval architect Bruce Whittemore and built by Marco Shipyard of Seattle. Commissioned by *Norseman Maritime Charters* in Summer 2005, Whittemore undertook a redesigned of *Norseman*. The goal? To fold the best qualities of a tested ship into a new vision for research and expedition charters. With excellent results, the vision expanded, and *Norseman's* sister ship, ***R/V Norseman II,*** was acquired. The 115'*R/V Norseman II* was also designed and built by the Whittemore-Marco Shipyard team for the challenges of the Bering Sea fishery. In Fall 2006, Whittemore was commissioned to redesign *R/V Norseman II,* with a complete re-fit completed in Spring 2007.

The result--- two exceptional U.S. registered vessels specifically designed for extended research and expedition charter. Quality workmanship combine with the ships' exceptional range, rugged construction and sea keeping abilities has resulted in vessels that are reliable in a wide range of conditions, safe, efficient and flexible. Each ship has ample dry storage room and two walk in freezers. These vessels are designed and operated to complete the mission.

Specifications

	Norseman	*Norseman II*
L. O. A.	108 ft.	115 ft.
Beam	28 ft.	28 ft.
Draft	13 ft.	13 ft.
Decks	3	3
Gross Tonnage	197	194
Fuel Capacity	40,000 gal.	40,000 gal.
Freshwater Capacity	4,000 gal.	14,000 gal.
Range	10,0000 miles	10,000 miles

To talk to one of our research vessel team members, please call 1-207-636-7958 or email norsemanchtr@comcast.net

Appendix G
Regulatory CALMET Settings

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

AUG 3 1 2009

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

MEMORANDUM

SUBJECT: Clarification on EPA-FLM Recommended Settings for CALMET

TO: Regional Modeling Contacts

FROM: Tyler J Fox, Group Leader
Air Quality Modeling Group, C439-01

The purpose of this memorandum is to update the draft recommendations for CALMET settings that were provided previously with the draft *Reassessment of the Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report: Revisions to Phase 2 Recommendations* (EPA, 2009).

On May 15, 2009, the EPA Model Clearinghouse issued a memorandum addressing a number of issues related to the operation of the CALMET diagnostic meteorological model in regulatory modeling applications for long-range transport (LRT). Additionally, a draft version of revisions to the existing IWAQM Phase 2 guidance was released on May 27, 2009 to provide technical context for the Clearinghouse memorandum. This draft document outlined a series of recommendations for CALMET settings that were intended to facilitate the direct "pass-through" of prognostic meteorological data to the CALPUFF modeling system using the same horizontal and vertical grid structure of the parent prognostic data set. This purpose is consistent with one of our overarching goals expressed at the 8th Conference on Air Quality Modeling promoting the use of prognostic meteorological model products in regulatory dispersion modeling applications.

Due to the time sensitive nature of the Clearinghouse memorandum, it was not possible to complete extensive testing of the recommended CALMET operational settings prior to release of the memorandum and draft IWAQM reassessment report. Subsequent testing of the CALMET model with the proposed settings against mesoscale tracer databases indicates that CALMET/CALPUFF performance using the draft recommendations deteriorates somewhat in comparison to other MM5/CALMET horizontal grid configurations that were tested. Specifically, testing against the Cross-Appalachian Tracer Experiment (CAPTEX) mesoscale tracer study dataset showed that when MM5 and CALMET were run on the same horizontal grid resolution, performance was poorer than other MM5/CALMET grid configurations tested. While the performance deterioration was not drastic, it was significant. These results have caused us to reconsider our interim guidance because it is inconsistent with our desire to promote the use of both the best meteorological products and prognostic data in general. The use of

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CALMET as a vehicle to "pass-through" MM5 or other numerical weather prediction (NWP) model data is no longer considered viable.

The EPA has dedicated considerable time and resources to the evaluation of the use of NWP data in conjunction with the CALMET/CALPUFF modeling system. As discussed in the draft IWAQM reassessment report, there are technical limitations to the applicability of diagnostic wind field models that together with advances in NWP model technology and resolution make the fuller use of NWP model data an attractive alternative. The draft IWAQM reassessment document also discusses EPA's intention to transition to the full use of NWP model data rather than continue reliance upon wind fields from DWMs for LRT applications. Therefore, rather than continue to dedicate time and resources to evaluating configurations for CALMET that would facilitate a direct "pass-through" of NWP data, EPA will focus its efforts toward expediting the testing and review of its MM5/WRF-to-CALPUFF software prototype discussed at the 9th Conference on Air Quality Modeling in anticipation of an early 2010 release.

In the interim, a revised series of recommendations for CALMET settings were agreed upon during a recent meeting with modelers from EPA and the Federal Land Manager (FLM) community. Therefore, as discussed during the EPA modelers' conference call on August 19th, the EPA Model Clearinghouse is providing all of the Regional Modeling Contacts with the attached revised list of recommended switch settings for CALMET. These recommendations are based in large part upon the understanding we have developed from the numerous tracer evaluations we have conducted in addition to the collective experience of the National Park Service, Forest Service, and US Fish and Wildlife from the BART process. In general the recommendations are based upon values from the VISTAS BART modeling protocol with limited modifications based on our internal testing.

As attached, these updated recommendations supersede the recommendations from the draft IWAQM reassessment report. While the draft IWAQM recommendations intended to configure CALMET to facilitate a direct "pass-through" of MM5 data are no longer considered viable, our position regarding grid resolution presented in the May 15, 2009, Model Clearinghouse memorandum have not changed. In particular, we wish to call to your attention that in most circumstances it is considered inappropriate to consider CALMET horizontal grid resolutions of less than four (4) kilometers, consistent with our discussion in the May 15, 2009 Model Clearinghouse memorandum. It is anticipated that the FLMs will likewise require adherence to these recommendations for modeling conducted pursuant to the Class I AQRV requirements of the PSD program. In those cases, it is important to remember that the FLMs have the affirmative responsibility for AQRV related studies, and usually take the lead in negotiating the protocol for model settings (per Section 6.2.3 of the *Guideline on Air Quality Models*, Appendix W to 40 CFR Part 51).

REFERENCES

USEPA, 2009: Reassessment of the Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report: Revisions to Phase 2 Recommendations (Draft). EPA- EPA-454/B-09-XXX, Research Triangle Park, NC, 56 pp.

cc: Richard Wayland
Bill Harnett
Raj Rao
Dan Deroeck
Roger Brode
Bret Anderson
John Vimont
Tim Allen
John Notar
Rick Graw

EPA-FLM Recommended CALMET Input File Values

August 28, 2009

Input Group	Subgroup	Variable	Description	Default	EPA-FLM
0 - Input and output file names	a	GEODAT	Input filename of geophysical data	GEO.DAT	User defined
		SRFDAT	Input filename of hourly meteorological data	SURF.DAT	User defined
		CLDDAT	Input filename of gridded cloud data	CLOUD.DAT	
		PRCDAT	Input filename of hourly precipitation data	PRECIP.DAT	User defined
		WTDAT	Input filename of gridded fields of terrain weighting factors	WT.DAT	
		METLST	Output filename of list file	CALMET.LST	User defined
		METDAT	Output filename of generated gridded met fields	CALMET.DAT	User defined
		PACDAT	Output filename of generated gridded met files (MESEOPUFF II)	PACOUT.DAT	
		LCFILES	Convert names to upper or lower case	User defined	T
		NUSTA	Number of upper air stations	User defined	User defined (>0)
		NOWSTA	Number of over water met stations	User defined	User defined
		NM3D	Number of MM4/MM5/3D.DAT files	User defined	User defined (>0)
		NIGF	Number of coarse grid CALMET fields as initial guess fields	User defined	0
	b	UPDAT	Input filenames of upper air data	UPn.DAT (n=1,2,3...)	User defined
	c	SEADAT	Input filename of over water stations	SEAn.DAT (n=1,2,3;..)	User defined
	d	M3DDAT	Input filename of MM4/MM5/3D.DAT	MM50n.DAT	User defined
	e	IGFDAT	Input filename of IGF-CALMET files	IGFn.DAT (n=1,2,3...)	
	f	DIADAT	Input filename of preprocessed sfc/UA data	DIAG.DAT	
		PRGDAT	Input filename of prognostic gridded wind fields	PROG.DAT	
		TSTPRT	Output filename of intermediate winds, and misc...etc	TEST.PRT	

Input Group	Subgroup	Variable	Description	Default	EPA-FLM
		TSTOUT	Output filename of final wind fields	TEST.OUT	
		TSTKIN	Output filename of wind fields after kinematic winds	TEST.KIN	
		TSTFRD	Output filename of winds after Froude Number effects	TEST.FRD	
		TSTSLP	Output filename winds after slope effects	TEST.SLP	
		DCSTGD	Output filename of distance land internal variables	DCST.GRD	
1 - General run and control parameters		IBYR	Beginning year	User defined	User defined
		IBMO	Beginning month	User defined	User defined
		IBDY	Beginning day	User defined	User defined
		IBHR	Beginning hour	User defined	User defined
		IBTZ	Base time zone	User defined	User defined
		IRLG	Length of run (hours)	User defined	User defined
		IRTYPE	Output type to create	1	1
		LCALGRD	Require fields for CALGRID	T	T
		ITEST	Flag to stop run after setup phase	2	2
		MREG	Conformity to regulatory values	User defined	1
2 - Map projection and grid control parameters		PMAP	Map projection	UTM	LCC
		FEAST	False Easting at projection origin (km)	0.0	0.0
		FNORTH	False northing at projection origin (km)	0.0	0.0
		IUTMZN	UTM zone	User defined	-999
		UTMHEM	Hemisphere of UTM projection	N	N
		RLAT0	Latitude of projection origin (decimal degrees - N)	User defined	User defined
		RLON0	Longitude of projection origin (decimal degrees - W)	User defined	User defined
		XLAT1	Matching latitude for projection (decimal degrees - N)	User defined	User defined

Input Group	Subgroup	Variable	Description	Default	EPA-FLM
		XLAT2	Matching latitude of projection (decimal degrees - N)	User defined	User defined
		Datum	Datum-region of output coordinates	WGS-84	User defined
		NX	Number of east to west or X grid cells	User defined	User defined
		NY	Number of north to south or Y grid cells	User defined	User defined
		DGRIDKM	Grid spacing in kilometers (km)	User defined	User defined (≥4km)
		XORIGKM	Southwest corner of grid cell (1,1), X-coordinate (km)	User defined	User defined
		YORIGKM	Southwest corner of grid cell (1,1), Y-coordinate (km)	User defined	User defined
		NZ	Number of vertical layers	User defined	10
		ZFACE	Cell face heights in arbitrary vertical grid (ZFACE (NZ+1)) (m)	User defined	0,20,40,80,160,320, 640,1200,2000,3000, 4000
3 - Output options		LSAVE	Save met fields in unformatted file	T	T
		IFORMO	Type of unformatted output file	1	1
		LPRINT	Print met fields	F	F
		IPRINF	Print interval in hours	1	1
		IUVOUT	Layers of U, V wind components to print (IUVOUT (NZ))	NZ*0	10*0
		IWOUT	Levels of W wind component to print (IWOUT (NZ))	NZ*0	10*0
		ITOUT	Levels of 3-D temps to print (ITOUT (NZ))	NZ*0	10*0
		STABILITY	Print PGT Stability	0	0
		USTAR	Print friction velocity	0	0
		MONIN	Print Monin-Obukhov	0	0
		MIXHT	Print mixing height	0	0
		WSTAR	Print convective velocity scale	0	0
		PRECIP	Print precipitation rate	0	0

Input Group	Subgroup	Variable	Description	Default	EPA-FLM
		SENSHEAT	Print sensible heat flux	0	0
		CONVZI	Print convective mixing height (Zic)	0	0
		LDB	Print met data and internal variables)	F	F
		NN1	Test and debug print options: first time step	1	1
		NN2	Test and debug print options: last time step	1	1
		LDBCST	Test and debug print options: distance to land internal variables	F	F
		IOUTD	Test and debug print options: control variables for writing winds	0	0
		NZPRN2	Test and debug print options: number of levels starting at sfc	1	0
		IPR0	Test and debug print options: interpolated winds	0	0
		IPR1	Test and debug print options: terrain adjusted surface wind	0	0
		IPR2	Test and debug print options: smoothed wind and diverge fields	0	0
		IPR3	Test and debug print options: final wind speed and direction	0	0
		IPR4	Test and debug print options: final divergence	0	0
		IPR5	Test and debug print options: winds after Kinematic effects	0	0
		IPR6	Test and debug print options: winds after Froude No. adjustment	0	0
		IPR7	Test and debug print options: winds after slope flow	0	0
		IPR8	Test and debug print options: final winds	0	0
4 - Meteorolo-gical data options		NOOBS	No observation mode	0	0
		NSSTA	Number of surface stations	User defined	User defined (>0)
		NPSTA	Number of precipitation stations	User defined	User defined (>0)
		ICLOUD	Gridded cloud fields	0	0
		IFORMS	Surface met data file format	2	2
		IFORMP	Precipitation data file format	2	2

Input Group	Subgroup	Variable	Description	Default	EPA-FLM
		IFORMC	Cloud data format	2	2
5 - Wind field options and parameters		IWFCOD	Wind model options	1	1
		IFRADJ	Compute Froude number adjustment effects	1	1
		IKINE	Compute Kinematic effects	0	0
		IOBR	Use O'Brien procedures for adjust vertical velocity	0	0
		ISLOPE	Compute slope effects	1	1
		IEXTRP	Extrapolate sfc wind obs to upper levels	-4	-4
		ICALM	Extrapolate sfc winds even if calm	0	0
		BIAS	Surface/upper weighting factors (BIAS (NZ))	NZ*0	10*0
		RMIN2	Minimum distance for extrapolation of winds	4	-1
		IPROG	Use prognostic model winds as input to diagnostic wind model	0	14
		ISTEPPG	Timestep (hours) of prognostic model data	1	1
		IGFMET	Use coarse CALMET fields as initial guess	0	0
		LVARY	Use varying radius of influence	F	F
		RMAX1	Maximum radius of influence in surface layer (km)	User defined	100
		RAMX2	Maximum radius of influence over land aloft (km)	User defined	200
		RMAX3	Maximum radius of influence over water (km)	User defined	200
		RMIN	Minimum radius of influence in wind field interpolation (km)	0.1	0.1
		TERRAD	Radius of influence of terrain features (km)	User defined	15
		R1	Relative weight at surface of 1st guess fields and obs (km)	User defined	50
		R2	Relative weight aloft of 1st guess fields and obs (km)	User defined	100
		RPROG	Weighting factors of prognostic wind field data (km)	User defined	0
		DIVLIM	Maximum acceptable divergence	5.0E-06	5.0E-06

Input Group	Subgroup	Variable	Description	Default	EPA-FLM
		NITER	Maximum number of iterations in divergence minimum	50	50
		NSMTH	Number of passes in smoothing (NSMITH (NZ))	2, (nxnz-1)*4	2, 9*4
		NINTR2	Maximum number of stations for interpolation (NINTR2(NZ))	99	10*99
		CRITFN	Critical Froude Number	1	1
		ALPHA	Empirical factor controlling influence of kinematic effects	0.1	0.1
		FEXTR2	Multiplicative scaling factor for extrap of sfc obs to upper layers (FEXTRS(NX))	NZ*0.0	10*0
		NBAR	Number of barriers to interpolation of wind fields	0	0
		KBAR	Level (1 to NZ) up to which barriers apply	NZ	10
		XBBAR (NBAR>0)	X coordinate of beginning of each barrier (km)	User defined	0
		YBBAR (NBAR>0)	Y coordinate of beginning of each barrier (km)	User defined	0
		XEBAR (NBAR>0)	X coordinate of ending of each barrier (km)	User defined	0
		YEBAR (NBAR>0)	Y coordinate of ending of each barrier (km)	User defined	0
		IDIOPT1	Compute surface temperature	0	0
		ISURFT [b]	Sfc met station to use for sfc temp	User defined	User defined
		IDIOPT2	Domain-averaged temp lapse rate	0	0
		IUPT (IDIOPT2=0) [b]	UA station to use for the domain-scale lapse rate	User defined	User defined
		ZUPT (IDIOPT2=0)	Depth through which domain-scale lapse rate is computed (m)	200	200
		IDIOPT3	Domain-averaged wind component	0	0
		IUPWIND (IDIOPT3=0)	UA station to use for domain-scale winds	-1	-1
		ZUPWIND (IDIOPT3=0)	Bottom and top of layer thru which domain winds computed (m)	1., 1000	1., 1000
		IDIOPT4	Read observed surface wind components	0	0
		IDIOPT5	Read observed upper wind components	0	0

Input Group	Subgroup	Variable	Description	Default	EPA-FLM
		LLBREZE	Use lake breeze module	F	F
		NBOX	Number of lake breeze regions	User defined	0
		XG1	X grid line 1 defining the region of interest	User defined	0
		XG2	X grid line 2 defining the region of interest	User defined	0
		YG1	Y grid line 1 defining the region of interest	User defined	0
		YG2	Y grid line 2 defining the region of interest	User defined	0
		XBCST	X point defining the coastline (km)	User defined	0
		YBCST	Y point defining the coastline (km)	User defined	0
		XECST	X point defining the coastline (km)	User defined	0
		YECST	Y point defining the coastline (km)	User defined	0
		NLB	Number of stations in the region (sfc + upper air)	User defined	0
		METBXID	Station ID's in the region (METBXID (NLB))	User defined	0
6 - Mixing height, temperature and precipitation parameters		CONSTB	Mix ht constant: neutral, mechanical equation	1.41	1.41
		CONSTE	Mix ht constant: convective equation	0.15	0.15
		CONSTN	Mix ht constant: stable equation	2400	2400
		CONSTW	Mix ht equation: over water	0.16	0.16
		FCORIOL	Absolute value of Coriolis parameter	1.0E-04	1.0E-04
		IAVEZI	Spatial averaging of Mix ht: conduct spatial averaging	1	1
		MNMDAV	Spatial averaging of Mix ht: Max search radius (# of grid cells)	1	1
		HAFANG	Spatial avg'n of Mix ht: 0.5-angle of upwind cone for avg (deg)	30	30
		ILEVZI	Spatial averaging of Mix ht: Layer of winds used in upwind	1	1
		IMIXH	Zic Mix Ht Options: Method to compute Mix ht	1	-1

Input Group	Subgroup	Variable	Description	Default	EPA-FLM
		THRESHL	Zic Mix Ht Options: Threshold buoyancy flux reqrd to sustain over land (W/m3)	0.05	0.0
		THRESHW	Zic Mix Ht Options: Threshold buoyancy flux reqrd sustain over water (W/m3)	0.05	0.05
		ITWPROG	Zic Mix Ht Options: Overwater lapse rates used in Zic growth	0	0
		ILUOC3D	Zic Mix Ht Options: Land use category in 3D.DAT	16	16
		DPTMIN	Min potential Temp lapse rate in stable layer above Zic (deg-K/m)	0.001	0.001
		DZZI	Depth of computing capping lapse rate (m)	200	200
		ZIMIN	Minimum over land mixing height (m)	50	50
		ZIMAX	Maximum over land mixing height (m)	3000	3000
		ZIMINW	Minimum over water mixing height (m)	50	50
		ZIMAXW	Maximum over water mixing height (m)	3000	3000
		ICOARE	Over water surface fluxes methods and parameters	10	0
		DSELF	Coastal/shallow water length scale (km)	0	0
		IWARM	COARE warm layer computation	0	0
		ICOOL	COARE cool skin layer computation	0	0
		ITPROG	3D temp from obs or from prognostic data	0	0
		IRAD	Temp interpolation type	1	1
		TRADKM	Radius of influence of temp interpolation (km)	500	500
		NUMTS	Max number of stations to include in interpolation	5	5
		IAVET	Conduct spatial averaging of temp	1	1
		TGDEFB	Default temp gradient below mix ht over water (deg-K/m)	-0.0098	-0.0098
		TGDEFA	Default temp gradient above mix ht over water (deg-K/m)	-0.0045	-0.0045

Input Group	Subgroup	Variable	Description	Default	EPA-FLM
		JWAT1	Beginning land use categories for temp interpolation over water	User defined - 999	55
		JWAT2	Ending land use categories for temp interpolation over water	User defined - 999	55
		NFLAGP	Method of precipitation interpolation	2	2
		SIGMAP	Radius of influence for precipitation (km)	100	100
		CUTP	Minimum precipitation rate cutoff (mm/hr)	0.01	.01
7 -Surface meteorolo-gical station parameters		CSNAM	Station name	User defined	User defined
		IDSSTA	Station identification number	User defined	User defined
		XSSTA	X-coordinate (km)	User defined	User defined
		YSSTA	Y-coordinate (km)	User defined	User defined
		XSTZ	Time zone	User defined	User defined
		ZANEM	Anemometer height (m)	User defined	User defined
8- Upper air meteorolo-gcal station parameters		CUNAM	Station name	User defined	
		IDUSTA	Station identification number	User defined	
		XUSTA	X-coordinate (km)	User defined	
		YUSTA	Y-coordinate (km)	User defined	
		UUTZ	Time zone	User defined	
9 - Precipitation station parameters		CPNAM	Station name	User defined	User defined
		IDPSTA	Station identification number	User defined	User defined
		XPSTA	X-coordinate (km)	User defined	User defined
		YPSTA	Y-coordinate (km)	User defined	User defined

Appendix H
Regulatory CALPUFF Settings

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

MAR 16 2006

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

MEMORANDUM

SUBJECT: Dispersion Coefficients for Regulatory Air Quality Modeling in CALPUFF

FROM Dennis Atkinson, Meteorologist Dennis Atkinson
Model Clearinghouse Director, C439-01

TO: Kay T. Prince, Chief
Regulatory Planning Branch, APTMD-12

THRU: Tyler Fox, Leader TF
Air Quality Modeling Group, C439-01

In response to your memo of February 23, 2006, the Model Clearinghouse has reviewed your request for details related to CALPUFF and its use of regulatory and non-regulatory settings. Specific responses to your questions follow.

1. What constitutes a regulatory version of the CALPUFF model?

M/C Response: The CALPUFF modeling system consists of the entire suite of CALPUFF components, including CALMET, CALPUFF, CALPOST, POSTUTIL, etc. The regulatory version of CALPUFF is that version that has been tested, along with its specific default options, and functions satisfactorily against a standard criteria of sources, building configurations, and receptor information. The regulatory version of CALPUFF, along with specific regulatory options, resides on the Earth Tech website, described as the "EPA-Approved Version." Accessing CALPUFF via the Support Center for Regulatory Atmospheric Modeling (SCRAM) website is the best way to ensure the regulatory version of CALPUFF is obtained. Updates to the regulatory version of CALPUFF versions will require a formal protocol which includes sensitivity testing and analysis employing the use of the standard evaluation criteria, as presented at the 8th Conference on Air Quality Modeling (http://www.epa.gov/ttn/scram/8thmodconf/presentations/day2morning/calpuffanalysistoolrevised.ppt).

2. What is the regulatory default setting for the MDISP option for the CALPUFF model?

M/C Response: The regulatory CALPUFF default setting is MDISP=3, which utilizes the Pasquill-Gifford (P-G) dispersion coefficients, as referenced in Appendix W to 40CFR Part 51, A.4(j),(k). These regulatory defaults implement the modeling recommendations as described in the document entitled "Interagency Workgroup on Air Quality Models (IWAQM) Phase 2 Summary Report and Recommendations for Modeling Long Range Transport Impacts" (EPA-454/R-98-019, Dec. 1998). A copy of the

CALMET regulatory defaults in Appendix A and the CALPUFF regulatory defaults in Appendix B is attached.

3. Does the distance of a source from a receptor have any impact on the choice of how the MDISP option is set?

M/C Response: Dispersion coefficients are expected to have a greater influence on output concentrations for estimating the design concentration, the closer the receptor is to the emission source. However, the primary justification for allowing the use of CALPUFF within 50km relates to the proper estimate of the design concentration requiring consideration of an existing non-uniform wind field (complex winds). The decision to use CALPUFF in the near field is primarily due to complex meteorological issues which normally could not be resolved by traditional near-field steady-state modeling techniques. Procedures outlined for use of CALPUFF in long-range transport analyses may not be universally appropriate due to the unique considerations in applying CALPUFF in the near-field for complex meteorological situations. Due to these meteorological complexities, the setup and application of the model should be determined in consultation with the appropriate reviewing authority consistent with limitations of paragraph 3.2.2(e) of Appendix W in 40CFR Part 51.

4. Does the promulgation of the AERMOD model mean that AERMOD-based dispersion coefficients must/could/should be used in any model for Gaussian regulatory air modeling applications?

M/C Response: No. The promulgation of the AERMOD model does not mean that AERMOD-based dispersion coefficients must be used in other regulatory models. To that end, the promulgation of a preferred/recommended model does not provide general approval to apply specific portions of that promulgated model to any other model, whether the model is regulatory or non-regulatory. As stated in response to #2, the Model Clearinghouse endorses the use of P-G dispersion coefficients in CALPUFF unless a rationale can be provided to support, on a case-by-case basis, why other dispersion options should be used. Scientific evaluations have been completed and currently others are underway by both EPA and the Federal Land Managers (FLM) to assess the performance results of non-P-G dispersion coefficients. It is possible there could be some scenarios and specific source configurations for which the use of a non-regulatory dispersion option in long-range transport applications is appropriate. This has to be demonstrated subject to Section 3.2.2 of Appendix W of 40CFR Part 51. EPA Regional Offices are willing to review case-by-case demonstrations that support the use of a non-regulatory approach. Subject to Section 3.2.2 of Appendix W, acceptability of a model is a Regional Office responsibility and subject to approval from the Regional Administrator.

5. Is the Frequently Asked Questions (FAQ) document that is maintained on the CALPUFF website (http://www.src.com/calpuff/FAQ-questions.htm) the source of EPA regulatory modeling guidance for the CALPUFF model?

M/C Response: No. CALPUFF regulatory modeling guidance is provided by the EPA on the Support Center for Regulatory Atmospheric Modeling (SCRAM) website, through the Modeling Support and Guidance area and

within Appendix W of 40CFR Part 51 (http://www.epa.gov/scram001/guidanceindex.htm). Supporting documentation for CALPUFF is provided on SCRAM in the CALPUFF model area, along with the link to the "EPA-Approved Version" (http://www.epa.gov/scram001/dispersion prefrec.htm#calpuff).

If you have any further questions or comments, please contact Dennis Atkinson at (919) 541-0518 or Tyler Fox at (919) 541-5562.

2 Attachments
Original Request
CALPUFF Regulatory Defaults

cc: Desmond Bailey, C439-01
Tom Curran, C304-02
Mark Evangelista, C439-03
Tyler Fox, C439-01
Bill Harnett, C304-03
Todd Hawes, C504-01
Joe Paisie, C504-02
Racqueline Shelton, C339-03
Regional Modeling Contacts

4APT-ATMB

MEMORANDUM

SUBJECT: Dispersion Coefficients for Regulatory Air Quality Modeling

FROM: Kay T. Prince, Chief
Regulatory Planning Branch

TO: Tyler Fox, Leader
Air Quality Modeling Group

The Air Planning Branch of the Environmental Protection Agency (EPA) Region 4 requests that the EPA Model Clearinghouse formally address the following questions with supporting details as appropriate.

1. What constitutes a regulatory version of the CALPUFF model?
2. What is the regulatory default setting for the MDSIP option for the CAPUFF model?
3. Does the distance of a source from a receptor have any impact on the choice of how the MDSIP option is set?
4. Does the promulgation of the AERMOD model mean that AERMOD-based dispersion coefficients must/could/should be used in any model for Gaussian regulatory air modeling applications?
5. Is the Frequently Asked Questions (FAQ) document that is maintained on the CALPUFF website (http://www.src.com/calpuff/FAQ-questions.htm) the source of EPA regulatory modeling guidance for the CALPUFF model?

Region 4 has a need for a very prompt and formal response from the EPA Model Clearinghouse. The above issues impacts work that the many of Visibility Improvement – State and Tribal Association of the Southeast (VISTAS) states need to have resolved immediately for their Best Available Retrofit Technology (BART) assessments. We would like for you to note that these issues have been raised informally to the Office of Air Quality Planning and Standards (OAQPS) and discussed in several Model Clearinghouse sponsored calls in recent months. For instance, they have been specifically discussed in reviews of the VISTAS BART protocol by many of the EPA Regional Offices and the Federal Land Managers (FLMs) in Model Clearinghouse sponsored calls. They were also discussed in much detail in a CALPUFF training meeting that, while not sponsored by EPA OAQPS, was attended by your staff. Therefore, your group should be aware of the issues and the opinions of the Regional Offices and FLMs.

Thank you for your prompt response. If questions arise, please do not hesitate to contact Brenda Johnson at 404-562-9037.

APPENDIX A

CALMET RECOMMENDATIONS

In the following, a listing is provided of the defaults currently assumed in CALMET for long-range transport analyses in involving assessments of not on concentration impacts, but also deposition flux impacts and visibility impacts. Some of the variables have the 'Value' is listed in bold. This is meant to indicate that these likely will need to be tailored for a given application.

Variable	Description	Value
GEO.DAT	Name of Geophysical data file	GEO.DAT
SURF.DAT	Name of Surface data file	SURF.DAT
PRECIP.DAT	Name of Precipitation data file	PRECIP.DAT
NUSTA	Number of upper air data sites	User Defined
UPn.DAT	Names of NUSTA upper air data files	UPn.DAT
IBYR	Beginning year	User Defines
IBMO	Beginning month	User Defines
IBDY	Beginning day	User Defines
IBHR	Beginning hour	User Defines
IBTZ	Base time zone	User Defines
IRLG	Number of hours to simulate	User Defines
IRTYPE	Output file type to create (must be 1 for CALPUFF)	1
LCALGRD	Are w-components and temperature needed?	T
NX	Number of east-west grid cells	**User Defines**
NY	Number of north-south grid cells	**User Defines**
DGRIDKM	Grid spacing	**User Defines**
XORIGKM	Southwest grid cell X coordinate	User Defines
YORIGKM	Southwest grid cell Y coordinate	User Defines
XLAT0	Southwest grid cell latitude	User Defines
YLON0	Southwest grid cell longitude	User Defines

IUTMZN	UTM Zone	User Defines
LLCONF	When using Lambert Conformal map coordinates, rotate winds from true north to map north?	F
XLAT1	Latitude of 1st standard parallel	**30**
XLAT2	Latitude of 2nd standard parallel	**60**
Variable	Description	Value
RLON0	Longitude used if LLCONF = T	**90**
RLAT0	Latitude used if LLCONF = T	**40**
NZ	Number of vertical layers	**User Defines**
ZFACE	Vertical cell face heights (NZ+1 values)	**User Defines**
LSAVE	Save met. data fields in an unformatted file?	T
IFORMO	Format of unformatted file (1 for CALPUFF)	1
NSSTA	Number of stations in SURF.DAT file	User Defines
NPSTA	Number of stations in PRECIP.DAT	User Defines
ICLOUD	Is cloud data to be input as gridded fields? (0 = No)	0
IFORMS	Format of surface data (2 = formatted)	2
IFORMP	Format of precipitation data (2 = formatted)	2
IFORMC	Format of cloud data (2 = formatted)	2
IWFCOD	Generate winds by diagnostic wind module? (1 = Yes)	1
IFRADJ	Adjust winds using Froude number effects? (1 = Yes)	1
IKINE	Adjust winds using kinematic effects? (1 = Yes)	0
IOBR	Use O'Brien procedure for vertical winds? (0 = No)	0
ISLOPE	Compute slope flows? (1 = Yes)	1
IEXTRP	Extrapolate surface winds to upper layers? (-4 = use similarity theory and ignore layer 1 of upper air station data)	-4

ICALM	Extrapolate surface calms to upper layers? (0 = No)	0
BIAS	Surface/upper-air weighting factors (NZ values)	NZ*0
Variable	Description	Value
IPROG	Using prognostic or MM-FDDA data? (0 = No)	0
LVARY	Use varying radius to develop surface winds?	**F**
RMAX1	Max surface over-land extrapolation radius (km)	**User Defines**
RMAX2	Max aloft over-land extrapolation radius (km)	**User Defines**
RMAX3	Maximum over-water extrapolation radius (km)	**User Defines**
RMIN	Minimum extrapolation radius (km)	0.1
RMIN2	Distance (km) around an upper air site where vertical extrapolation is excluded (Set to -1 if IEXTRP = ±4)	4
TERRAD	Radius of influence of terrain features (km)	**User Defined**
R1	Relative weight at surface of Step 1 field and obs	**User Defines**
R2	Relative weight aloft of Step 1 field and obs	**User Defines**
DIVLIM	Maximum acceptable divergence	5.E-6
NITER	Max number of passes in divergence minimization	50
NSMTH	Number of passes in smoothing (NZ values)	2, 4*(NZ-1)
NINTR2	Max number of stations for interpolations (NA values)	**99**
CRITFN	Critical Froude number	1
ALPHA	Empirical factor triggering kinematic effects	0.1
IDIOPT1	Compute temperatures from observations (0 = True)	0
ISURFT	Surface station to use for surface temperature (between 1 and NSSTA)	**User Defines**
IDIOPT2	Compute domain-average lapse rates? (0 = True)	0
IUPT	Station for lapse rates (between 1 and NUSTA)	**User Defines**

ZUPT	Depth of domain-average lapse rate (m)	200
Variable	Description	Value
IDIOPT3	Compute internally inital guess winds? (0 = True)	0
IUPWND	Upper air station for domain winds (-1 = 1/r**2 interpolation of all stations)	-1
ZUPWND	Bottom and top of layer for 1st guess winds (m)	1, 1000
IDIOPT4	Read surface winds from SURF.DAT? (0 = True)	0
IDIOPT5	Read aloft winds from UPn.DAT? (0 = True)	0
CONSTB	Neutral mixing height B constant	1.41
CONSTE	Convective mixing height E constant	0.15
CONSTN	Stable mixing height N constant	2400
CONSTW	Over-water mixing height W constant	0.16
FCORIOL	Absolute value of Coriolis parameter	1.E-4
IAVEXZI	Spatial averaging of mixing heights? (1 = True)	1
MNMDAV	Max averaging radius (number of grid cells)	1
HAFANG	Half-angle for looking upwind (degrees)	30
ILEVZI	Layer to use in upwind averaging (between 1 and NZ)	1
DPTMIN	Minimum capping potential temperature lapse rate	0.001
DZZI	Depth for computing capping lapse rate (m)	200
ZIMIN	Minimum over-land mixing height (m)	50
ZIMAX	Maximum over-land mixing height (m)	3000
ZIMINW	Minimum over-water mixing height (m)	50
ZIMAXW	Maximum over-water mixing heigh (m)	3000
IRAD	Form of temperature interpolation (1 = 1/r)	1
TRADKM	Radius of temperature interpolation (km)	500
Variable	Description	Value

NUMTS	Max number of stations in temperature interpolations	5
IAVET	Conduct spatial averaging of temperature? (1 = True)	1
TGDEFB	Default over-water mixed layer lapse rate (K/m)	-0.0098
TGDEFA	Default over-water capping lapse rate (K/m)	-0.0045
JWAT1	Beginning landuse type defining water	999
JWAT2	Ending landuse type defining water	999
NFLAGP	Method for precipitation interpolation (2 = 1/r**2)	2
SIGMAP	Precip radius for interpolations (km)	100
CUTP	Minimum cut off precip rate (mm/hr)	0.01
SSn	NSSTA input records for surface stations	User Defines
USn	NUSTA input records for upper-air stations	User Defines
PSn	NPSTA input records for precipitation stations	User Defines

APPENDIX B

CALPUFF RECOMMENDATIONS

In the following, a listing is provided of the defaults currently assumed in CALPUFF for long-range transport analyses in involving assessments of not on concentration impacts, but also deposition flux impacts and visibility impacts. Some of the variables have the 'Value' is listed in bold. This is meant to indicate that these likely will need to be tailored for a given application.

Variable	Description	Value
METDAT	CALMET input data filename	CALMET.DAT
PUFLST	Filename for general output from CALPUFF	CALPUFF.LST
CONDAT	Filename for output concentration data	CONC.DAT
DFDAT	Filename for output dry deposition fluxes	DFLX.DAT
WFDAT	Filename for output wet deposition fluxes	WFLX.DAT
VISDAT	Filename for output relative humidities (for visibility)	VISB.DAT
METRUN	Do we run all periods (1) or a subset (0)?	0
IBYR	Beginning year	User Defined
IBMO	Beginning month	User Defined
IBDY	Beginning day	User Defined
IBHR	Beginning hour	User Defined
IRLG	Length of run (hours)	User Defined
NSPEC	Number of species modeled (for MESOPUFF II chemistry)	5
NSE	Number of species emitted	3
MRESTART	Restart options (0 = no restart), allows splitting runs into smaller segments	**0**
METFM	Format of input meteorology (1 = CALMET)	1
AVET	Averaging time lateral dispersion parameters (minutes)	60
MGAUSS	Near-field vertical distribution (1 = Gaussian)	1

MCTADJ	Terrain adjustments to plume path (3 = Plume path)	**3**
MCTSG	Do we have subgrid hills? (0 = No), allows CTDM-like treatment for subgrid scale hills	**0**
MSLUG	Near-field puff treatment (0 = No slugs)	0
Variable	Description	Value
MTRANS	Model transitional plume rise? (1 = Yes)	1
MTIP	Treat stack tip downwash? (1 = Yes)	1
MSHEAR	Treat vertical wind shear? (0 = No)	0
MSPLIT	Allow puffs to split? (0 = No)	**0**
MCHEM	MESOPUFF-II Chemistry? (1 = Yes)	1
MWET	Model wet deposition? (1 = Yes)	1
MDRY	Model dry deposition? (1 = Yes)	1
MDISP	Method for dispersion coefficients (3 = PG & MP)	3
MTURBVW	Turbulence characterization? (Only if MDISP = 1 or 5)	3
MDISP2	Backup coefficients (Only if MDISP = 1 or 5)	3
MROUGH	Adjust PG for surface roughness? (0 = No)	0
MPARTL	Model partial plume penetration? (0 = No)	1
MTINV	Elevated inversion strength (0 = compute from data)	0
MPDF	Use PDF for convective dispersion? (0 = No)	0
MSGTIBL	Use TIBL module? (0 = No) allows treatment of subgrid scale coastal areas	0
MREG	Regulatory default checks? (1 = Yes)	1
CSPECn	Names of species modeled (for MESOPUFF II, must be SO2, SO4, NOX, HNO3, NO3)	**User Defined**
Specie Names	Manner species will be modeled	**User Defined**
Specie Groups	Grouping of species, if any.	**User Defined**

NX	Number of east-west grids of input meteorology	User Defined
NY	Number of north-south grids of input meteorology	User Defined
NZ	Number of vertical layers of input meteorology	User Defined
Variable	Description	Value
DGRIDKM	Meteorology grid spacing (km)	User Defined
ZFACE	Vertical cell face heights of input meteorology	User Defined
XORIGKM	Southwest corner (east-west) of input meteorology	User Defined
YORIGIM	Southwest corner (north-south) of input meteorology	User Defined
IUTMZN	UTM zone	User Defined
XLAT	Latitude of center of meteorology domain	User Defined
XLONG	Longitude of center of meteorology domain	User Defined
XTZ	Base time zone of input meteorology	User Defined
IBCOMP	Southwest Xindex of computational domain	**User Defined**
JBCOMP	Southwest Y-index of computational domain	**User Defined**
IECOMP	Northeast Xindex of computational domain	**User Defined**
JECOMP	Northeast Y-index of computational domain	**User Defined**
LSAMP	Use gridded receptors? (T = Yes)	F
IBSAMP	Southwest Xindex of receptor grid	User Defined
JBSAMP	Southwest Y-index of receptor grid	User Defined
IESAMP	Northeast Xindex of receptor grid	User Defined
JESAMP	Northeast Y-index of receptor grid	User Defined
MESHDN	Gridded recpetor spacing = DGRIDKM/MESHDN	1
ICON	Output concentrations? (1 = Yes)	1
IDRY	Output dry deposition flux? (1 = Yes)	1
IWET	Output west deposition flux? (1 = Yes)	1
IVIS	Output RH for visibility calculations (1 = Yes)	1
LCOMPRS	Use compression option in output? (T = Yes)	T

Variable	Description	Value
ICPRT	Print concentrations? (0 = No)	0
IDPRT	Print dry deposition fluxes (0 = No)	0
IWPRT	Print wet deposition fluxes (0 = No)	0
ICFRQ	Concentration print interval (1 = hourly)	1
IDFRQ	Dry deposition flux print interval (1 = hourly)	1
IWFRQ	West deposition flux print interval (1 = hourly)	1
IPRTU	Print output units (1 = g/m**3; g/m**2/s)	1
IMESG	Status messages to screen? (1 = Yes)	1
Output Species	Where to output various species	**User Defined**
LDEBUG	Turn on debug tracking? (F = No)	F
Dry Gas Dep	Chemical parameters of gaseous deposition species	**User Defined**
Dry Part. Dep	Chemical parameters of particulate deposition species	**User Defined**
RCUTR	Reference cuticle resistance (s/cm)	30.
RGR	Reference ground resistance (s/cm)	10.
REACTR	Reference reactivity	8
NINT	Number of particle-size intervals	9
IVEG	Vegetative state (1 = active and unstressed)	1
Wet Dep	Wet deposition parameters	**User Defined**
MOZ	Ozone background? (1 = read from ozone.dat)	1
BCKO3	Ozone default (ppb) (Use only for missing data)	**80**
BCKNH3	Ammonia background (ppb)	**10**
RNITE1	Nighttime SO2 loss rate (%/hr)	0.2
RNITE2	Nighttime NOx loss rate (%/hr)	2
RNITE3	Nighttime HNO3 loss rate (%/hr)	2
Variable	Description	Value

SYTDEP	Horizontal size (m) to switch to time dependence	550.
MHFTSE	Use Heffter for vertical dispersion? (0 = No)	0
JSUP	PG Stability class above mixed layer	5
CONK1	Stable dispersion constant (Eq 2.7-3)	0.01
CONK2	Neutral dispersion constant (Eq 2.7-4)	0.1
TBD	Transition for downwash algorithms (0.5 = ISC)	0.5
IURB1	Beginning urban landuse type	10
IURB2	Ending urban landuse type	19
Use Following Only For Single-Point Meteorological Input (CALPUFF Screen)		
ILANDUIN	Land use type (20 = Unirrigated agricultural land)	20
ZOIN	Roughness length (m)	0.25
XLAIIN	Leaf area index	3
ELEVIN	Met. Station elevation (m above MSL)	0
XLATIN	Met. Station North latitude (degrees)	**User Defined**
XLONIN	Met. Station West longitude (degrees)	**User Defined**
ANEMHT	Anemometer height of ISC meteorological data (m)	10.0
ISIGMAV	Lateral turbulence (Not used with ISC meteorology)	1
IMIXCTDM	Mixing heights (Not used with ISC meteorology)	0
End of Single Point Meteorology Input Variables		
XMXLEN	Maximum slug length in units of DGRIDKM	1
XSAMLEN	Maximum puff travel distance per sampling step (units of DGRIDKM)	1
Variable	Description	Value
MXNEW	Maximum number of puffs per hour	99
MXSAM	Maximum sampling steps per hour	99
SL2PF	Maximum Sy/puff length	10
PLX0	Wind speed power-law exponents	0.07,0.07,0.10,0.15,0.35,0.55

WSCAT	Upper bounds 1st 5 wind speed classes (m/s)	1.54,3.09,5.14,8.23.10.8
PGGO	Potential temperature gradients PG E and F (deg/km)	0.020, 0.035
SYMIN	Minimum lateral dispersion of new puff (m)	1.0
SZMIN	Minimum vertical dispersion of new puff (m)	1.0
SVMIN	Array of minimum lateral turbulence (m/s)	6*0.50
SWMIN	Array of minimum vertical turbulence (m/s)	0.20, 0.12, 0.08, 0.06, 0.03, 0.016
CDIV	Divergence criterion for dw/dz (1/s)	0.01
WSCALM	Minimum non-calm wind speed (m/s)	0.5
XMAXZI	Maximum mixing height (m)	3000
XMINZI	Minimum mixing height (m)	50
PPC	Plume path coefficients (only if MCTADJ = 3)	0.5,0.5,0.5,0.5,0.35,0.35
NSPLIT	Number of puffs when puffs split	3
IRESPLIT	Hours when puff are eligible to split	**User Defined**
ZISPLIT	Previous hour's mixing height (minimum), (m)	100
ROLDMAX	Previous Max mixing height/current mixing height ratio, must be less then this value to allow puff split	0.25
Variable	Description	Value
EPSSLUG	Convergence criterion for slug sampling integration	1.0E-04
PESAREA	Convergence criterion for area source integration	1.0E-06
NPT1	Number of point sources	User Defined
IPTU	Units of emission rates (1 = g/s)	1
NSPT1	Number of point source-species combinations	0
NPT2	Number of point sources with fully variable emission rates	0
Point	Point sources characteristics	User Defined

Sources		
Area Sources	Area sources characteristics	User Defined
Line Sources	Buoyant lines source characteristics	User Defined
Volume Sources	Volume sources characteristics	User Defined
NREC	Number of user defined receptors	User Defined
Receptor Data	Location and elevation (MSL) of receptors	User Defined

Appendix I
Sensitivity Analyses Conducted in Support of the CALPUFF Simulation

Sensitivity Analyses Conducted in Support of the CALPUFF Simulation

1.0 Introduction

A series of sensitivity analyses were conducted to ensure that the air quality compliance demonstration is not sensitive to project source characterization or the modeled location of the sources. Sensitivity tests of 1-hour NO_2 and 24-hour $PM_{2.5}$ impacts were conducted with the CALPUFF model for comparison to impacts from a base case, which is the simulation developed for the compliance demonstration. Note that NO_2 and $PM_{2.5}$ emissions used in the compliance demonstration were also used for the sensitivity analyses described in this appendix.

Section 2.0 describes the tests conducted and summarizes the model inputs. Section 3.0 provides sensitivity test results and conclusions.

2.0 Description of Sensitivity Analyses

The following provides a description of the sensitivity analyses, including modeled source parameters.

Group 1 – A series of tests that evaluated stack and volume source parameterization, as well as source type selection for simulating emissions from the drill rig and static vessels located near the drill rig.

- **Test A – Stack and Volume Source Parameterization:** To show that the compliance demonstration is not sensitive to the use of the "lowest M-Value" approach, impacts were evaluated using parameters determined by taking the opposite approach (i.e., maximizing the M-Value for point sources and the release height for the modeled volume source). **Table I-1** summarizes the modeled parameters.

- **Test B – Stack Orientation:** To understand the sensitivity of the compliance demonstration to the stack orientation, impacts were evaluated by modeling all vertical sources as horizontal. Since stack orientation does not factor into a volume source characterization, this analysis only affects the modeling of the drill rig and the support vessel fleet that remains relatively static near the drill rig. **Table I-2** summarizes the modeled parameters.

- **Test C – Source Type for Static Emission Sources**: To test the sensitivity of the characterization of emissions associated with the drill rig and static support vessels operating near the drill rig as point sources, impacts were evaluated by modeling these sources as a two volume sources. The size of the both volume sources was based on the approximate size of the rig (100 meters across). **Table I-3** summarizes the modeled parameters.

Group 2 – A series of tests that evaluated the project source locations, both the modeled location of the OCS Source on Devil's Paw Prospect as well as the modeled location of the COP support vessels relative to the drill rig.

- **Test A – Location of the COP OCS Source on the Devil's Paw Prospect**: To show that the compliance demonstration is not sensitive to where on the prospect the OCS Source is modeled,

impacts were evaluated with the OCS Source located on a more northerly extreme of the Devil's Paw Prospect, specifically Lease Block 7101. For this test, the volume source representing mobile COP support vessels was located in between the drill rig and the nearest point of compliance. **Table I-4** summarizes the coordinates of the modeled locations. Modeled source parameters were equal to the base case simulation developed for the compliance demonstration.

- **Test B1 / B2 – Location of COP Support Vessels Relative to the Drill Rig**: In order to maximize model predicted project impacts, the base case assumed the volume source representing mobile COP support vessels was located in between the drill rig and the nearest point of compliance. To show that the compliance demonstration is not sensitive to this approach, impacts were evaluated with the support vessel volume source at two additional locations based on the two highest frequency wind directions blowing toward shore during the drilling season. **Table I-5** shows the frequency of wind directions developed from the processed CALMET data for the months of July-Oct for 2007-2009. Winds from 250 degrees through 15 degrees blow toward the coast. The highest frequency wind direction in that sector is 15 degrees. The second-highest frequency wind direction is in the 275°-285° category. Therefore, the support vessels were modeled downwind of the drill rig, in between the drill rig and the point of compliance, along an axis aligned with a wind direction of:
    - **Test B1:** 15 degrees, and
    - **Test B2:** 280 degrees.

  Table I-4 summarizes the coordinates of the modeled source locations. Note that modeled source parameters as well as the location of the drill rig/static vessel point sources were set equal to that of the base case simulation developed for the compliance demonstration.

Table I-1 Source Parameters for Group 1 Test A (Maximize M-Value)

Point Source Model ID (Source Group)	X-Coord. (LCC, km)	Y-Coord. (LCC, km)	Base Elevation (m)	Height (m)	Temperature (K)	Exit Velocity [1] (m/sec)	Exit Diameter [1] (m)
Rig 1 Point Source (Drill Rig and Static Vessel Vertical Emission Units)	73.5554	-32.8255	12.5	13.5 (14.8)	589	49.29	0.406
Rig 2 Point Source (Drill Rig and Static Vessel Horizontal Emission Units)	73.5554	-32.8255	12.5	29	589	0.001 (20.0)	86.3 (0.61)

[1] Actual stack parameters are shown in parentheses if they are different from the modeled parameters. For vertical stacks, the difference is the result of reducing the actual height by three times the diameter to maximize stack tip downwash. For the horizontal stacks, the difference is the result of the approach used to simulate horizontal releases by eliminating the vertical momentum while conserving the volumetric flow rate.

Volume Source Model ID (Source Group)	X-Coord. (LCC, km)	Y-Coord. (LCC, km)	Base Elevation (m)	Height (m)	Initial Lateral Dimension (m)	Initial Vertical Dimension (m)
Vessel (All Mobile Vessels)	109.2680	-50.2438	0.0	30.5	233	7.09

Table I-2 Source Parameters for Group 1 Test B (All Vertical Point Sources as Horizontal)

Point Source Model ID (Source Group)	X-Coord. (LCC, km)	Y-Coord. (LCC, km)	Base Elevation (m)	Height (m)	Temperature (K)	Exit Velocity [1] (m/sec)	Exit Diameter [1] (m)
Rig 1 Point Source (Drill Rig and Static Vessel Vertical Emission Units)	73.5554	-32.8255	12.5	13.5	589	0.001 (13.6)	23.7 (0.203)
Rig 2 Point Source (Drill Rig and Static Vessel Horizontal Emission Units)	73.5554	-32.8255	12.5	7.26	589	0.001 (38.8)	25 (0.127)

[1] Actual stack parameters are shown in parentheses if they are different from the modeled parameters. For horizontal stacks, the difference is the result of the approach used to simulate horizontal releases by eliminating the vertical momentum while conserving the volumetric flow rate.

Volume Source Model ID (Source Group)	X-Coord. (LCC, km)	Y-Coord. (LCC, km)	Base Elevation (m)	Height (m)	Initial Lateral Dimension (m)	Initial Vertical Dimension (m)
Vessel Volume (All Mobile Vessels)	109.2680	-50.2438	0.0	3.2	233	0.744

Table I-3 Source Parameters for Group 1 Test C (Rig and Static Vessel Sources as a Volume Sources)

Volume Source Model ID (Source Group)	X-Coord. (LCC, km)	Y-Coord. (LCC, km)	Base Elevation (m)	Height (m)	Initial Lateral Dimension (m)	Initial Vertical Dimension (m)
Rig 1 Point Source (Drill Rig and Static Vessel Vertical Emission Units)	73.5554	-32.8255	12.5	13.5	23.3	3.14
Rig 2 Point Source (Drill Rig and Static Vessel Horizontal Emission Units)	73.5554	-32.8255	12.5	7.26	23.3	1.69
Vessel Volume (All Mobile Vessels)	109.2680	-50.2438	0.0	3.2	233	0.744

Table I-4 Source Locations for Group 2 Sensitivity Tests

Source ID (source group)	Group 2 Test A		Group 2 Test B1		Group 2 Test B2	
	X-Coord. (LCC, km)	Y-Coord. (LCC, km)	X-Coord. (LCC, km)	Y-Coord. (LCC, km)	X-Coord. (LCC, km)	Y-Coord. (LCC, km)
Rig 1 Point Source (Drill Rig and Static Vessel Vertical Emission Units)	77.1880	0.7740	73.5554	-32.8255	73.5554	-32.8255
Rig 2 Point Source (Drill Rig and Static Vessel Horizontal Emission Units)	77.1880	0.7740	73.5554	-32.8255	73.5554	-32.8255
Vessel Volume (All Mobile Vessels)	111.7707	-18.7919	63.2714	-71.2056	112.6857	-39.7253

Table I-5 Frequency of Wind Directions for the Months of July-Oct for 2007-2009

Wind Directions (deg)	Wind Classes (m/sec)						Total
	0.5 - 2.1	2.1 - 3.6	3.6 - 5.7	5.7 - 8.8	8.8 - 11.1	>= 11.1	
355 - 5	0.2%	0.2%	0.5%	0.4%	0.1%	0.0%	1.3%
5-15	**0.2%**	**0.4%**	**0.7%**	**0.9%**	**0.2%**	**0.1%**	**2.6%**
15 - 25	0.2%	0.2%	0.6%	0.6%	0.1%	0.2%	2.1%
25 - 35	0.3%	0.5%	0.8%	1.1%	0.5%	0.4%	3.5%
35 - 45	0.2%	0.3%	1.1%	1.6%	0.8%	1.0%	5.1%
45 - 55	0.3%	0.5%	1.3%	2.1%	0.8%	1.5%	6.5%
55 - 65	0.3%	0.4%	1.1%	3.0%	2.0%	2.8%	9.6%
65 - 75	0.2%	0.5%	1.2%	2.4%	1.3%	3.4%	9.0%
75 - 85	0.2%	0.3%	1.3%	1.8%	1.7%	3.2%	8.6%
85 - 95	0.1%	0.4%	0.8%	1.6%	1.2%	2.4%	6.5%
95 - 105	0.1%	0.3%	0.6%	1.5%	0.4%	1.1%	4.0%
105 - 115	0.1%	0.3%	0.6%	0.8%	0.3%	0.3%	2.3%
115 - 125	0.1%	0.2%	0.6%	0.5%	0.4%	0.3%	2.2%
125 - 135	0.1%	0.2%	0.8%	0.6%	0.3%	0.0%	2.0%
135 - 145	0.1%	0.3%	0.6%	0.8%	0.2%	0.2%	2.2%
145 - 155	0.1%	0.1%	0.4%	0.4%	0.2%	0.1%	1.4%
155 - 165	0.1%	0.2%	0.5%	0.5%	0.2%	0.0%	1.5%
165 - 175	0.1%	0.3%	0.4%	0.5%	0.1%	0.2%	1.5%
175 - 185	0.1%	0.4%	0.4%	0.8%	0.3%	0.3%	2.3%
185 - 195	0.1%	0.3%	0.5%	0.8%	0.4%	0.4%	2.6%
195 - 205	0.1%	0.2%	0.3%	0.7%	0.4%	0.4%	2.1%
205 - 215	0.1%	0.2%	0.4%	0.4%	0.5%	0.3%	1.9%
215 - 225	0.1%	0.2%	0.2%	0.5%	0.2%	0.4%	1.7%
225 - 235	0.1%	0.1%	0.2%	0.7%	0.3%	0.2%	1.6%
235 - 245	0.1%	0.2%	0.2%	0.4%	0.2%	0.2%	1.3%
245 - 255	0.1%	0.1%	0.2%	0.5%	0.2%	0.1%	1.2%
255 - 265	0.0%	0.1%	0.2%	0.4%	0.2%	0.1%	1.0%
265 - 275	0.0%	0.1%	0.2%	0.5%	0.3%	0.4%	1.5%
275 - 285	**0.1%**	**0.1%**	**0.2%**	**0.8%**	**0.5%**	**0.4%**	**2.0%**
285 - 295	0.1%	0.1%	0.3%	0.6%	0.3%	0.1%	1.5%
295 - 305	0.0%	0.1%	0.3%	0.4%	0.2%	0.1%	1.1%
305 - 315	0.0%	0.1%	0.3%	0.5%	0.1%	0.0%	1.1%
315 - 325	0.1%	0.2%	0.3%	0.4%	0.1%	0.1%	1.1%
325 - 335	0.1%	0.1%	0.4%	0.6%	0.2%	0.2%	1.5%
335 - 345	0.1%	0.2%	0.5%	0.6%	0.1%	0.1%	1.6%
345 - 355	0.1%	0.1%	0.4%	0.4%	0.0%	0.0%	1.0%
Sub-Total	4.5%	8.5%	19.3%	30.9%	15.1%	21.4%	99.7%
Calms							0.2%
Missing/Incomplete							0.1%
Total							100%

Includes a wind direction toward the coast

3.0 Results of the Sensitivity Analyses

The results of the sensitivity tests, summarized in **Table I-6**, indicate very little difference in modeled impacts when comparing the sensitivity tests to the base case. Thus, the ambient air quality impact analysis is not sensitive to either source characterization or modeled location on the prospect and altering these inputs to CALPUFF would not affect the conclusions of the compliance demonstration.

Table I-6 Sensitivity Test Results

Pollutant	Averaging Period	Rank	3-Year Maximum [1] ($\mu g/m^3$)						
			Base Case	Group 1 Test A	Group 1 Test B	Group 1 Test C	Group 2 Test A	Group 2 Test B1	Group 2 Test B2
NO_2 [2]	1-Hour	Max	6.2	6.4	6.2	6.3	4.0	4.1	6.7
$PM_{2.5}$	24-Hour	Max	0.32	0.33	0.32	0.31	0.24	0.27	0.30

1 The 3-year average value is shown for 1-hour NO_2.

2 80% ambient ratio method of NO_x to NO_2 assumed.