Petitioner’s Exhibit 34

Woodward-Clyde
Consultants

OCS AIR QUALITY PERMIT APPLICATION AND REVIEW DOCUMENTS FOR EXPLORATION IN THE BEAUFORT SEA, ALASKA OCS

Prepared for

ARCO Alaska, Inc.
Anchorage, Alaska

February 1993

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conditions are noted in the Executive Summary and explicitly listed in Appendix H. We look forward to working with you to develop specific procedures which would implement these special conditions.

With regard to the Final Permit processing schedule, we would appreciate confirmation of critical processing milestones.

Again, your efforts to date are greatly appreciated. Please direct your questions or comments to either of the undersigned at (907) 263-4766 or (907) 263-4741 respectively. Thank you.

Sincerely,

Randy Poteet

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Enclosures

EXECUTIVE SUMMARY

ARCO Alaska, Inc. (AAI) is submitting to the United States Environmental Protection Agency (EPA), Region X, an Outer Continental Shelf (OCS) permit application to meet requirements specified by the OCS rule published on September 4, 1992 (FR 1992). This Application is for multi-year exploratory oil and gas well drilling in the Beaufort Sea. This Application also serves as the final application submitted subsequent to the Transitional Permit Application (TPA) which was submitted to EPA on October 5, 1992. AAI requests that the Final Permit be specially conditional (see Appendix H).

Exploratory drilling in the Beaufort Sea, for at least the next five years, has been characterized and modeled by six possible cases. These possible cases are described in Section 2.1 and are referred to as the Project. The modeling domain (see Figure 2-1) is bounded by Brownlow Point to the west and just to the east of Konganevik Point. The modeling domain is bounded on the south by the approximate six mile shoreline limit. The northern boundary is depicted arbitrarily for purpose of modeling. The six modeled cases are described as follows:

> Case I incorporates one floating drilling vessel located 12 miles from Brownlow Point. Case I is similar to AAI's exploration operation which is described in the TPA submitted to EPA Region IX (AAI 1992) which includes BeauDril's Kulluk and support by seven additional vessels. Duration of Case I is 120 days (mid-July to mid-November).
>
> Case II includes two floating drilling vessels located six miles apart and each 12 miles offshore. Each drilling unit would be supported by up to seven vessels, and would operate up to 120 days during the same period described as Case I.
>
> Case III comprises one floating drilling vessel 12 miles offshore as in Case I and one bottom-founded (temporarily ballasted) drilling unit located six miles offshore. These drilling units would be at least six miles apart. The floating drilling vessel is supported by up to seven additional vessels during the same period as described in Case I. The bottom-founded unit would be supported by up to seven vessels for 20

days; 10 days during ballasting to the ocean bottom and 10 days during deballasting, both periods probably occurring in mid-July and mid-August. The bottom-founded drilling unit would operate and remain in place without support vessels for at least one full year.

Case IV incorporates one floating drilling vessel as in Case I, and one floating vessel located six miles offshore. These drilling vessels would be at least 6 miles apart. Each drilling vessel would be supported by up to seven additional vessels, and would operate up to 120 days during the same period as described in Case I.

Case V incorporates two floating drilling vessels six miles offshore and 6 miles apart. This case describes the closest locations to shore. Each drilling vessel would operate up to 120 days during the period described in Case I.

Case VI incorporates one floating drilling vessel and one bottom-founded drilling unit, each operating 6 miles offshore and six miles apart. Like Case V, Case VI is a modeling scenario that is closest to shore. The floating drill vessel would operate up to 120 days during the period described in Case I. The bottom-founded unit would operate and remain in-place at least one full year.

Based upon the estimated nitrogen oxide (NO_x) emissions from the Project, OCS permitting requirements for a major source are triggered. Emission factors for criteria pollutants for the Project were derived using AP-42, Compilation of Air Pollution Emission Factors (EPA - 1992a), vendor estimates, or mass balance techniques.

The U.S. Minerals Management Service (MMS) Offshore Coastal and Dispersion (OCD) (MMS 1989) Model was used to assess potential air quality impacts over water and at onshore receptor points during the mid-July to mid-November period. EPA's Industrial Source Complex 2 short-term (ISC2) model (EPA 1992b) was used to predict potential air quality impacts on the arctic ice pack during remaining months. A number of overestimation assumptions were used in the impact assessment approach, including use of maximum hourly emission rates.

The meteorological data input to the model was taken from the Prudhoe Bay Unit (PBU) Pad A monitoring site because of the uniform, flat terrain for the North Slope of Alaska and proximity to the Project. The Pad A data set is representative of meteorological conditions at the Project. The Pad A data set is supported previous projects including the PBU Flow Station 2, GHX-1 and GHX-2 PSD applications.

The maximum predicted annual NO_2 impact resulting from the six cases is 22.96 ug/m^3. Long-term maximum predicted particulate matter was 0.88 ug/m^3, while the 24-hour, concentration was predicted to be 18.08 ug/m^3. The predicted maximum annual, 24-hour, and 3-hour SO_2 concentrations were 0.92, 28.26, and 57.25 ug/m^3, respectively. The maximum 8-hour CO concentration predicted was 83.93 ug/m^3, while the 1-hour CO concentration predicted was 130.48 ug/m^3.

The maximum annual NO_2 impact at the closest onshore Class II area is estimated at 13.72 ug/m^3.

The nearest Class I area is Denali National Park, located 450 miles from the Project.

The Project will not adversely affect air quality related values (AQRVs). Similarly, the potential impacts on soils, vegetation and wildlife at ANWR are well below levels known to cause adverse effects.

Based on the assessment presented herein, the Project meets or exceeds applicable Best Available Control Technology (BACT) requirements and New Source Performance Standards (NSPS), and will not cause or contribute to an exceedance of air quality standards or increments.

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1.0
INTRODUCTION

This application is submitted by ARCO Alaska, Inc. (AAI) for an Outer Continental Shelf (OCS) Air Permit for multi-year (initial five year term) drilling in the Beaufort Sea. The application also serves as the final application filed subsequent to the Transitional Permit Application (TPA) which was submitted to the United States Environmental Protection Agency (EPA) on October 5, 1992. The area where exploration will initially occur is described in Section 2.1 and will be referred to as the modeling domain. Future exploration may take place outside the modeling domain. In such a case, AAI requests that a condition be included in the final permit that addresses circumstances for approval of these operations. The six cases described in Section 2.1 are for Beaufort Sea exploration and will hereafter be referred to as the Project. Project operations in the modeling domain will begin in July 1993. The exploratory sites lie in the nearshore OCS area and are subject to the final OCS rule promulgated on September 4, 1992. The nearshore OCS is defined as that area within 25 miles of states' seaward boundary. Operation of these sources will result in emissions of criteria pollutants above the significant levels specified in the Prevention of Significant Deterioration (PSD) rules and presented in Table 1-1. Thus, the Project is subject to review under OCS and PSD permitting requirements.

The analyses described in this permit application include: (1) Best Available Control Technology (BACT) evaluation, (2) dispersion modeling of emissions to determine compliance with PSD increments and state and federal ambient air quality standards, (3) analyses of the project's impact on associated air quality related values (AQRV) such as vegetation and regional population growth and (4) a human health risk assessment for the community of Kaktovik. BACT has been evaluated following EPA's guidance (see Section 4.3). Other alternative emission controls were identified and evaluated in the permit application.

The air quality impacts of the Project were analyzed using the latest version of the EPA-approved Industrial Source Complex Short Term (ISC2) (1992b) air quality dispersion model and U.S. Minerals Management Service (MMS 1989) Offshore Coastal and Dispersion (OCD) model. These analyses included all Project emission sources as well as other regional

Prudhoe Bay sources. The modeling results demonstrate that the Project will not result in any federal PSD increment or air quality standard being exceeded. Studies of the effect on local vegetation, regional population growth, and threatened and endangered species indicate that these air quality related values will not be adversely affected by the Project. In addition, a human health risk assessment shows no unacceptable risk to the residents of Kaktovik.

This permit application contains several sections. Section 2.0 provides a short summary description of the Project. Section 3.0 presents an emission inventory for the sources. Section 4.0 is the assessment of BACT for the new sources. Emissions from other sources are discussed in Section 5.0. A summary of the existing air quality and meteorological conditions in the Prudhoe Bay area is discussed in Section 6.0. The air quality impact analysis is described in Section 7.0 along with technical descriptions of the modeling approach and selected model input options, and a discussion of the model results. Section 8.0 provides a discussion of human health risk assessment of the Project on the local population. Section 9.0 addresses associated "Air Quality Related Values," such as the impact of the Project on vegetation, regional population growth, and threatened and endangered species. A short summary and conclusion is given in Section 10.0, while technical references cited in the report are listed in Section 11.0. Additional supporting technical data are included in Appendices to the application.

TABLE 1-1

SIGNIFICANT EMISSIONS OR EMISSIONS INCREASE

Pollutant	Emissions Rate (tons per year)
Carbon monoxide	100
Nitrogen oxides	40
Sulfur dioxide	40
Particulate matter:	
TSP	25
PM_{10}	15
Ozone	40 of volatile organic compounds
Lead	0.6
Asbestos	0.007
Beryllium	0.0004
Mercury	0.1
Vinyl chloride	1
Fluorides	3
Sulfuric acid mist	7
Hydrogen sulfide (H_2S)	10
Total reduced sulfur (including H_2S)	10
Reduced sulfur compounds (including H_2S)	10

2.0
PROJECT DESCRIPTION

2.1 PROJECT LOCATION

The exploration operation documented in the TPA (AAI 1992) is located in 110 feet of water about 16 miles offshore from Brownlow Point in the eastern Beaufort Sea, Alaska, as shown in Figure 2-1. Future drilling will be conducted at least over the next five years and has been characterized and modeled as six possible cases, which are referred to as the Project. The modeling domain is bounded by Brownlow Point to the west and just east of Konganevik Point. The modeling domain is bounded on the south by the approximate six-mile shoreline limit. The northern boundary is arbitrary. The six cases are described as follows:

Case I incorporates one floating drilling vessel located approximately 12 miles from Brownlow Point. Case I is similar to AAI's exploration operation described in the TPA submitted to EPA Region IX (AAI 1992). Case I includes BeauDril's Kulluk and support by seven additional vessels for a duration of 120 days (mid-July to mid-November).

Case II includes two floating drilling vessels located six miles apart, each approximately 12 miles offshore parallel to the coastline eastward from Brownlow Point. Each drilling unit would be supported by up to seven vessels, and would operate up to 120 days during the same period as Case I.

Case III comprises one floating drilling vessel located approximately 12 miles offshore (as in Case I) and one bottom-founded (temporary ballasted) drilling unit located approximately six miles offshore. These drilling vessels/units would be at least six miles apart. The floating drilling vessel is supported by up to seven additional vessels during the same period as described in Case I. The bottom-founded unit would be supported by up to seven vessels for 20 days; 10 days during ballasting to the ocean bottom, and 10 days during deballasting, both periods probably occurring in mid-July and mid-August. The bottom-founded drilling unit would operate and remain in place without support vessels for at least one full year.

Case IV incorporates one floating drilling vessel as in Case I, and one floating drilling vessel located approximately six miles offshore. These drilling vessels would be at least six miles apart. Each drilling vessel would be supported by up to seven additional vessels, and would operate up to 120 days during the same period as Case I.

Case V incorporates two floating drilling vessels approximately six miles offshore, and six miles apart. Each drilling vessel would operate up to 120 days during the same period as Case I.

Case VI incorporates one floating drilling vessel and one bottom-founded drilling unit each operating approximately six miles offshore and six miles apart. The floating drill vessel would operate up to 120 days during the same period as described in Case I. The bottom-founded unit would operate and remain in place at least one full year.

Floating Drilling Vessel

Drilling in 1992 was conducted from BeauDril's floating drilling vessel, Kulluk, which is designed and constructed for extended season operations in deep arctic waters. Potential emission rates were developed by maximizing emissions based on the Kulluk design, and are representative of other floating drilling vessels which might be used on the Project. The Kulluk is designated as Arctic Class IV by the Canadian Coast Guard and as Ice Class IAA by the American Bureau of Shipping. It is a conically shaped, ice-strengthened floating drilling vessel with a 24-faceted double-walled hull. It is moored to the sea floor via anchor lines. Additional key features of the Kulluk are presented in Appendix A.

Each floating drilling vessel is supported by up to seven additional vessels. Five of these vessels are involved in ice management and other support services. The other two vessels are tug boats which tow barges of supplies to the Project during the operations.

Project life for the floating drilling vessels is estimated at 120 days, including time of arriving on location in mid-July, to travel off location and back to harbor at the end of each year's operation. Intermittent periods off location may occur during the Project due to severe weather or ice conditions.

Bottom-Founded Drilling Unit

Emission rates have been estimated based on equipment and operation information for the Global Marine Drilling Company's Glomar Beaufort Sea I Concrete Island Drilling Structure (CIDS), Canadian Marine's (CANMAR) SSDC/MAT and BeauDril's Molikpaq. The CIDS inventory has greater emissions capacity than these other bottom-founded drilling units, therefore, it is considered to be the worst case. Emission rates for the CIDS will be an overestimate of emissions if one of the other bottom-founded units is used. In addition, potential emissions were estimated by generally assuming full-time operation of all sources, an assumption that exceeds actual operation.

The CIDS is a mobile offshore drilling unit designed specifically for year-round exploratory drilling in the harsh offshore arctic environments in water depths ranging from 35 to 55 feet. The drilling unit is classified by the American Bureau of Shipping as an A1 caisson drilling unit and is completely certified by the United States Coast Guard. The CIDS consists of six structural modules: (1) steel, (2) mud base, (3) a center structure of honeycomb concrete, (4) two steel deck storage barges, (5) the quarters unit, and (6) the drilling rig. Combined, these modules form a drilling unit which can be towed to and ballasted down at the drill site. When required, the unit can be deballasted, refloated, and towed to another drill site. The deballasting and refloating operation can be accomplished within approximately 72 hours under normal conditions. Brochures documenting the power generation equipment and other air pollutant emissions sources of the CIDS, SSDC/MAT, and Molikpaq are provided in Appendix A.

2.2 SOURCE DESCRIPTION

Source descriptions for each vessel/unit, including the number of sources and known or estimated rated capacity are shown in the emissions inventory in Section 3.0. Because support vessels may change in future years, each support vessel, excluding tugboats, is shown with similar source groups, such as main engines, generators, hot water heaters, heating boilers, and incineration equipment. Unknown equipment ratings were estimated from equipment specified on support vessels with similar known main engine ratings. Section 3.0 provides further details about air pollution sources with the emission rate estimates of this equipment.

2.3 OCS AIR REGULATIONS APPLICABILITY

EPA-promulgated rules that establish new requirements to control air emission sources in the OCS of the United States (40 CFR Part 55), were published in the Federal Register on September 4, 1992. The rule regulates federal and state criteria pollutants emissions, and their precursors, from OCS sources, and applies to all OCS lands except the western Gulf of Mexico OCS sources, which will continue to be regulated by the Department of Interior Minerals Management Service (MMS).

The rule change is mandated in the Clean Air Act Amendments of 1990 (CAAA), to attain and maintain federal and state ambient air quality standards through control of OCS emission sources. The rule requires that OCS air emission sources located within 25 miles of a state boundary (nearshore areas) meet the same state air pollution control requirements established for onshore sources in the "corresponding onshore area" (COA).

Exploratory sources (drilling vessels/units and support vessels) are included in the air emission sources affected by this rule. The rule acknowledges the short duration and limited nature of the emission sources associated with exploration activities. Exploratory activities need not conduct an evaluation to determine if the nearest onshore area (NOA) is the COA. All other requirements under the federal air program or the COA will apply to exploratory sources.

EPA has chosen not to regulate support vessels used to support OCS activities in this rule. EPA reasons that since the vessels are not attached to the seabed, they are not an OCS source under the Outer Continental Shelf Lands Act. However, these vessel sources are to be accounted for by including their emissions in the "potential to emit," a statutory requirement of the CAAA. The vessel emissions are included in PSD analyses for impact to ambient air quality and increment consumption, but are not subject to BACT. If air quality standards or increments would be found to be significantly affected, then reductions/offsets of emissions from the activity would be necessary.

OCS sources located beyond 25 miles of state boundaries are required to comply with PSD rules (40 CFR 52.21), New Source Performance Standards (NSPS) (40 CFR Part 60), and National Emissions Standards for Hazardous Air Pollutants (NESHAPS) (40 CFR part 61).

In addition, these OCS sources are to meet the new federal operating permit program, compliance and monitoring regulations when they are finalized.

According to the final rule, new sources are to comply with the requirements when promulgated. Existing OCS sources have 24 months after promulgation to attain compliance. Sources that had commenced operation prior to publication of the final rule (September 4, 1992), but after the publication of the proposed rule (December 5, 1991) are addressed through a TPA process.

The Project, being an exploratory activity in the Alaskan OCS, is subject to the requirements of the OCS air rules. As the State of Alaska has not been delegated OCS authority, the EPA, Region X is the permitting agency for this project. This Project commenced operations during the period between proposal and promulgation of the OCS air rule. A TPA was prepared and submitted to EPA 30 days following promulgation of the final rule in accordance with 40 CFR 55.6(e).

Following submittal of the TPA, sources subject to this provision are required to submit a final permit application as expeditiously as possible [40 CFR 55.6 (e)(2)(ii)]. This application serves as compliance with this requirement for ongoing exploratory activity in the Beaufort Sea that AAI began in 1992.

3.0
EMISSIONS INVENTORY

The Project, which will operate for at least the next five years, has been characterized and modeled using six scenarios described in Section 2.0. The Project will result in emissions of oxides of nitrogen (NO_x), carbon monoxide (CO), sulfur dioxide (SO_2), volatile organic compounds (VOCs) and particulate matter (PM), as summarized in Table 3-1 for each case.

The emissions inventory was developed from emissions data provided by equipment manufacturers, the Compilation of Air Pollutant Emission Factors, AP-42 (EPA 1992c), and mass balance technique. It was assumed that sources are generally in continuous operation and generally at full load, which exceeds actual operations. Emission factors, their references, and the emissions inventory for a single floating drilling vessel and support vessels are presented in Table 3-2. Table 3-3 presents the emission factors, references, and emissions inventory for the bottom-founded drilling unit and support vessels. Emission rates in grams per second (gm/sec) are shown in these tables. Total Project emissions in tons are also shown for the Project period, or partial periods where relevant.

Maximum short-term hourly emission rates which represent possible operating configurations were calculated for the short-term impact analyses. Tables 3-2 and 3-3 provide detailed information about specific equipment operated on the drilling vessels/units, and each of the associated support vessels.

Tables 3-4 and 3-5 present the emission rates and source characteristics as input to the air dispersion models for the floating vessels and bottom-founded drilling units. Emission rates in gm/sec for SO_2, CO, and PM in Tables 3-4 and 3-5, are based on the maximum hourly emission rates expected with all sources operating concurrently. The NO_x emissions are for the life of the Project (120 days for a floating vessel, and 365 days for a bottom-founded unit). Backup documentation used to develop these emission rates is provided in Appendix B. Tables of emission factors from AP-42 which were used in developing the emission rates are also provided in Appendix B.

Use of these maximum hourly emission rates to assess the potential short-term impacts of the drilling vessels/units is an over-estimate for evaluating the Project's potential impacts on ambient air quality. Use of worst-case maximum emissions provides flexibility in selecting contractors and alternative drilling vessel/units. This approach provides confidence that Federal and State Ambient Air Quality Standards (AAQS) will be met if predicted maximum impacts fall below the applicable standards, regardless of which specific drilling vessels/units are used.

3.1 FLOATING DRILLING VESSEL EMISSION RATES

Three main engines and ancillary equipment comprise the emission sources for the floating drilling vessel (as represented by the Kulluk). The Model number MD16E9B main engines are manufactured by Electromotive Division of General Motors. GM supplied the emission factors of these 2816 BHP units for the gaseous pollutants of concern, and references are provided in Appendix B. Particulate emissions were calculated from AP-42 emission factors for the rating on these engines. Operation of the engines was assumed to be 100 percent load for all three engines. Spark retardation will be used as BACT for the Project (see Section 4.4.1.3). Spark retardation results in a 20 percent reduction in NO_x emissions while increasing CO emissions by 20 percent. An additional 10 percent reduction in NO_x emissions is attained with the modification of aftercooler cores. The total reduction in NO_x emissions is expected to be approximately 30 percent, which meets EPAs expectation for NO_x control. The result of spark retardation causes a 5 percent increase in fuel consumption. Thus, emissions rates for SO_2, VOC and PM were increased by this amount. Table 3-2 presents emission rate summaries of these three main engines and the ancillary equipment.

Rating of the emergency generator was estimated at 630 kW. Vendor-supplied emission rates for SO_2, CO, VOC and NO_x are provided in Appendix B, while PM was calculated from AP-42 emission factors. Emission rates for three 259 kW, Mercedes Benz deck cranes were estimated from AP-42. The three cranes are assumed to operate 100 percent of the time. The survival anchor winch is estimated to operate 100 percent of the time for the 120-day period. Emission rates were developed from AP-42. Well logging equipment, including a small generator and winch, were assumed to operate 100 percent of the time during the Project. Gaseous emissions for the winch were provided by the vendor as shown in Appendix B, while PM emission rates, and all pollutant emission rates for the generator were estimated with AP-

42 emission factors. Short-term emission rates are based on continuous operation of this equipment.

Two 2.4 million Btu per hour (MMBtu/hr) heating boilers were assumed to operate for 100 percent of the time during the Project. Emission factors were estimated from AP-42 emission factors. Emission rates of two 0.54 MMBtu/hr hot water heaters were estimated with AP-42 emission factors. Gaseous emission rates of the flash steam generator operating for 100 percent of the Project period were provided by the vendor, while the PM emission factor was estimated from AP-42. The incinerator for disposal of trash has a charge rate capacity of 400 pounds per hour, with AP-42 emission factors used to calculate these emission rates for full time use. Fuel usage to ignite the incinerator was considered negligible. Flare emission rates were estimated from AP-42 emission factors. The SO_2 emission rates were estimated from a mass balance calculation assuming 100 ppm H_2S concentration. The calculated SO_2 emission rate equals 0.02 lb SO_2 per MMBtu. Flare volumes are estimated at 10 million standard cubic feet per day (MMscfd) for 40 days.

Three 370 BHP forklifts were assumed to operate 100 percent of the time. Emission rates were calculated using AP-42 emission factors for the ratings on these engines.

Emission rates of an emergency air compressor, two bulk handling units, and two cementing units were estimated with AP-42 emission factors (Table 3.3-1, January 1975) for sources with unknown engine ratings. The emergency air compressor was assumed to operate one half hour per week, while the other units were assumed to operate 100 percent of the time.

3.2 BOTTOM-FOUNDED DRILLING UNIT EMISSION RATES

Equipment configurations for three bottom-founded drilling units which are designed to carry out year-round exploratory drilling under arctic environmental conditions were compared to estimate maximum potential emissions. These units include the CANMAR Single Steel Drilling Caisson (SSDC/MAT), the BeauDril Mobile Arctic Caisson (Molikpaq), and the Global Marine Glomar Beaufort Sea I Concrete Island Drilling Structure (CIDS). Information concerning these units is contained in Appendix A. All three units incorporate similar main engines for drilling and power generation. However, the CIDS uses three additional 550 BHP engines which can be used to build an ice berm during the initial phase of operations. Thus, the emissions inventory for bottom-founded drilling units was developed from the CIDS emission sources to address worst-case emissions from a bottom-founded unit.

Four CAT D399 engines comprise the emission sources powering the drilling equipment for the CIDS. Emission factors of these 1250 BHP units for SO_2 were calculated using mass balance and sulfur fuel content of 0.05 percent by weight. Particulate and the other gaseous pollutants were calculated from vendor-supplied emission factors for the rating on these engines as referenced in Table 3-3. The engines were assumed to operate at 100 percent load for .100 percent of the time over one year.

Three CAT D379 engines are used to provide power for general use on the CIDS. Emission rates for these 550 BHP engines were calculated using vendor-supplied emission factors for the rating on this engine. The engines were assumed to operate at 100 load for 100 percent of the time over one year.

Three additional CAT D399 engines comprise the emission sources powering the water spray system for the CIDS. This system utilizes high pressure water cannons to build a grounded ice berm around the platform, creating passive protection from advancing ice forces. As with the drilling main engines, emission factors of these 1250 BHP units for SO_2 were calculated using mass balance and sulfur fuel content of 0.05 percent. Particulate and the other gaseous pollutants were calculated from vendor-supplied emission factors for the rating on these engines as referenced in Table 3-3. The engines were assumed to operate 100 percent of the time over 60 days.

NO_x controls for these 10 engines using spark retardation results in a 20 percent reduction in NO_x emissions while increasing CO emissions by 20 percent. An additional 10 percent reduction in NO_x emissions is attained with the modification of aftercooler cores. Emissions rates for SO_2 VOC and PM were increased as a result of a 5 percent increase in fuel consumption caused by spark retardation. Table 3-3 presents emission rate summaries of these sources which are then totaled with the ancillary equipment emission rates.

Rating of the emergency generator was estimated at 640 kW. Sulfur dioxide emission factors for this unit were calculated using mass balance and sulfur fuel content of 0.05 percent. Particulate and the other gaseous pollutants were calculated from AP-42 emission factors for the rating on this engine as referenced in Table 3-3. The emergency generator was assumed to operate about one half hour per week. The three cranes were assumed to operate continuously at full load for one year. Emissions were calculated using mass balance for SO_2 and AP-42 emission factors for other pollutants based on engine ratings. The survival anchor winch emission rates were estimated from AP-42. Well logging equipment, including a small generator, and winch, were estimated to operate at 100 percent load for 365 days during the Project. Gaseous emissions for the winch were provided by the vendor as shown in Appendix B, while PM emission rates, and all pollutant emission rates for the generator, were estimated with AP-42 emission factors. Emission rates are based on continuous operation of this equipment.

Three 370 BHP forklifts were assumed to operate continuously at full load for one year. Emission rates were calculated using AP-42 emission factors for the ratings on these engines.

Three 0.8 MMBtu/hr heating boilers were assumed to operate continuously during the Project. Emission factors were estimated from AP-42. Emission rates of an emergency air compressor, two bulk handling units, and two cementing units were estimated with AP-42 emission factors (Table 3.3-1, January 1975) for sources with unknown engine ratings. The emergency air compressor was assumed to operate one half hour per week, while the other units were assumed to operate continuously. Gaseous emission rates of the flash steam generator operating continuously were provided by the vendor, while the PM emission factor was estimated from AP-42. The incinerator for disposal of trash was estimated to have a charge rate capacity of 400 pounds per hour, which was used with AP-42 emission factors to calculate these emission rates for full time use. Fuel usage to ignite the incinerator was considered negligible. Flare emission rates were estimated from AP-42 emission factors. The SO_2 emission rates were estimated from a mass balance calculation assuming 100 ppm H_2S concentration. The calculated SO_2 emission rate equals 0.02 lb SO_2 per MMBtu. Flare volumes are estimated at 10 MMscfd for 40 days.

3.3 SUPPORT VESSELS EMISSION RATES

Up to seven support vessels are assumed to support either the floating drilling vessel or the bottom-founded drilling unit. The seven support vessels would operate for up to 120 days per year in support of the floating drilling vessel. The seven support vessels would only operate 20 days per year to support the bottom-founded drilling unit (see Section 2.1).

The largest emission sources on Support Vessel 1 are the four 4265 kW main engines. All engines are assumed to operate continuously. All emission factors except for SO_2 were calculated using AP-42 emission factors, assuming these engines are operating in 2/3 mode. SO_2 emissions were based on mass balance assuming a sulfur fuel content of 0.05 percent by weight. These emission rates are based on fuel consumption. The August 1992 ship's logs from a vessel of this type operating at the Project were used to calculate actual fuel use of 0.56 m^3/hr for these engines. Fuel consumption by the two 980 kW generators was also calculated from ship's logs at the Project and was used with the vendor-supplied emission factors. Both generators are assumed to operate continuously. Emission rates are based on vendor information, except for VOC emissions which are taken from AP-42. Emission rates for an emergency generator operating 0.3 percent of the time were based on AP-42 emission factors. Emission rates for one heat boiler, one hot water heater, and one incinerator were calculated with the same parameters as for the floating drilling vessel, except the charge rate for the incinerator is only 65 pounds per hour.

Most air pollutant emissions from Vessel 2 will result from operation of the four 2780 kW main engines. Carbon monoxide, VOC and PM emission factors were taken from AP-42, while NO_x was supplied by the vendor, and SO_2 was calculated from a mass balance of 0.05 percent sulfur contained in the fuel. Ship's logs from this type of vessel, operating at the project, were used to calculate actual fuel use of 0.26 m^3/hr in August 1992 for these engines. All four engines were assumed to operate continuously. Emission factors for the two 260 kW generators were from AP-42. Both generators are assumed to operate continuously. Emission rates for one heat boiler, one hot water heater, and one incinerator were calculated with the same parameters as for Vessel 1, except the charge rate for the incinerator is 75 pounds per hour.

Vessel 3 is identical to Vessel 2, and thus the emission rates were calculated in the same way as Vessel 2.

Vessel 4 has two main engines rated at 6270 kW, operating continuously at 2/3 mode. The fuel consumption was taken from vendor-supplied data which appears in Appendix B.

Emission factors are from the same sources as for Vessel 1. The generator, heat boiler, hot water heater, and incinerator emission rates were assumed identical to Vessel 2.

Vessels 5 and 6 each have two 1600 kW engines and are assumed to operate continuously. The fuel use was proportioned based on the engine power rating of Vessel 2, and Vessel 1 emission factors were used to calculate emission rates.

Vessel 7 consists of two 300 kW main engines, and two generators. All emission sources were assumed to operate continuously. The emission factors were taken from AP-42.

TABLE 3-1

SUMMARY OF AIR POLLUTANT EMISSIONS* - ARCO ALASKA BEAUFORT SEA EXPLORATION PROJECT

(Total Tons Per Year)

	CO	NO_x	SO_2	PM	VOC
PSD Signficant Emissions Levels	100	40	40	25	40
Case I					
One Floating Drilling Vessel (12 miles)	264.1	2,311.9	82.7	74.6	119.7
Case II					
One Floater (12 miles)	264.1	2,311.9	82.7	74.6	119.7
One Floater (12 miles)	264.1	2,311.9	82.7	74.6	119.7
TOTAL	528.2	4,623.8	165.4	149.2	239.4
Case III					
One Floater (12 miles)	264.1	2,311.9	82.7	74.6	119.7
One Bottom-Founded (6 miles)	256.8	1,101.0	53.6	54.5	60.0
TOTAL	520.9	3,412.9	136.3	129.1	179.7
Case IV					
One Floater (12 miles)	264.1	2,311.9	82.7	74.6	119.7
One Floater (6 miles)	264.1	2,311.9	82.7	74.6	119.7
TOTAL	528.2	4,623.8	165.4	149.2	239.4
Case V					
One Floater (6 miles)	264.1	2,311.9	82.7	74.6	119.7
One Floater (6 miles)	264.1	2,311.9	82.7	74.6	119.7
TOTAL	528.2	4623.8	165.4	149.2	239.4
Case VI					
One Floater (6 miles)	264.1	2,311.9	82.7	74.6	119.7
One Bottom-founded (6 miles)	256.8	1,101.0	53.6	54.5	60.0
TOTAL	520.9	3,412.9	136.3	129.1	179.7

* Project emissions are based on maximum hourly emission rates. Actual emissions for the Project may be significantly less because operating time and load will vary.

20% = 15.0

TABLE 3-2 FLOATING DRILLING VESSEL EMISSIONS IN[illegible]TORY - ARCO ALASKA BEAUFORT SEA PROJECT

.13 x (8/5) = — lb/hr

lb/hr 2.8 — 2.1

Source	Size	Units	% Usage	Fuel Use	Fuel Units	No. Day Ops	Emission Factors CO	NOX	SO2	PM	VOC	Emission Factor Units	Emission Factor Source	gm/sec CO	NOX	SO2	PM	VOC	Ton/yr CO	NOX	SO2	PM	VOC
FLOATING DRILLING VESSEL																							
Main Engines	2816	BHP	100%	NA	NA	120	0.444	9.45	1.37	0.26	0.336	g/BHPh	PM AP42 3.4-5,Vendor	0.35	7.39	1.07	0.20	0.26	4.0	84.5	12.2	2.3	3.0
Main Engines	2816	BHP	100%	NA	NA	120	0.444	9.45	1.37	0.26	0.336	g/BHPh	PM AP42 3.4-5,Vendor	0.35	7.39	1.07	0.20	0.26	4.0	84.5	12.2	2.3	3.0
Main Engines	2816	BHP	100%	NA	NA	120	0.444	9.45	1.37	0.26	0.336	g/BHPh	PM AP42 3.4-5,Vendor	0.35	7.39	1.07	0.20	0.26	4.0	84.5	12.2	2.3	3.0
Emergency Gen	630	kW	0.30%	0.5	hr/wk	0.36	2120	9.15	1900	205	257	g/hr	PM AP42 3.4-5,Vendor	0.29	0.00	0.26	0.03	0.04	0.0	0.0	0.0	0.0	0.0
Deck crane	259	kW	100%	NA	NA	120	4.06	18.8	1.25	1.34	1.53	g/kWh	AP42 3.3-2	0.29	1.35	0.09	0.10	0.11	3.3	15.5	1.0	1.1	1.3
Deck Crane	259	kW	100%	NA	NA	120	4.06	18.8	1.25	1.34	1.53	g/kWh	AP42 3.3-2	0.29	1.35	0.09	0.10	0.11	3.3	15.5	1.0	1.1	1.3
Deck Crane	259	kW	100%	NA	NA	120	4.06	18.8	1.25	1.34	1.53	g/kWh	AP42 3.3-2	0.29	1.35	0.09	0.10	0.11	3.3	15.5	1.0	1.1	1.3
Anchor Winch	Unknown	Unknown	100%	NA	NA	120	197	910	60.5	65	72.8	g/hr	AP42 3.3-1(1/75)	0.05	0.25	0.02	0.02	0.02	0.6	2.9	0.2	0.2	0.2
Wellog Gen	11	kW	100%	NA	NA	120	4.06	18.8	1.25	1.34	1.53	g/kWh	AP42 3.3-2	0.01	0.06	0.00	0.00	0.00	0.1	0.7	0.0	0.0	0.1
Welllog Winch	Unknown	Unknown	100%	NA	NA	120	740	1460	200	65	56	g/hr	PM AP42 3.3-1(1/75),Vend	0.21	0.41	0.06	0.02	0.02	2.3	4.6	0.6	0.2	0.2
Heat Boiler	2.1	MMBtuh	100%	17.65	gal/hr	120	5	20	7.1	2	0.34	lb/1000ga	AP42 1.3-1	0.01	0.04	0.02	0.00	0.00	0.1	0.5	0.2	0.1	0.0
Heat Boiler	2.4	MMBtuh	100%	17.65	gal/hr	120	5	20	7.1	2	0.34	lb/1000ga	AP42 1.3-1	0.01	0.04	0.02	0.00	0.00	0.1	0.5	0.2	0.1	0.0
Hot Water Heat	0.54	MMBtuh	100%	4.0	gal/hr	120	5	20	7.1	2	0.34	lb/1000ga	AP42 1.3-1	0.00	0.01	0.00	0.00	0.00	0.0	0.1	0.0	0.0	0.0
Hot Water Heat	0.54	MMBtuh	100%	4.0	gal/hr	120	5	20	7.1	2	0.34	lb/1000ga	AP42 1.3-1	0.00	0.01	0.00	0.00	0.00	0.0	0.1	0.0	0.0	0.0
Flash Steam Gen	Unknown	Unknown	100%	NA	NA	120	3.1	54	38	3.44	3.85	lb/day	PM AP42 3.3-1 (1/75),Ven	0.02	0.28	0.20	0.02	0.02	0.2	3.2	2.3	0.2	0.2
Incinerator	400	lb/hr	100%	400	lb/hr	120	10	3	2.5	7	3	lb/ton	AP42 2.1-3	0.25	0.08	0.06	0.18	0.08	2.9	0.9	0.7	2.0	0.9
Fork Lift	370	BHP	100%	NA	NA	120	3.03	14	0.931	1	1.14	g/BHPh	AP42 3.3-1	0.31	1.44	0.10	0.10	0.12	3.6	16.4	1.1	1.2	1.3
Fork Lift	370	BHP	100%	NA	NA	120	3.03	14	0.931	1	1.14	g/BHPh	AP42 3.3-1	0.31	1.44	0.10	0.10	0.12	3.6	16.4	1.1	1.2	1.3
Fork Lift	370	BHP	100%	NA	NA	120	3.03	14	0.931	1	1.14	g/BHPh	AP42 3.3-1	0.31	1.44	0.10	0.10	0.12	3.6	16.4	1.1	1.2	1.3
Air Compressor Emgc	Unknown	Unknown	100%	NA	NA	120	197	910	60.5	65	72.8	g/hr	AP42 3.3-1(1/75)	0.05	0.25	0.02	0.02	0.02	0.6	2.9	0.2	0.2	0.0
Bulk Handling Compr	Unknown	Unknown	100%	NA	NA	120	197	910	60.5	65	72.8	g/hr	AP42 3.3-1(1/75)	0.05	0.25	0.02	0.02	0.02	0.6	2.9	0.2	0.2	0.0
Bulk Handling Compr	Unknown	Unknown	100%	NA	NA	120	197	910	60.5	65	72.8	g/hr	AP42 3.3-1(1/75)	0.05	0.25	0.02	0.02	0.02	0.6	2.9	0.2	0.2	0.0
Cementing Unit	Unknown	Unknown	100%	NA	NA	120	197	910	60.5	55	72.8	g/hr	AP42 3.3-1(1/75)	0.05	0.25	0.02	0.02	0.02	0.6	2.9	0.2	0.2	0.0
Cementing Unit	Unknown	Unknown	100%	NA	NA	120	197	910	60.5	65	72.8	g/hr	AP42 3.3-1(1/75)	0.05	0.25	0.02	0.02	0.02	0.6	2.9	0.2	0.2	0.0
TOTAL						120								4.0	33.0	4.5	1.6	1.7	42.2	377.1	48.3	17.5	18.4
FLARE																							
Flare NG	1E+07	cfd	100%	1000	btu/cf	40	0.37	0.068	0.017	0.00	0.063	lb/MMBtu	AP42 11.5-1 SO2 MB	19.43	3.57	0.89	0.00	3.31	74.0	13.6	3.4	0.0	12.6
VESSEL #1																							
Main Engine	4265	kW	100%	0.562	m3/hr	120	3.4	43.0	0.80	1.78	3.0	kg/m3	AP42 II-3.3(2/3 Mode) SO2	0.53	6.71	0.12	0.28	0.47	6.1	76.7	1.4	3.2	5.4
Main Engine	4265	kW	100%	0.562	m3/hr	120	3.4	43.0	0.80	1.78	3.0	kg/m3	PM AP42 II-3.2	0.53	6.71	0.12	0.28	0.47	6.1	76.7	1.4	3.2	5.4
Main Engine	4265	kW	100%	0.562	m3/hr	120	3.4	43.0	0.80	1.78	3.0	kg/m3	AP42 II-3.3(2/3 Mode) SO2	0.53	6.71	0.12	0.28	0.47	6.1	76.7	1.4	3.2	5.4
Main Engine	4265	kW	100%	0.562	m3/hr	120	3.4	43.0	0.80	1.78	3.0	kg/m3	PM AP42 II-3.2	0.53	6.71	0.12	0.28	0.47	6.1	76.7	1.4	3.2	5.4
Generator	980	kW	100%	0.13	m3/hr	120	1000	9173	140	196	431.2	g/hr	Vendor Supplied	0.28	2.55	0.04	0.05	0.12	3.2	29.1	0.4	0.6	1.4
Generator	980	kW	100%	0.13	m3/hr	120	1000	9173	140	196	431.2	g/hr	VOC AP42 3.4-2	0.28	2.55	0.04	0.05	0.12	3.2	29.1	0.4	0.6	1.4
Emergency Gen	200	kW	0.3%	0.5	hr/wk	0.36	4.06	18.8	1.25	1.34	1.53	g/kWh	AP42 3.3-2	0.06	0.52	0.03	0.04	0.04	0.01	0.04	0.00	0.00	0.00
Heat Boiler	2.1	MMBtuh	100%	17.65	gal/hr	120	5	20	7.1	2	0.34	lb/1000ga	AP42 1.3-1	0.01	0.04	0.02	0.00	0.00	0.1	0.5	0.2	0.1	0.0
Hot Water Heat	0.54	MMBtuh	100%	4.0	gal/hr	120	5	20	7.1	2	0.34	lb/1000ga	AP42 1.3-1	0.00	0.01	0.00	0.00	0.00	0.0	0.1	0.0	0.0	0.0
Incinerator	65	lb/hr	100%	65	lb/hr	120	10	3	2.5	7	3	lb/ton	AP42 2.1-3	0.04	0.01	0.01	0.03	0.01	0.5	0.1	0.1	0.3	0.1
TOTALS						120								2.79	32.54	0.64	1.29	2.17	31.2	365.9	6.9	14.3	24.3
VESSEL #2																							
Main Engines	2780	kW	100%	0.264	m3/hr	120	3.4	37	0.80	1.78	3.0	kg/hrNOX	NOx Vendor Supplied	0.25	10.28	0.06	0.13	0.22	2.8	117.5	0.7	1.5	2.5
Main Engines	2780	kW	100%	0.264	m3/hr	120	3.4	37	0.80	1.78	3.0	kg/m3	PM AP42 II-3.2	0.25	10.28	0.06	0.13	0.22	2.8	117.5	0.7	1.5	2.5
Main Engines	2780	kW	100%	0.264	m3/hr	120	3.4	37	0.80	1.78	3.0	kg/m3	CO AP42 II-3.3 (2/3 Mode)	0.25	10.28	0.06	0.13	0.22	2.8	117.5	0.7	1.5	2.5
Main Engines	2780	kW	100%	0.264	m3/hr	120	3.4	37	0.80	1.78	3.0	kg/m3	SO2 Mass Balance	0.25	10.28	0.06	0.13	0.22	2.8	117.5	0.7	1.5	2.5
Generator	260	kW	100%	0.13	m3/hr	120	4.06	18.8	1.25	1.34	1.53	g/kWh	AP-42 3.3-2	0.29	1.36	0.09	0.10	0.11	3.4	15.5	1.0	1.1	1.3
Generator	260	kW	100%	0.13	m3/hr	120	4.06	18.8	1.25	1.34	1.53	g/kWh	AP-42 3.3-2	0.29	1.36	0.09	0.10	0.11	3.4	15.5	1.0	1.1	1.3
Heat Boiler	2.4	MMBtuh	100%	17.65	gal/hr	120	5	20	7.1	2	0.34	lb/1000ga	AP42 1.3-1	0.01	0.04	0.02	0.00	0.00	0.1	0.5	0.2	0.1	0.0
Hot Water Heat	0.54	MMBtuh	100%	4.0	gal/hr	120	5	20	7.1	2	0.34	lb/1000ga	AP42 1.3-1	0.00	0.01	0.00	0.00	0.00	0.0	0.1	0.0	0.0	0.0
Incinerator	75	lb/hr	100%	75	lb/hr	120	10	3	2.5	7	3	lb/ton	AP42 2.1-3	0.05	0.01	0.01	0.03	0.01	0.5	0.2	0.1	0.4	0.2
TOTALS						120								1.64	43.90	0.45	0.75	1.12	18.8	501.7	5.1	8.6	12.8
VESSEL #3																							
Main Engines	2780	kW	100%	0.264	m3/hr	120	3.4	37	0.80	1.78	3.0	kg/hrNOX	NOx Vendor Supplied	0.25	10.28	0.06	0.13	0.22	2.8	117.5	0.7	1.5	2.5
Main Engines	2780	kW	100%	0.264	m3/hr	120	3.4	37	0.80	1.78	3.0	kg/m3	PM AP42 II-3.2	0.25	10.28	0.06	0.13	0.22	2.8	117.5	0.7	1.5	2.5
Main Engines	2780	kW	100%	0.264	m3/hr	120	3.4	37	0.80	1.78	3.0	kg/m3	CO AP42 II-3.3 (2/3 Mode)	0.25	10.28	0.06	0.13	0.22	2.8	117.5	0.7	1.5	2.5
Main Engines	2780	kW	100%	0.264	m3/hr	120	3.4	37	0.80	1.78	3.0	kg/m3	SO2 Mass Balance	0.25	10.28	0.06	0.13	0.22	2.8	117.5	0.7	1.5	2.5

~.4% S

w 30% NOx Red,

~.3% S

w 0.05% S fuel

correction: Fork Lifts will be electric

SO2 based on 0.05% S fu

no NOx red. accounted for

TABLE 3-2 FLOATING DRILLING VESSEL EMISSIONS INVENTORY - ARCO ALASKA BEAUFORT SEA PROJECT

Source	Size	Units	% Usage	Fuel Use	Fuel Units	No. Day Ops	Emission Factors					Emission Factor Units	Emission Factor Source	gm/sec					Ton/yr				
							CO	NOX	SO2	PM	VOC			CO	NOX	SO2	PM	VOC	CO	NOX	SO2	PM	VOC
Generator	260	kW	100%	0.13	m3/hr	120	4.06	18.8	1.25	1.34	1.53	g/kWh	AP-42 3.3-2	0.29	1.36	0.09	0.10	0.11	3.4	15.5	1.0	1.1	1.3
Generator	260	kW	100%	0.13	m3/hr	120	4.06	18.8	1.25	1.34	1.53	g/kWh	AP-42 3.3-2	0.29	1.36	0.09	0.10	0.11	3.4	15.5	1.0	1.1	1.3
Heat Boiler	2.4	MMBtuh	100%	17.65	gal/hr	120	5	20	7.1	2	0.34	lb/1000ga	AP42 1.3-1	0.01	0.04	0.02	0.00	0.00	0.1	0.5	0.2	0.1	0.0
Hot Water Heat	0.54	MMBtuh	100%	4.0	gal/hr	120	5	20	7.1	2	0.34	lb/1000ga	AP42 1.3-1	0.00	0.01	0.00	0.00	0.00	0.0	0.1	0.0	0.0	0.0
Incinerator	75	lb/hr	100%	75	lb/hr	120	10	3	2.5	7	3	lb/ton	AP42 2.1-3	0.05	0.01	0.01	0.03	0.01	0.5	0.2	0.1	0.4	0.2
TOTALS						120								1.64	43.90	0.45	0.75	1.12	18.8	501.7	5.1	8.6	12.8
VESSEL #4																							
Main Engines	6270	kW	100%	1.40	m3/hr	120	3.4	43.0	0.80	1.78	3.0	kg/m3	See Vessel 1	1.32	16.72	0.31	0.69	1.17	15.1	191.1	3.6	7.9	13.3
Main Engines	6270	kW	100%	1.40	m3/hr	120	3.4	43.0	0.80	1.78	3.0	kg/m3	See Vessel 1	1.32	16.72	0.31	0.69	1.17	15.1	191.1	3.6	7.9	13.3
Generator	300	kW	100%	0.13	m3/hr	120	4.06	18.8	1.25	1.34	1.53	g/kWh	AP-42 3.3-2	0.34	1.57	0.10	0.11	0.13	3.9	17.9	1.2	1.3	1.5
Generator	300	kW	100%	0.13	m3/hr	120	4.06	18.8	1.25	1.34	1.53	g/kWh	AP-42 3.3-2	0.34	1.57	0.10	0.11	0.13	3.9	17.9	1.2	1.3	1.5
Generator	300	kW	100%	0.13	m3/hr	120	4.06	18.8	1.25	1.34	1.53	g/kWh	AP-42 3.3-2	0.34	1.57	0.10	0.11	0.13	3.9	17.9	1.2	1.3	1.5
Heat Boiler	2.4	MMBtuh	100%	17.65	gal/hr	120	5	20	7.1	2	0.34	lb/1000ga	AP42 1.3-1	0.01	0.04	0.02	0.00	0.00	0.1	0.5	0.2	0.1	0.0
Hot Water Heat	0.54	MMBtuh	100%	4.00	gal/hr	120	5	20	7.1	2	0.34	lb/1000ga	AP42 1.3-1	0.00	0.01	0.00	0.00	0.00	0.0	0.1	0.0	0.0	0.0
Incinerator	75	lb/hr	100%	75	lb/hr	120	10	3	2.5	7	3	lb/ton	AP42 2.1-3	0.05	0.01	0.01	0.03	0.01	0.5	0.2	0.1	0.4	0.2
TOTALS						120								3.72	38.21	0.97	1.76	2.73	42.5	436.7	11.0	20.1	31.2
VESSEL # 5																							
Main Engines	1600	kW	100%	0.16	m3/hr	120	15.2	39.1	0.80	1.78	1.80	kg/m3	See Vessel 1	0.68	1.74	0.04	0.08	0.08	7.7	19.9	0.4	0.9	0.9
Main Engines	1600	kW	100%	0.16	m3/hr	120	15.2	39.1	0.80	1.78	1.80	kg/m3	See Vessel 1	0.68	1.74	0.04	0.08	0.08	7.7	19.9	0.4	0.9	0.9
TUGBOAT 1 TOTAL						120								1.35	3.48	0.07	0.16	0.16	15.4	39.7	0.8	1.8	1.8
VESSEL # 6																							
Main Engines	1600	kW	100%	0.16	m3/hr	120	15.2	39.1	0.80	1.78	1.80	kg/m3	See Vessel 1	0.68	1.74	0.04	0.08	0.08	7.7	19.9	0.4	0.9	0.9
Main Engines	1600	kW	100%	0.16	m3/hr	120	15.2	39.1	0.80	1.78	1.80	kg/m3	See Vessel 1	0.68	1.74	0.04	0.08	0.08	7.7	19.9	0.4	0.9	0.9
TUGBOAT 2 TOTAL						120								1.35	3.48	0.07	0.16	0.16	15.4	39.7	0.8	1.8	1.8
VESSEL #7																							
Main Engines	300	kw	100%	75.7	l/hr	120	5.7	46.7	0.80	1.78	6.10	kg/m3	See Vessel 1	0.12	0.98	0.02	0.04	0.13	1.4	11.2	0.2	0.4	1.5
Main Engines	300	kw	100%	75.7	l/hr	120	5.7	46.7	0.80	1.78	6.10	kg/m3	See Vessel 1	0.12	0.98	0.02	0.04	0.13	1.4	11.2	0.2	0.4	1.5
Generator	112	kw	100%	0.13	m3/hr	120	4.06	18.8	1.25	1.3	1.53	g/kWh	AP42 3.3-2	0.13	0.58	0.04	0.04	0.05	1.4	6.7	0.4	0.5	0.5
Generator	112	kw	100%	0.13		120	4.06	18.8	1.25	1.3	1.53	g/kWh	AP42 3.3-2	0.13	0.58	0.04	0.04	0.05	1.4	6.7	0.4	0.5	0.5
VESSEL 7 TOTALS														0.49	3.13	0.11	0.16	0.35	5.6	35.8	1.3	1.8	4.0
PROJECT TOTALS																			264.1	2311.9	82.7	74.6	119.7

NOTE: NA - Not Available

TABLE 3-3 BOTTOM FOUNDED DRILLING STRUCTURE EMISSIONS INVENTORY - ARCO ALASKA BEAUFORT SEA PROJECT

Source	Size	Units	% Usage	Fuel Use	Fuel Units	No. Day Ops	Emission Factors					Emission Factor Units	Emission Factor Source	gm/sec					Ton/yr				
							CO.	NOX	SO2	PM	VOC			CO	NOX	SO2	PM	VOC	CO	NOX	SO2	PM	VOC
GLOMAR CIDS																							
Drilling Main Engines																							
Main Engines	1529	BHP	100%	NA	NA	365	0.45	3.83	0.19	0.23	0.041	g/BHPh	Vendor ,SO2 MB	0.19	1.63	0.08	0.10	0.02	6.7	56.5	2.8	3.5	0.6
Main Engines	1529	BHP	100%	NA	NA	365	0.45	3.83	0.19	0.23	0.041	g/BHPh	Vendor ,SO2 MB	0.19	1.63	0.08	0.10	0.02	6.7	56.5	2.8	3.5	0.6
Main Engines	1529	BHP	100%	NA	NA	365	0.45	3.83	0.19	0.23	0.041	g/BHPh	Vendor ,SO2 MB	0.19	1.63	0.08	0.10	0.02	6.7	56.5	2.8	3.5	0.6
Main Engines	1529	BHP	100%	NA	NA	365	0.45	3.83	0.19	0.23	0.041	g/BHPh	Vendor ,SO2 MB	0.19	1.63	0.08	0.10	0.02	6.7	56.5	2.8	3.5	0.6
Barge Main Engines																							
Main Engines	550	BHP	100%	NA	NA	365	1.36	5.1	0.20	0.07	0.096	g/BHPh	Vendor	0.21	0.77	0.03	0.01	0.01	7.2	26.9	1.0	0.4	0.5
Main Engines	550	BHP	100%	NA	NA	365	1.36	5.1	0.20	0.07	0.096	g/BHPh	Vendor	0.21	0.77	0.03	0.01	0.01	7.2	26.9	1.0	0.4	0.5
Main Engines	550	BHP	100%	NA	NA	365	1.36	5.1	0.20	0.07	0.096	g/BHPh	Vendor	0.21	0.77	0.03	0.01	0.01	7.2	26.9	1.0	0.4	0.5
Water Spray																							
Main Engines	1250	BHP	100%	NA	NA	60	0.72	3.72	0.19	0.09	0.042	g/BHPh	Vendor ,SO2 MB	0.25	1.29	0.06	0.03	0.01	1.4	7.4	0.4	0.2	0.1
Main Engines	1250	BHP	100%	NA	NA	60	0.72	3.72	0.19	0.09	0.042	g/BHPh	Vendor ,SO2 MB	0.25	1.29	0.06	0.03	0.01	1.4	7.4	0.4	0.2	0.1
Main Engines	1250	BHP	100%	NA	NA	60	0.72	3.72	0.19	0.09	0.042	g/BHPh	Vendor ,SO2 MB	0.25	1.29	0.06	0.03	0.01	1.4	7.4	0.4	0.2	0.1
Emergency Gen	640	BHP	0.3%	NA	NA	2	2.4	14	0.06	0.24	0.33	g/BHPh	PM AP42 3.4-5,3.4-1,SO2 M	0.43	1.96	0.01	0.04	0.06	0.1	0.4	0.0	0.0	0.0
Deck Crane Pedestal	507	kW	100%	NA	NA	365	3.2	14	0.08	0.33	0.44	g/kWh	PM AP42 3.4-5,3.4-2,SO2 M	0.45	1.97	0.01	0.05	0.06	15.7	68.5	0.4	1.6	2.2
Deck Crane Crawler	507	kW	100%	NA	NA	365	3.2	14	0.08	0.33	0.44	g/kWh	PM AP42 3.4-5,3.4-2,SO2 M	0.45	1.97	0.01	0.05	0.06	15.7	68.5	0.4	1.6	2.2
Deck Crane Wheeled	259	kW	100%	NA	NA	365	4.06	18.8	1.25	1.34	1.53	g/kWh	AP42 3.3-2	0.29	1.35	0.09	0.10	0.11	10.2	47.0	3.1	3.4	3.8
Anchor Winch	Unknow	Unknown	100%	NA	NA	365	197	910	60.5	65	72.8	g/hr	AP42 3.3-1(1/75)	0.05	0.25	0.02	0.02	0.02	1.9	8.8	0.6	0.6	0.7
Welling Gen	11	kW	100%	NA	NA	365	4.06	18.8	1.25	1.34	1.53	g/kWh	AP42 3.3-2	0.01	0.06	0.00	0.00	0.00	0.4	2.0	0.1	0.1	0.2
Welling Winch	Unknow	Unknown	100%	NA	NA	365	740	1460	200	65	56	g/hr	PM AP42 3.3-1(8/84),Vendo	0.21	0.41	0.06	0.02	0.02	7.1	14.1	1.9	0.6	0.5
Fork Lift	370	BHP	100%	NA	NA	365	3.03	14	0.931	1	1.14	g/BHPh	AP42 3.3-1	0.31	1.44	0.10	0.10	0.12	10.8	50.0	3.3	3.6	4.1
Fork Lift	370	BHP	100%	NA	NA	365	3.03	14	0.931	1	1.14	g/BHPh	AP42 3.3-1	0.31	1.44	0.10	0.10	0.12	10.8	50.0	3.3	3.6	4.1
Fork Lift	370	BHP	100%	NA	NA	365	3.03	14	0.931	1	1.14	g/BHPh	AP42 3.3-1	0.31	1.44	0.10	0.10	0.12	10.8	50.0	3.3	3.6	4.1
Heat Boiler 3-800MBh	2.4	MMBtuh	100%	17.65	gal/hr	365	5	20	7.1	2	0.34	lb/1000ga	AP42 1.3-1	0.01	0.04	0.02	0.00	0.00	0.4	1.5	0.5	0.2	0.0
Air Compressor Eng	Unknow	Unknown	100%	NA	NA	2	197	910	60.5	65	72.8	g/hr	AP42 3.3-1(1/75)	0.05	0.25	0.02	0.02	0.02	0.0	0.0	0.0	0.0	0.0
Bulk Handling Compr	Unknow	Unknown	100%	NA	NA	365	197	910	60.5	65	72.8	g/hr	AP42 3.3-1(1/75)	0.05	0.25	0.02	0.02	0.02	1.9	8.8	0.6	0.6	0.0
Bulk Handling Compr	Unknow	Unknown	100%	NA	NA	365	197	910	60.5	65	72.8	g/hr	AP42 3.3-1(1/75)	0.05	0.25	0.02	0.02	0.02	1.9	8.8	0.6	0.6	0.0
Cementing Unit	Unknow	Unknown	100%	NA	NA	365	197	910	60.5	65	72.8	g/hr	AP42 3.3-1(1/75)	0.05	0.25	0.02	0.02	0.02	1.9	8.8	0.6	0.6	0.0
Cementing Unit	Unknow	Unknown	100%	NA	NA	365	197	910	60.5	65	72.8	g/hr	AP42 3.3-1(1/75)	0.05	0.25	0.02	0.02	0.02	1.9	8.8	0.6	0.6	0.0
Flash Steam Gen	Unknow	Unknown	100%	NA	NA	365	3.1	51	38	2.9	3.85	lb/day	PM AP42 3.3-1,Vendor	0.02	0.28	0.20	0.02	0.02	0.6	9.9	6.9	0.5	0.7
Incinerator	400	lb/hr	100%	400	lb/hr	365	10	3	2.5	7	3	lb/ton	AP42 2.1-3	0.25	0.08	0.06	0.18	0.08	8.8	2.6	2.2	6.1	2.6
TOTALS						365								5.52	26.64	1.45	1.39	1.04	153.5	737.4	44.0	43.5	29.3
FLARE																							
Flare NG	1E+07	cfd	100%	1000	btu/cf	40	0.37	0.068	0.017	0.00	0.063	lb/MMBtu	AP42 11.5-1 SO2 MB	19.43	3.57	0.89	0.00	3.31	74.0	13.6	3.4	0.0	12.6
VESSEL #1																							
Main Engine	4265	kW	100%	0.56	m3/hr	20	3.4	43.0	0.80	1.78	3.0	kg/m3	AP42 II-3.3(2/3 Mode) SO2	0.53	6.71	0.12	0.28	0.47	1.0	12.8	0.2	0.5	0.9
Main Engine	4265	kW	100%	0.56	m3/hr	20	3.4	43.0	0.80	1.78	3.0	kg/m3	PM AP42 II-3.2	0.53	6.71	0.12	0.28	0.47	1.0	12.8	0.2	0.5	0.9
Main Engine	4265	kW	100%	0.56	m3/hr	20	3.4	43.0	0.80	1.78	3.0	kg/m3	AP42 II-3.3(2/3 Mode) SO2	0.53	6.71	0.12	0.28	0.47	1.0	12.8	0.2	0.5	0.9
Main Engine	4265	kW	100%	0.56	m3/hr	20	3.4	43.0	0.80	1.78	3.0	kg/m3	PM AP42 II-3.2	0.53	6.71	0.12	0.28	0.47	1.0	12.8	0.2	0.5	0.9
Generator	980	kW	100%	0.13	m3/hr	20	1000	9173	140	196	431.2	g/hr	Vendor Supplied	0.28	2.55	0.04	0.05	0.12	0.5	4.9	0.1	0.1	0.2
Generator	980	kW	100%	0.13	m3/hr	20	1000	9173	140	196	431.2	g/hr	VOC AP42 3.4-2	0.28	2.55	0.04	0.05	0.12	0.5	4.9	0.1	0.1	0.2
Emergency Gen	200	kW	0.3%	0.5	lu/wk	0.1	4.06	18.8	1.25	1.34	1.53	g/kWh	AP42 3.3-2	0.11	0.52	0.03	0.04	0.04	0.0	0.0	0.0	0.0	0.0
Heat Boiler	2.4	MMBtuh	100%	17.65	gal/hr	20	5	20	7.1	2	0.34	lb/1000ga	AP42 1.3-1	0.01	0.04	0.02	0.00	0.00	0.0	0.1	0.0	0.0	0.0
Hot Water Heat	0.54	MMBtuh	100%	4.0	gal/hr	20	5	20	7.1	2	0.34	lb/1000ga	AP42 1.3-1	0.00	0.01	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0
Incinerator	65	lb/hr	100%	65	lb/hr	20	10	3	2.5	7	3	lb/ton	AP42 2.1-3	0.04	0.01	0.01	0.03	0.01	0.1	0.0	0.0	0.1	0.0
TOTALS						20								2.85	32.54	0.64	1.29	2.17	5.2	61.0	1.2	2.4	4.0
VESSEL #2																							
Main Engines	2780	kW	100%	0.26	m3/hr	20	3.4	37	0.80	1.78	3.0	kg/hrNOX	NOx Vendor Supplied	0.25	10.28	0.06	0.13	0.22	0.5	19.6	0.1	0.2	0.4
Main Engines	2780	kW	100%	0.26	m3/hr	20	3.4	37	0.80	1.78	3.0	kg/m3	PM AP42 II-3.2	0.25	10.28	0.06	0.13	0.22	0.5	19.6	0.1	0.2	0.4
Main Engines	2780	kW	100%	0.26	m3/hr	20	3.4	37	0.80	1.78	3.0	kg/m3	CO AP42 II-3.3 (2/3 Mode)	0.25	10.28	0.06	0.13	0.22	0.5	19.6	0.1	0.2	0.4
Main Engines	2780	kW	100%	0.26	m3/hr	20	3.4	37	0.80	1.78	3.0	kg/m3	SO2 Mass Balance	0.25	10.28	0.06	0.13	0.22	0.5	19.6	0.1	0.2	0.4
Generator	260	kW	100%	0.13	m3/hr	20	4.06	18.8	1.25	1.34	1.53	g/kWh	AP-42 3.3-2	0.29	1.36	0.09	0.10	0.11	0.6	2.6	0.2	0.2	0.2
Generator	260	kW	100%	0.13	m3/hr	20	4.06	18.8	1.25	1.34	1.53	g/kWh	AP-42 3.3-2	0.29	1.36	0.09	0.10	0.11	0.6	2.6	0.2	0.2	0.2
Heat Boiler	2.4	MMBtuh	100%	17.65	gal/hr	20	5	20	7.1	2	0.34	lb/1000ga	AP42 1.3-1	0.01	0.04	0.02	0.00	0.00	0.0	0.1	0.0	0.0	0.0
Hot Water Heat	0.54	MMBtuh	100%	4.0	gal/hr	20	5	20	7.1	2	0.34	lb/1000ga	AP42 1.3-1	0.00	0.01	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0
Incinerator	75	lb/hr	100%	75	lb/hr	20	10	3	2.5	7	3	lb/ton	AP42 2.1-3	0.05	0.01	0.01	0.03	0.01	0.1	0.0	0.0	0.1	0.0
TOTALS						20								1.64	43.90	0.45	0.75	1.12	3.1	83.6	0.9	1.4	2.1
VESSEL #3																							
Main Engines	2780	kW	100%	0.26	m3/hr	20	3.4	37	0.80	1.78	3.0	kg/hrNOX	NOx Vendor Supplied	0.25	10.28	0.06	0.13	0.22	0.5	19.6	0.1	0.2	0.4
Main Engines	2780	kW	100%	0.26	m3/hr	20	3.4	37	0.80	1.78	3.0	kg/m3	PM AP42 II-3.2	0.25	10.28	0.06	0.13	0.22	0.5	19.6	0.1	0.2	0.4
Main Engines	2780	kW	100%	0.26	m3/hr	20	3.4	37	0.80	1.78	3.0	kg/m3	CO AP42 II-3.3 (2/3 Mode)	0.25	10.28	0.06	0.13	0.22	0.5	19.6	0.1	0.2	0.4
Main Engines	2780	kW	100%	0.26	m3/hr	20	3.4	37	0.80	1.78	3.0	kg/m3	SO2 Mass Balance	0.25	10.28	0.06	0.13	0.22	0.5	19.6	0.1	0.2	0.4
Generator	260	kW	100%	0.13	m3/hr	20	4.06	18.8	1.25	1.34	1.53	g/kWh	AP-42 3.3-2	0.29	1.36	0.09	0.10	0.11	0.6	2.6	0.2	0.2	0.2
Generator	260	kW	100%	0.13	m3/hr	20	4.06	18.8	1.25	1.34	1.53	g/kWh	AP-42 3.3-2	0.29	1.36	0.09	0.10	0.11	0.6	2.6	0.2	0.2	0.2
Heat Boiler	2.4	MMBtuh	100%	17.65	gal/hr	20	5	20	7.1	2	0.34	lb/1000ga	AP42 1.3-1	0.01	0.04	0.02	0.00	0.00	0.0	0.1	0.0	0.0	0.0
Hot Water Heat	0.54	MMBtuh	100%	4.0	gal/hr	20	5	20	7.1	2	0.34	lb/1000ga	AP42 1.3-1	0.00	0.01	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0

NOx rate assumes 30% red due to retard & aftercooling

20% = 11.2

TABLE 3-3 BOTTOM FOUNDED DRILLING STRUCTURE EMISSIONS INVENTORY - ARCO ALASKA BEAUFORT SEA PROJECT

Source	Size	Units	% Usage	Fuel Use	Fuel Units	No. Day Ops	Emission Factors CO	NOX	SO2	PM	VOC	Emission Factor Units	Emission Factor Source	gm/sec CO	NOX	SO2	PM	VOC	Ton/yr CO	NOX	SO2	PM	VOC
Incinerator	75	lb/hr	100%	75	lb/hr	20	10	3	2.5	7	3	lb/ton	AP42 2.1-3	0.05	0.01	0.01	0.03	0.01	0.1	0.0	0.0	0.1	0.0
TOTALS						20								1.64	43.90	0.45	0.75	1.12	3.1	83.6	0.9	1.4	2.1
VESSEL #4																							
Main Engines	6270	kW	100%	1.40	m3/hr	20	3.4	43.0	0.80	1.78	3.0	kg/m3	See Vessel 1	1.32	16.72	0.31	0.69	1.17	2.5	31.9	0.6	1.3	2.2
Main Engines	6270	kW	100%	1.40	m3/hr	20	3.4	43.0	0.80	1.78	3.0	kg/m3	See Vessel 1	1.32	16.72	0.31	0.69	1.17	2.5	31.9	0.6	1.3	2.2
Generator	300	kW	100%	0.13	m3/hr	20	4.06	18.8	1.25	1.34	1.53	g/kWh	AP-42 3.3-2	0.34	1.57	0.10	0.11	0.13	0.6	3.0	0.2	0.2	0.2
Generator	300	kW	100%	0.13	m3/hr	20	4.06	18.8	1.25	1.34	1.53	g/kWh	AP-42 3.3-2	0.34	1.57	0.10	0.11	0.13	0.6	3.0	0.2	0.2	0.2
Generator	300	kW	100%	0.13	m3/hr	20	4.06	18.8	1.25	1.34	1.53	g/kWh	AP-42 3.3-2	0.34	1.57	0.10	0.11	0.13	0.6	3.0	0.2	0.2	0.2
Heat Boiler	2.4	MMBtuh	100%	17.65	gal/hr	20	5	20	7.1	2	0.34	lb/1000ga	AP42 1.3-1	0.01	0.04	0.02	0.00	0.00	0.0	0.1	0.0	0.0	0.0
Hot Water Heat	0.54	MMBtuh	100%	4.00	gal/hr	20	5	20	7.1	2	0.34	lb/1000ga	AP42 1.3-1	0.00	0.01	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0
Incinerator	75	lb/hr	100%	75	lb/hr	20	10	3	2.5	7	3	lb/ton	AP42 2.1-3	0.05	0.01	0.01	0.03	0.01	0.1	0.0	0.0	0.1	0.0
TOTALS						20								3.72	38.21	0.97	1.76	2.73	7.1	72.8	1.8	3.3	5.2
VESSEL # 5																							
Main Engines	1600	kW	100%	0.16	m3/hr	20	15.2	39.1	0.80	1.78	1.80	kg/m3	See Vessel 1	0.68	1.74	0.04	0.08	0.08	1.3	3.3	0.1	0.2	0.2
Main Engines	1600	kW	100%	0.16	m3/hr	20	15.2	39.1	0.80	1.78	1.80	kg/m3	See Vessel 1	0.68	1.74	0.04	0.08	0.08	1.3	3.3	0.1	0.2	0.2
TOTALS						20								1.35	3.48	0.07	0.16	0.16	2.6	6.6	0.1	0.3	0.3
VESSEL # 6																							
Main Engines	1600	kW	100%	0.16	m3/hr	20	15.2	39.1	0.80	1.78	1.80	kg/m3	See Vessel 1	0.68	1.74	0.04	0.08	0.08	1.3	3.3	0.1	0.2	0.2
Main Engines	1600	kW	100%	0.16	m3/hr	20	15.2	39.1	0.80	1.78	1.80	kg/m3	See Vessel 1	0.68	1.74	0.04	0.08	0.08	1.3	3.3	0.1	0.2	0.2
TOTALS						20								1.35	3.48	0.07	0.16	0.16	2.6	6.6	0.1	0.3	0.3
VESSEL #7																							
Main Engines	300	kw	100%	75.7	l/hr	120	5.7	46.7	0.80	1.78	6.10	kg/m3	See Vessel 1	0.12	0.98	0.02	0.04	0.13	1.4	11.2	0.2	0.4	1.5
Main Engines	300	kw	100%	75.7	l/hr	120	5.7	46.7	0.80	1.78	6.10	kg/m3	See Vessel 1	0.12	0.98	0.02	0.04	0.13	1.4	11.2	0.2	0.4	1.5
Generator	112	kw	100%	0.13	m3/hr	120	4.06	18.8	1.25	1.3	1.53	g/kWh	AP42 3.3-2	0.13	0.58	0.04	0.04	0.05	1.4	6.7	0.4	0.5	0.5
Generator	112	kw	100%	0.13		120	4.06	18.8	1.25	1.3	1.53	g/kWh	AP42 3.3-2	0.13	0.58	0.04	0.04	0.05	1.4	6.7	0.4	0.5	0.5
TOTALS														0.49	3.13	0.11	0.16	0.4	5.6	35.8	1.3	1.8	4.0
PROJECT TOTALS																			256.8	1101.0	53.6	54.5	60.0

NOTE: NA - Not Available

Ship annual g/s emissions spread over number of days of ships operation (20 days)

TABLE 3-4 SUMMARY OF MODELING INPUTS FLOATING DRILLING VESSEL- ARCO ALASKA BEAUFORT SEA PROJECT

					Short-Term Maximum Emission Rates					Annual Average Emission Rates					Annual Average Emission Rates				
					gm/sec					Tons/yr					gm/sec				
Source	St Ht. (m)	Vel (m/s)	Dia (m)	Temp (K)	CO	NOX	SO2	PM	VOC	CO	NOX	SO2	PM	VOC	CO	NOX	SO2	PM	VOC
FDV	19.8	32.0	0.6	672	3.99	33.00	4.49	1.56	1.75	42.24	377.12	48.26	17.51	18.38	3.70	33.00	4.22	1.53	1.61
Flare	38.6	20.0	3.6	1273	19.43	3.57	0.89	0.00	3.31	74.00	13.60	3.38	0.00	12.60	19.43	3.57	0.89	0.00	3.31
Vessel 1	22.8	29.4	0.81	554	2.79	32.54	0.64	1.29	2.17	31.24	365.91	6.94	14.34	24.30	2.73	32.02	0.61	1.25	2.13
Vessel 2	19.8	17.5	0.6	665	1.64	43.90	0.45	0.75	1.12	18.80	501.66	5.10	8.62	12.76	1.64	43.90	0.45	0.75	1.12
Vessel 3	19.8	17.5	0.6	665	1.64	43.90	0.45	0.75	1.12	18.80	501.66	5.10	8.62	12.76	1.64	43.90	0.45	0.75	1.12
Vessel 4	22.8	29.4	0.81	554	3.72	38.21	0.97	1.76	2.73	42.52	436.72	11.04	20.09	31.21	3.72	38.21	0.97	1.76	2.73
Vessel 5	22.8	29.4	0.81	554	1.35	3.48	0.07	0.16	0.16	15.44	39.72	0.81	1.81	1.83	1.35	3.48	0.07	0.16	0.16
Vessel 6	22.8	29.4	0.81	554	1.35	3.48	0.07	0.16	0.16	15.44	39.72	0.81	1.81	1.83	1.35	3.48	0.07	0.16	0.16
Vessel 7	22.8	29.4	0.81	554	0.49	3.13	0.11	0.16	0.35	5.63	35.81	1.27	1.81	4.02	0.49	3.13	0.11	0.16	0.35
Project Total										264.1	2311.9	82.7	74.6	119.7	36.1	204.7	7.8	6.5	12.7

Note: FDV is Floating Drilling Vessel Based on the Kulluk

Table 3-5 SUMMARY OF MODELING INPUTS BOTTOM-FOUNDED DRILLING UNIT - ARCO ALASKA BEAUFORT SEA PROJECT

Source	St Ht. (m)	Vel (m/s)	Dia (m)	Temp (K)	Short-Term Maximum Emission Rates gm/sec					Annual Project Emission Rates Tons/yr					Annualize Project Emission Rates gm/sec				
					CO	NOX	SO2	PM	VOC	CO	NOX	SO2	PM	VOC	CO	NOX	SO2	PM	VOC
BFDU	50.5	45.6	0.3	755	5.52	26.64	1.45	1.39	1.04	153.5	737.4	44.0	43.5	29.3	4.4	21.2	1.3	1.3	0.8
Flare	37.3	20.0	3.6	1273	19.43	3.57	0.89	0.00	3.31	74.0	13.6	3.4	0.0	12.6	19.43	3.57	0.89	0.00	3.31
Vessel 1	22.8	29.4	0.81	554	2.85	32.54	0.64	1.29	2.17	5.2	61.0	1.2	2.4	4.0	2.73	32.01	0.61	1.25	2.13
Vessel 2	19.8	17.5	0.6	665	1.64	43.90	0.45	0.75	1.12	3.1	83.6	0.9	1.4	2.1	1.64	43.90	0.45	0.75	1.12
Vessel 3	19.8	17.5	0.6	665	1.64	43.90	0.45	0.75	1.12	3.1	83.6	0.9	1.4	2.1	1.64	43.90	0.45	0.75	1.12
Vessel 4	22.8	29.4	0.81	554	3.72	38.21	0.97	1.76	2.73	7.1	72.8	1.8	3.3	5.2	3.72	38.21	0.97	1.76	2.73
Vessel 5	22.8	29.4	0.81	554	1.35	3.48	0.07	0.16	0.16	2.6	6.6	0.1	0.3	0.3	1.35	3.48	0.07	0.16	0.16
Vessel 6	22.8	29.4	0.81	554	1.35	3.48	0.07	0.16	0.16	2.6	6.6	0.1	0.3	0.3	1.35	3.48	0.07	0.16	0.16
Vessel 7	22.8	29.4	0.81	554	0.49	3.13	0.11	0.16	0.35	5.6	35.8	1.3	1.8	4.0	0.49	3.13	0.11	0.16	0.35
Project Total										256.8	1101.0	53.6	54.5	60.0	36.8	192.9	4.9	6.2	11.9

Note: BFDU is Bottom Founded Drilling Unit Based on the CIDS

4.0
BEST AVAILABLE CONTROL TECHNOLOGY

4.1 LEGISLATIVE HISTORY OF BACT

The Federal Clean Air Act of 1970 established, among other things, National Ambient Air Quality Standards (NAAQS). The Act required each state to develop control strategies for the attainment and maintenance of the NAAQS, which included the adoption of emission limitations. The 1977 amendment to the Act introduced the PSD program, which included the concept of BACT. Prior to 1977, Federal NSPS were the only federal emission limitation requirements for new sources in attainment areas, which allowed certain new sources to automatically establish their own emission limits. Under the PSD program, BACT is required for any air pollutant regulated under the Act emitted from a major stationary source in quantities equal to or exceeding the significant emission rates presented in the PSD regulations. The 1977 amendment denotes BACT as an emission limitation based on the maximum degree of reduction with respect to each pollutant; taking into account energy, environmental, and economic impacts, as well as other costs. Control technology requirements that fulfill BACT are determined on a case-by-case basis, considering the type of source, precedent BACT determinations, potential energy penalties and environmental impacts associated with stringent control measures, and economic impacts. In all cases, BACT must be at least as stringent as NSPS. The Clean Air Act authorizes EPA to implement PSD and BACT. EPA has delegated its authority to the appropriate regulatory agency within each state (with some exceptions). The concept of BACT has been included in several regulatory programs, including the new OCS regulations.

4.2 REVIEW OF POTENTIAL CONTROL ALTERNATIVES

The OCS regulations require that BACT be applied to major sources on the drilling vessel/units. Both floating vessels and bottom-founded units may be used for the Project. Both types use diesel-fired engines to power electric motors. These motors power the prime movers on the vessels/units. The drilling vessel/units will be equipped with flares to combust natural gas found during exploration. Flaring this gas is necessary to maintain safe working and living conditions on the vessel/units.

In discussions with EPA, AAI learned that for offshore production operations, BACT is recommended to be: retarded ignition timing to reduce NO_x emissions; use of low sulfur diesel fuel; and smokeless flares. To ensure that a complete BACT assessment for exploration was conducted, several data sources were reviewed. These included the EPA BACT/LAER Clearinghouse, conversations with EPA staff, and review of controls applied to other exploratory activities. The Clearinghouse provides an on-line database which allows agencies to enter information regarding BACT and/or LAER determinations for several types of sources and pollutants. The Clearinghouse data for diesel engines contain several entries for on-land, stationary sources, but none for exploratory drilling operations.

The majority of information is available from exploratory activities in Southern California. In June 1987, the Santa Barbara Air Pollution Control District (SBAPCD) released a study of potential control options for diesel engines on crew and supply boats. The report also contained information relevant to the type and size of engines to be used for this Project.

Alternatives considered for reduction of NO_x included installation of catalytic converters, exhaust gas recirculation, alternative fuels and retardation of engine timing. SO_2 emissions are directly related to fuel sulfur content, hence only low sulfur diesel fuel was considered.

4.3 APPROACH

The Project will comply with recommendations for BACT presented by EPA. Because the Project will employ these BACT recommendations and pursuant to EPA's guidance, a more rigorous analysis of these and other alternatives was not performed. Nevertheless, some alternatives were reviewed for their potential applicability to the Project.

4.4 BACT ASSESSMENT

This section evaluates BACT alternatives for diesel engines and flares. EPA recommendations for NO_x emission control and SO_2 reduction are addressed in Section 4.4.1. The flare control recommendations are addressed in Section 4.4.2.

4.4.1 Diesel Engines

Control alternatives for diesel engines that were examined include non-selective catalytic reduction (non-SCR), exhaust gas circulation (EGR), and timing retardation.

4.4.1.1 Nitrogen Oxides BACT Non-SCR

Nitrogen oxides are the primary pollutant of concern from large diesel engines. Non-SCR has been applied to both gasoline and natural gas-fired engines. These converters are similar to those applied to automobile exhaust. A catalyst bed first oxidizes CO to CO_2, unburned hydrocarbons to water, and NO_x to N_2 under oxygen-deficient conditions. Thus, the engines must operate in a rich-burn mode. According to the SBAPCD (1987), such catalysts are not technically feasible for diesel engines because these types of engines operate at air/fuel ratios well below stoichiometric (lean-burn). These diesel engines cannot be modified to operate efficiently in a rich-burn mode. Because non-SCR is not technically feasible for these diesel engines, it is not considered BACT.

4.4.1.2 Nitrogen Oxides BACT EGR

Recirculation of exhaust gas back to the intake of a reciprocating engine reduces the production of NO_x emissions by reducing the maximum combustion temperature. Since the formation of NO_x increases exponentially with temperature, small reductions in peak cylinder temperature will result in significant reductions in NO_x.

The application of EGR consists of replacing the excess air within the combustion chamber with exhaust gas. As long as the exhaust gas content does not exceed the excess air within the combustion chamber, no decrease in potential horsepower output is expected. However, excessive EGR rates can result in one or more of the following: large increases in fuel consumption, high CO emissions, and misfire or incomplete combustion. Experience indicates that maximum NO_x reductions with EGR are typically accompanied by a 4 percent increase in brake-specific fuel consumption and CO emissions greater than 2,000 ppm, adjusted to 15 percent oxygen.

EGR potentially has practical application to engines with significant excess oxygen (i.e., lean-burn engines) in the exhaust. Cooling and filtering the exhaust to be recirculated into the engine is considered necessary to eliminate concerns with pre-ignition and engine durability. However, cooling the exhaust can make the recycled exhaust gas very corrosive if cooled to the dewpoint. This is a major concern in an arctic environment. An EGR retrofit also requires a complex control system that measures and controls the flow rate of the exhaust gas into the engine. A review of the applicable methods indicates that there is no system available at this time which can control EGR in a typical, variable-load diesel engine. In addition, the measurement of flow rates, fuel composition, exhaust composition, and intake mixture are required for effective control. Thus, a system to provide precise control of EGR appears to be even more complex than the system required to control non-SCR.

As a result of the uncertainties associated with successfully operating a control system for EGR, potential energy penalties associated with large increases in fuel consumption, and the lack of historical information concerning reliable field operation of a diesel engine with EGR, the feasibility of implementing EGR on a diesel engine is unproven. The SBAPCD report confirms that corrosion in marine environments severely impacts engine durability.

Due to the technical and energy drawbacks already indicated for EGR, this control technology alternative is not considered BACT.

4.4.1.3 Nitrogen Oxides BACT Timing Retardation

The SBAPCD (1987) report indicates that ignition timing retard of between 2 and 4 degrees represents a feasible method for controlling NO_x emissions. Reductions are enhanced by modifying engine aftercoolers. Ignition retardation and modified aftercooling reduce NO_x emissions by reducing peak combustion temperatures in the diesel engine. Such reductions are associated with some decrease in horsepower output and some increase in CO emissions. NO_x reduction of 30 percent is expected.

AAI has estimated the capital cost of these controls to be approximately $80,000. Annualized costs are estimated to be approximately $21,500, for a cost effectiveness of approximately $1,700 per ton.

Need: (1) Test Procedures / Methods ...
(2) actual emission rates or g/BHB type values that represent BACT
Table 3-4 gm/sec
(3) certification check

for all diesel ICE

Given that ignition retardation and modified aftercooling are technically feasible and result in acceptable costs these technologies are proposed as BACT.

4.4.1.4 Sulfur Dioxide (SO_2) BACT

Based upon a review of available technologies, reduction of SO_2 emissions from such engines is achieved primarily through reduction of sulfur in the fuel. Alternate fuels such as methanol or natural gas are not feasible for this source. AAI will reduce SO_2 emissions by firing the engines with low sulfur diesel fuel. The vessels/units and the support vessels will use a fuel having 0.05 percent sulfur or lower by weight. This fuel will be used throughout exploration and is proposed BACT for SO_2.

4.4.1.5 Carbon Monoxide (CO) BACT

Control measures for nitrogen oxides may increase levels of CO emissions. However, ambient standards for CO are much higher than for NO_2, reflecting a lesser health threat for CO. Potential CO technologies were selected by reviewing EPA Clearinghouse data and data available from state air pollution agencies. The main technologies applied to internal combustion engines for control of CO are oxidizing catalysts or non-selective catalytic reduction (non-SCR). Oxidizing catalysts may reduce CO by 80 percent. Non-SCR, in the form of three-way tailpipe converters, may reduce CO by 70 percent or greater. These technologies have been applied to land-based stationary, gas-fired engines.

Control technology vendors were contacted regarding the feasibility of adapting these technologies to diesel engines used in an arctic marine environment. Representatives of Englehard Company and Johnson-Mathey stated that oxidizing catalyst have not been used in exploratory operations. The major feasibility issues associated with such catalytic reduction include transportation of catalysts, the amount of space required for a catalyst system, and the intermittent operation of the diesel engines during typical exploration activities. Vendors indicated that significant space requirements would be required to accommodate the volume flows from multiple, large diesel engines. Significant filtering for particulate matter would also be required to avoid poisoning of the catalyst.

The more significant barrier to oxidizing catalyst operation involves the wide swings in engine load, and flow rates typically involved in exploration activities. Catalyst systems are typically designed to operate under specific conditions of load and exhaust temperature. Operation outside these ranges greatly reduces catalyst life and efficiency. For these reasons, oxidizing catalysts are not considered to be a proven, feasible alternative.

Non-SCR systems are designed to operate in a rich burn environment such as gas-fired engines. According to the vendors, these systems can not be used on lean burn engines such as diesel drivers. Thus Non-SCR systems are not feasible for this application.

Based on our assessment, BACT for CO is the existing engines, as modified to reduce NO_x emissions.

4.4.1.6 Volatile Organic Compound (VOC) BACT

Review of alternatives for VOC control indicate that non-SCR systems are typically applied to gas-fired, land-based sources. As discussed above, non-SCR is not feasible for this application. Thus, existing engine design as modified to reduce NO_x emissions is considered BACT for these engines.

4.4.1.7 Particulate Matter (PM) BACT

Control of PM emissions from diesel engines is typically accomplished with the use of particulate traps or filters. Based upon a review of available information, such controls have only been applied to engines much smaller than those in use on the drilling vessels/units. Thus no additional controls are proposed for PM emissions.

Use of Low S fuel

VE / opacity
5%, <10%

4.4.2 Flares

EPA has requested that AAI evaluate the control of visible emissions from flares on the drill vessels/units. No similar precedent BACT determinations were found for flares in exploratory activities. It appears there are two types of smokeless technology available for use in exploratory operations: high energy assist flares (using the kinetic energy of the flare gas) or other flare assist techniques (using water, steam, or air). AAI has evaluated both types of technology and proposes a kinetic energy-type assist flare which involves the principle of the Coanda effect as BACT.

Henri Coanda observed that when fluid such as gas or air passes over a curved surface, it will adhere to the surface and create a vacuum. On a Coanda-effect type flare, the waste gas is introduced at pressure through an annular slot. It then adheres to the curved surface of the flare tip and a low-pressure region is created on either side of the gas. This low-pressure area entrains up to 20 volumes of air per volume of gas. The entrainment is augmented by the change in direction of gas as it follows the curved surface.

The premixture of air and waste gas improves combustion, so the mixture burns more efficiently and cleaner than raw gas. The resulting flame is shorter, cleaner, and does not produce smoke. A Coanda-effect type flare also produces less radiant heat than a conventional flare.

Water, steam, and air assisted flares were evaluated and rejected based upon feasibility and safety concerns. At estimated full flare rate, the required amount of water, steam, or air exceeds the capacity of the systems supplying those utilities. Also, the rate of flaring in exploratory projects is highly variable, unlike production situations. Therefore, it is not possible to preset the mixture of water, steam, or air. These fluctuations could lead to excess water, steam, or air and cause flame-out of the flare. A drilling vessel/unit is a confined living space, and the emission of raw gas caused by a flame-out represents a safety hazard. Also, the use of water or steam in the arctic is not desirable because of potential freeze-up in the lines carrying these components.

Injecting steam or air to the flares would be infeasible with the equipment currently available. High volumes of steam or air, which are currently unavailable, would be needed to effectively reduce opacity. Current recommendations are to inject 1 to 2 lb/hr of steam per lb/hr of produced gas. For air, it is recommended that 3 to 7 lb/hr be injected per lb/hr of produced gas.

At 10 MMscfd of produced gas (the assumed flare rate), the steam requirement would be 20,800 to 62,500 lb/hr. The air requirement would be 62,500 to 145,800 lb/hr. These volumes would be extremely difficult to achieve without a major redesign of the system at very high cost.

For these reasons, water, air and steam assist are not considered BACT for the flare. The Coanda-type smokeless flare is BACT for the flare.

opacity limit ______ %

5.0
EMISSIONS FROM OTHER SOURCES

Because baseline air quality concentrations have not been monitored over the Beaufort Sea, a dispersion model analysis was conducted which considered emissions from the Project facilities and from sources on the North Slope, Alaska. This analysis included all the existing Prudhoe Bay sources, adjacent facilities associated with the Lisburne and Endicott developments, the PWT/PWI addition to the FS-2 facility, GHX-1, and the proposed GHX-2 expansion. The detailed emissions data for these sources are listed in Appendix H of the GHX-2 PSD Application (AAI 1991). Emissions from existing sources were based on previous modeling of North Slope emissions.

6.0
EXISTING CONDITIONS

6.1 AMBIENT AIR QUALITY STANDARDS AND PSD INCREMENTS

In 1970 the United States Congress instructed EPA to establish standards for air pollutants which were of nationwide concern. This directive came about from the concern of the effects of these pollutants on the health and welfare of the public. The resulting action was a bill called the Clean Air Act (CAA) which set forth air quality standards to protect the health and welfare of the public. Two levels of standards were promulgated--primary standards and secondary standards. Primary national ambient air quality standards (NAAQS) are "those which, in the judgment of the administrator (of the EPA), based on air quality criteria and allowing an adequate margin of safety, are requisite to protect the public health (state of general health of community or population)." The secondary NAAQS are "those which in the judgment of the administrator (of the EPA), based on air quality criteria, are requisite to protect the public welfare and ecosystems associated with the presence of air pollutants in the ambient air." To date, NAAQS have been established for six contaminants termed "criteria pollutants": sulfur dioxide (SO_2), carbon monoxide (CO), ozone (O_3) (photochemical oxidants), nitrogen dioxide (NO_2), sub 10-micron particulate matter (PM_{10}), and lead (Pb). The criteria pollutants are those that have been demonstrated historically to be widespread and have a potential for adverse health impacts. EPA developed comprehensive documents detailing the basis of, or criteria for, the standards that limit the ambient concentrations of these pollutants. Table 6-1 shows the NAAQS for the criteria pollutants.

In addition to the primary and secondary standards, the EPA has also promulgated a program for Prevention of Significant Deterioration of existing air quality through the establishment of increments for specified pollutants with the Clean Air Act Amendments of 1977. These increments establish the maximum increase in a given pollutant concentration allowed above a baseline level. Hence, the increments define the amount of growth-related air pollution impact that is allowed for specific areas. The increments are intended to regulate the specific amount of additional growth in an area. Increases above air quality standards will not be allowed.

Originally, the only pollutants Congress specifically regulated with the incremental approach were SO_2 and total suspended particulates (TSP). In 1988, Congress included NO_2 with an annual increment. Therefore, SO_2, TSP, and NO_2 concentrations exceeding increment could cause EPA to impose a restriction on growth for the affected area. It does not necessarily indicate an adverse health impact. These increments are also presented in Table 6-1.

EPA has also established Significant Impact Levels which are presented in Table 6-1. Impacts of criteria pollutants which are less than these values are not considered to be significant.

In September 1992, EPA promulgated rules that establish requirements for PSD review and attainment of NAAQS from air emission sources in the OCS of the United States.

6.2 BACKGROUND AIR QUALITY

Table 6-2 summarizes the measured air quality concentrations over the past 5 years at Prudhoe Bay Unit (PBU) Pad A and the Central Compressor Plant (CCP). Figure 6-1 shows the location of the monitoring locations. The data show concentrations well below the NAAQS for all pollutants except for one isolated instance of elevated ozone (O_3) levels at Pad A. Only O_3 and NO_2 air quality data were obtained at Pad A.

The Pad A monitoring site is relatively isolated from major PBU emission sources. As such, the Pad A data are probably more representative of regional air quality conditions in the PBU area.

Nitrogen Dioxide (NO_2). The annual federal and state standard for nitrogen dioxide is 100 $\mu g/m^3$ while the annual NO_2 increment is 25 $\mu g/m^3$. Primary man-made sources of this pollutant include the burning of fossil fuels in industrial and transportation-related activities.

NO_2 levels are monitored continuously at Pad A. Since monitoring at this site began in 1986, no violations of the standard have been recorded. During this monitoring period, as illustrated in Table 6-2, NO_2 concentrations have been relatively low, averaging 9 $\mu g/m^3$ annually, approximately 10 percent of the standard.

Ozone (O_3). The federal standard for O_3 is 235 $\mu g/m^3$ for an averaging time of one hour. One exceedance of this standard has been observed at Pad A. The high O_3 concentration at Pad A is believed to be attributable to nearby welding activity on the pad which occurred during the period of high ozone measurements. As such, the data during this period are not representative of normal ambient ozone concentrations.

The production of photochemical oxidants, or ozone, in the atmosphere is a result of a series of chemical reactions involving sunlight, warm ambient temperatures, and certain precursor pollutants. The primary precursor pollutants include nitrogen oxides and volatile organic compounds.

Sulfur Dioxide (SO_2). Ambient air quality standards for sulfur dioxide have been established for three averaging periods. These standards have been maintained at the CCP with a wide margin of safety over recent years. The primary source of SO_2 emissions is the burning of fossil fuels.

The CCP monitoring site began operating in 1986. The maximum annual value recorded at this station was less than 8 $\mu g/m^3$ (below detection limit). The second maximum 24-hour level at the CCP since 1986 is 16 $\mu g/m^3$, while the second highest 3-hour level is 21 micrograms per cubic meter.

Carbon Monoxide (CO). As shown in Table 6-1, two standards have been established for carbon monoxide, a 1-hour standard of 40,000 $\mu g/m^3$ and an 8-hour standard of 10,000 $\mu g/m^3$. Carbon monoxide background concentrations have not been measured in PBU.

Total Suspended Particulates (TSP). Although the TSP NAAQS has been superseded by a NAAQS for PM_{10}, two federal PSD increments still apply to TSP. The second highest 24-hour TSP concentration measured at CCP is 66 $\mu g/m^3$. The maximum annual concentration is 10 $\mu g/m^3$.

Particulate Matter 10 microns (PM_{10}). Two federal primary air quality standards are applicable for evaluating PM_{10} concentrations. These standards are 50 $\mu g/m^3$ for annual average, and 150 $\mu g/m^3$ for 24-hour averages. PM_{10} has been monitored at the CCP site since 1989. The maximum annual average is 6 $\mu g/m^3$ and the second maximum 24-hour concentration was 21 $\mu g/m^3$. These values were be used to represent onshore baseline concentration for PM_{10}.

6.3 METEOROLOGY

Hourly over land and estimated over water meteorological data were used in the air dispersion modeling using the OCD model. The over land meteorological data included stability class, wind speed, wind direction, air temperature, and mixing height. The over water data included mixing height, humidity, air temperature, and sea-surface temperature. Sensitivity tests have shown that OCD is not dependent on relative humidity.

Over Land Meteorological Data Set

The closest regional surface station to the Project site is the PBU Pad A site which is located 75 miles west of the Project site. Surface data has been collected at PBU since October 1986. The twice daily estimates of mixing height were obtained from the National Climatic Data Center (NCDC) for October 1986 through September 1987 using surface temperatures and upper air soundings from the Barter Island, Alaska weather station (located 120 miles east of PBU and 45 miles east of the modeling domain).

Figures 6-2 and 6-3 present 12-month wind roses and Table 6-3 summarizes the frequency distributions of Pasquill stability class for the last five years at Pad A. The first year time period (October 1986 to September 1987) was selected for use in the dispersion modeling because of the availability of concurrent mixing height data for this period. However, each of the time periods shows essentially the same wind and stability patterns, therefore, no significant differences in model concentration predictions would be expected between the five data sets.

The meteorological data measured at Pad A are representative of general North Slope meteorological conditions in the Project area due to the relatively isolated location of the monitoring site. The meteorological data also is representative of the Project area near Camden Bay because terrain is relatively flat and the coastlines are similarly oriented at both locations. Severe demarcation of terrain could create different localized flows. A sharp contrast in coastline orientation could also affect wind direction; however, the two coastlines are very similar, and thus predominant northeastern winds are representative of the Project area.

Because of the uniform, flat terrain of the North Slope of Alaska, and proximity to the project, the Pad A data set is representative of meteorological conditions at the Project site. A comparison of surface wind rose data for Barter Island, PBU, and the Kuparuk River Unit (KRU) would verify the similarity among these data sets. This demonstration will be submitted to EPA under separate cover.

Preparing the meteorological data for input into the dispersion models included accounting for missing data and estimating hourly values for stability categories and mixing heights. Missing values in the Pad A October 1986 to September 1987 data were treated in the following manner:

- Wind Speed and Direction - wind speed data were set to 1 meter per second and wind direction was assumed to persist from the previous hour.
- Temperature - data values were set from the previous hour.
- Mixing Height - data values were set from the previous hour.

Hourly stability categories were estimated from the hourly standard deviation of the horizontal wind direction fluctuation (sigma-theta).

The technique used to assign the Pasquill stability is based on the horizontal wind direction fluctuations (σ_θ), mean wind velocity, and day/night hour assignment following the procedures stated in the EPA reference document, "On-Site Meteorological Program Guidance for Regulatory Modeling Applications" (EPA 1987b). Tables 6-4 and 6-5 provide the assignment criteria for stability.

Due to the extreme northern latitude of the Project site, calculation of daily sunrise and sunset needed for the stability category estimates required special treatment. During the winter period from November 26 through January 27, sunrise and sunset were set to identical times (1 p.m.), which simulated a 24-hour nighttime period. Summer period sunrise/sunset times from May 25 through July 31 were set to identical times near 1 a.m., which simulated a 24-hour daylight period. This procedure resulted in estimates of only neutral and unstable atmospheric conditions during the all-daylight summer period and estimates of only neutral and stable conditions during the all-night winter period. During the other parts of the year, the sunrise/sunset data were computed from date, latitude, longitude, and time zone.

The Pad A data set has been approved for use by the Alaska Department of Conservation (ADEC), and accepted by EPA, Region X in numerous PSD applications. The meteorological data set monitored during the 1986 to 1987 period exceeded the 90 percent collection criteria set forth in the PSD guidelines. Missing data periods never extended beyond a consecutive six hour time frame.

Hourly values of the mixing height were determined following procedures developed for the EPA RAMMET preprocessor (Turner and Novak 1978). These methods utilize: (1) twice daily estimates of mixing height, (2) local standard time of sunrise and sunset, and (3) hourly estimates of stability. The twice-daily estimates of mixing height are based on the method of Holzworth (1972) and were obtained on diskette from the National Climatic Data Center (NCDC) using surface temperatures and upper air sounding from the Barter Island, Alaska weather station (located 120 miles east of PBU and 45 miles east of the modeling domain). In cases when mixing height data were absent from the database, the last non-missing mixing height value was used. The sunrise/sunset data were computed from date, latitude/longitude, and time zone.

The method by which hourly mixing heights are interpolated by RAMMET from the twice-daily values is as follows. The procedure uses values for the maximum mixing height (MAX) from the previous day (i-1), the computation day (i), and the following day (i+1). For rural sites between midnight and sunrise, the interpolation is between MAX_{i-1} at sunset and MAX_i at 1400 local standard time (LST). During the hours between sunrise and 1400 LST, if stability was classified as neutral in the hour before sunrise, the earlier interpolation between MAX_{i-1} and MAX_i is continued; if the hour before sunrise was classified as stable, the interpolation is between zero and MAX_i. For the period 1400 LST to sunset, the value for MAX_i is used. During sunset to midnight, the interpolation is between MAX_i at sunset and MAX_{i+1} at 1400 LST the following day. However, the interpolation scheme is slightly modified during the summer and winter periods described earlier. For such days, hourly mixing heights were estimated by constant interpolation from MAX_{i-1} to MAX_i. This interpolation occurred from 1 p.m. to 1 p.m. during the winter period and from 1 a.m. to 1 a.m. during the summer period.

Over Water Meteorological Data Set

There are few boundary layer data sets for the Beaufort Sea, primarily due to highly variable and adverse weather conditions. Kozo (1982) reports that sea breeze formation typically results in strong inversions over the water in summertime. The sea breeze's initial driving mechanism depends on a horizontal pressure gradient force and is in response to a surface horizontal temperature contrast. The arctic breeze initially faces a strong ground-based inversion which implies extreme stability and small eddy thermal diffusivity. This factor limits the vertical extent of the circulation since the depth of landward flow is often seen to be less than 400 meters. In contrast, extreme instabilities are observed over arctic areas in winter where cold air in contact with an ice surface suddenly finds itself over relatively warm open water (Andreas et al. 1979).

Given the lack of a good over-water data set, the modeling used the following parameters:

- $T_{air} - T_{sea} = +2.0$ degrees C. The area is relatively shallow in terms of ocean depth. In addition, the diurnal range of delta T is found to decrease with increasing latitude (Arya 1988).

- Over water mixing height set to 100 meters.

- Over water horizontal turbulence intensity set to observed worst case = 0.045, as per model guidance.

  JOPT(8) = 1

- Over water vertical turbulence intensity parameterized by OCD.

  JOPT(9) = 0

- Over water vertical potential temperature gradient = 0.04 degrees C/m. This represents a very stable atmospheric profile, as would occur when a warm air mass is advected over a cold water surface.

- Relative humidity = 90 percent (%).

- Over land wind speeds were adjusted by the model to represent over-water wind speeds.

TABLE 6-1

SUMMARY OF AMBIENT AIR QUALITY STANDARDS AND PSD INCREMENTS FOR CRITERIA POLLUTANTS

(micrograms per cubic meter, $\mu g/m^3$)

Pollutant[1]	Averaging Period	Federal Standards[2]		PSD Increments		Significant Impact Level
		Primary	Secondary	Class I	Class II	
Particulate Matter (PM_{10})	Annual	50	NA	NA	NA	1
	24-Hour	150	NA	NA	NA	5
Total Suspended Particulates (TSP)	Annual	NA	NA	5	19	1
	24-Hour	NA	NA	10	37	5
Sulfur Dioxide (SO_2)	Annual	80		2	20	1
	24-Hour	365		5	91	5
	3-Hour	1,300	NA	25	512	25
Carbon Monoxide (CO)	8-Hour	10,000	10,000	NA	NA	500
	1-Hour	40,000	40,000	NA	NA	2,000
Nitrogen Dioxide (NO_2)	Annual	100	NA	2.5	25	1
Lead (Pb)	3-Month	1.5	NA	NA	NA	NA
Ozone (O_3)	1-Hour	235	NA	NA	NA	NA

[1] Gaseous concentrations are corrected to a reference temperature of 25°C and to a reference pressure of 760 millimeters of mercury.

[2] All maximum values are not to be exceeded more than once per year and ozone standard is not to be exceeded during more than one day per year.

NA Not applicable

Source: U.S. Congress (1977, 1988)

TABLE 6-2

HISTORICAL AIR QUALITY MEASUREMENTS TAKEN AT THE PRUDHOE BAY UNIT ($\mu g/m^3$)

Site	Time Period	NO_2 (Annual)	O_3 (1-Hour)	SO_2			TSP[3]		PM_{10}	
				(3-hr)	(24-hr)	(Annual)[2]	(24-hr)	(Annual)	(24-hr)	(Annual)
CCP	10/86 - 9/87	16	92	21	16	8	80	8	--	--
	10/87 - 9/88	19	94	34	21	8	66	7	--	--
	1/89 - 12/89	13	106	16	13	8	54	6	24	6
	1/90 - 12/90	17	98	13	10	5	61	10	16	5
	1/91 - 12/91	19	92	13	8	3	62	6	21	5
Pad A	10/86 - 9/87	8	170	--	--	--	--	--	--	--
	10/87 - 9/88	8	247[1]	--	--	--	--	--	--	--
	1/89 - 12/89	9	120	--	--	--	--	--	--	--
	1/90 - 12/90	9	106	--	--	--	--	--	--	--
	1/91 - 12/91	10	147	--	--	--	--	--	--	--
NAAQS		100	235	1,300	365	80	150	60	150	50

[1] Isolated 2-hour event associated with near field temporary emissions.
[2] At or below instrument detection level.
[3] Total Suspended Particulate.

TABLE 6-3

FREQUENCY DISTRIBUTIONS OF STABILITY CLASS MEASUREMENTS AT PRUDHOE BAY PAD A

Category	Frequency (%)				
	1987[1]	1988[2]	1989	1990	1991
A - Extremely Unstable	3.7	6.4	6.0	3.1	3.4
B - Unstable	2.5	3.7	4.2	2.6	2.9
C - Slightly Unstable	6.2	8.4	8.8	8.1	8.2
D - Neutral	49.8	64.0	63.6	64.9	66.6
E - Slightly Stable	28.3	10.4	10.4	14.0	14.2
F - Stable	9.6	7.2	7.0	7.3	4.3

[1] October 1986 through September 1987

[2] October 1987 through September 1988

TABLE 6-4

PASQUILL STABILITY CATEGORIES VERSUS HORIZONTAL WIND DIRECTION FLUCTUATIONS, σ_θ

Stability Category	Range of Standard Deviation Degrees[1]
A (Extremely Unstable)	$\sigma_\theta \geq 22.5$
B (Unstable)	$22.5 > \sigma_\theta \geq 17.5$
C (Slightly Unstable)	$17.5 > \sigma_\theta \geq 12.5$
D (Neutral)	$12.5 > \sigma_\theta \geq 7.5$
E (Slightly Stable)	$7.5 > \sigma_\theta \geq 3.8$
F (Stable)	$3.8 > \sigma_\theta$

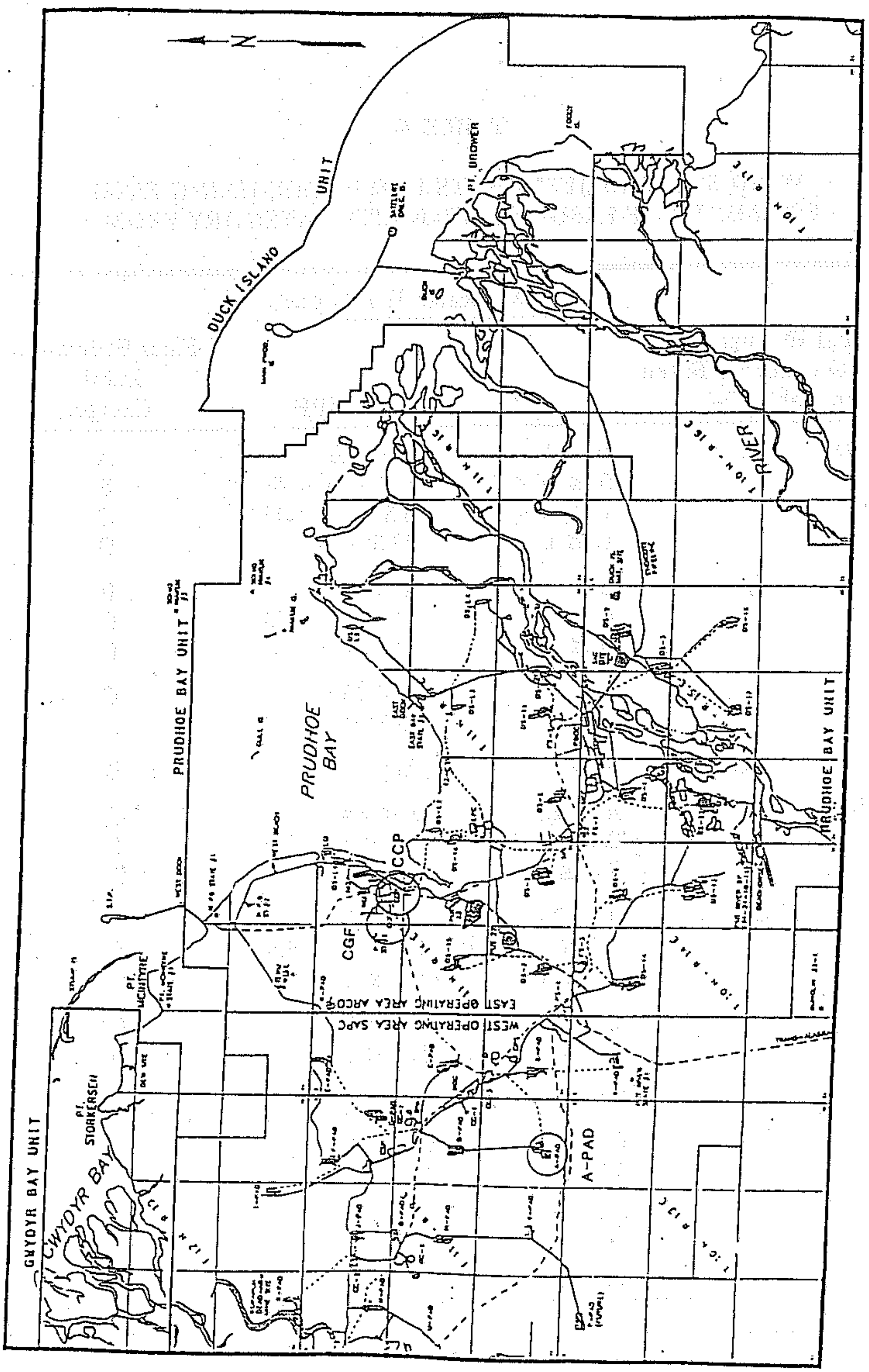
[1] The table values σ_θ should be adjusted for surface roughness by multiplying each of the values in the table by $(z_o/15\ \text{cm})^{0.2}$ where z_o is the average surface roughness length within a 3 km radius of the source. The surface roughness length was assumed to be 15 cm for purposes of the analysis.

TABLE 6-5

WIND SPEED ADJUSTMENTS FOR DETERMINING FINAL ESTIMATES OF PASQUILL STABILITY CATEGORY FROM σ_θ

Initial Estimate of Stability Category Based on Table G-1		10m Scalar Wind Speed (u)		Final Estimate of Stability Category
		M/S	MPH	
Daytime	A	$u < 3$	$u < 6.6$	A
		$3 \leq u < 4$	$6.6 \leq u < 8.8$	B
		$4 \leq u < 6$	$8.8 \leq u < 13.3$	C
		$6 \leq u$	$13.3 \leq u$	D
	B	$u < 4$	$u < 8.8$	B
		$4 \leq u < 6$	$8.8 \leq u < 13.3$	C
		$6 \leq u$	$13.3 \leq u$	D
	C	$u < 6$	$u < 13.3$	C
		$6 \leq u$	$13.3 \leq u$	D
	D,E, or F	Any	Any	D
Nighttime	A	$u < 2.9$	$u < 6.4$	F
		$2.9 \leq\ <3.6$	$6.4 \leq u < 7.9$	E
		$3.6 \leq u$	$7.9 \leq u$	D
	B	$u < 2.4$	$u < 5.3$	F
		$2.4 \leq u < 3.0$	$5.3 \leq u < 6.6$	E
		$3.0 \leq u$	$6.6 \leq u$	D
	C	$u < 2.4$	$u < 5.3$	E
		$2.4 \leq u$	$5.3 \leq u$	D
	D	Any	Any	D
	E	$u < 5.0$	$u < 10.5$	E
		$5.0 \leq u$	$10.5 \leq u$	D
	F	$u < 3.0$	$u < 6.6$	F
		$3.0 \leq u < 5.0$	$6.6 \leq u < 10.5$	E
		$5.0 \leq u$	$10.5 \leq u$	D

Source: EPA 1987



Job No. : 23086E

Prepared by : W.R.P.

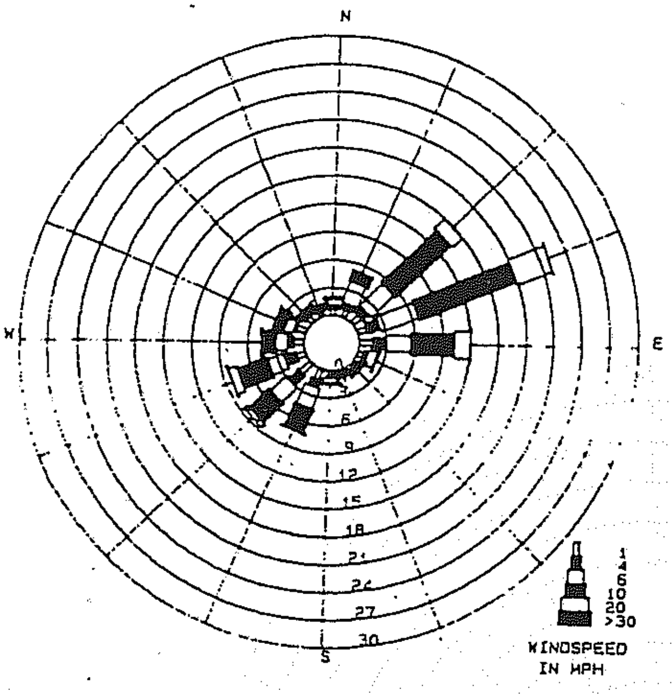
Date : 1/27/93

PRUDHOE BAY UNIT AIR QUALITY MONITORING STATION LOCATIONS

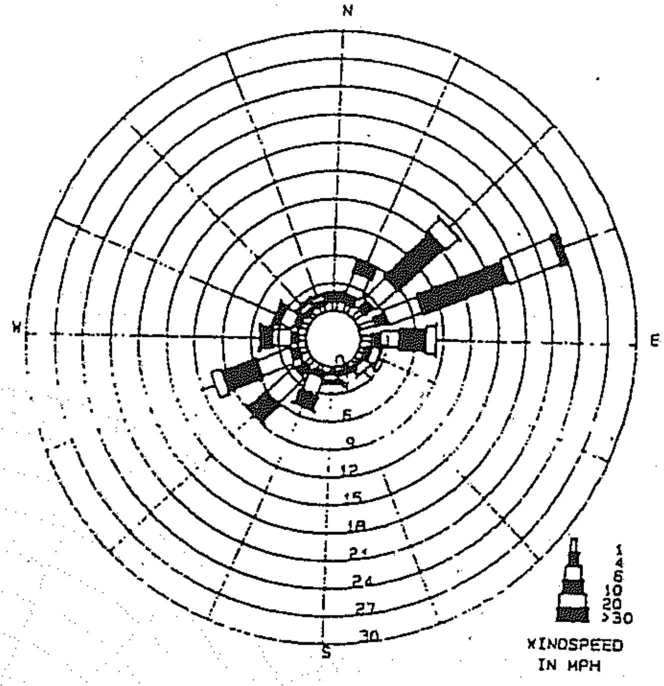
150271

Woodward-Clyde Consultants

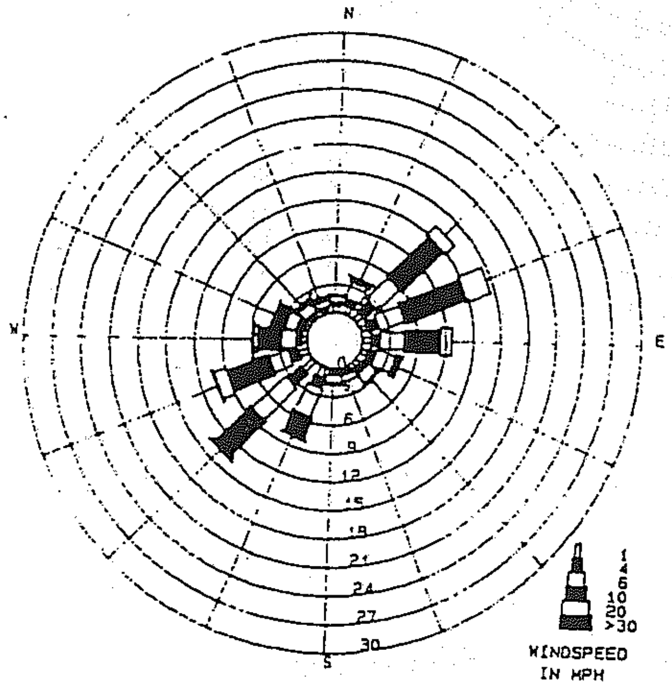
ANNUAL WINDROSE
PRUDHOE BAY, ALASKA - PAD A
OCTOBER 1986 - SEPTEMBER 1987



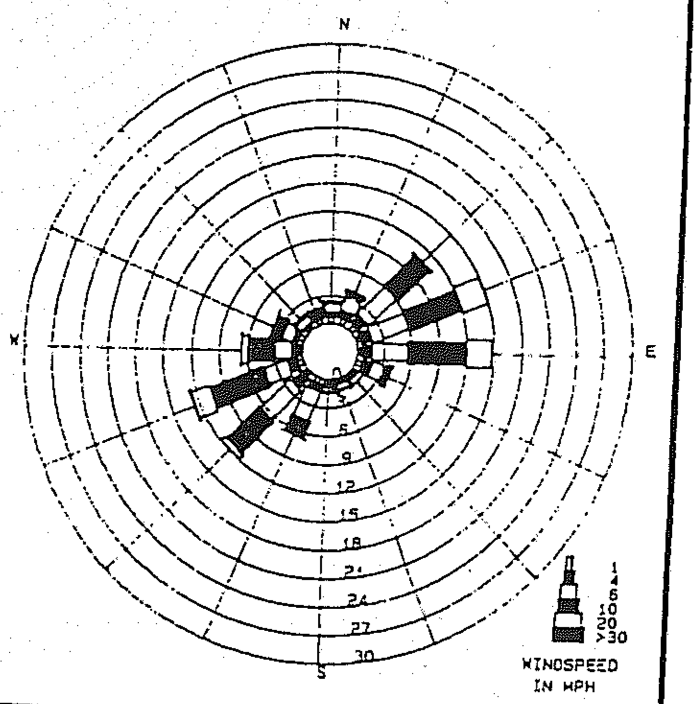
ANNUAL WINDROSE
PRUDHOE BAY, ALASKA - PAD A
OCTOBER 1987 - SEPTEMBER 1988



ANNUAL WINDROSE
PRUDHOE BAY, ALASKA - PAD A
JANUARY 1989 - DECEMBER 1989

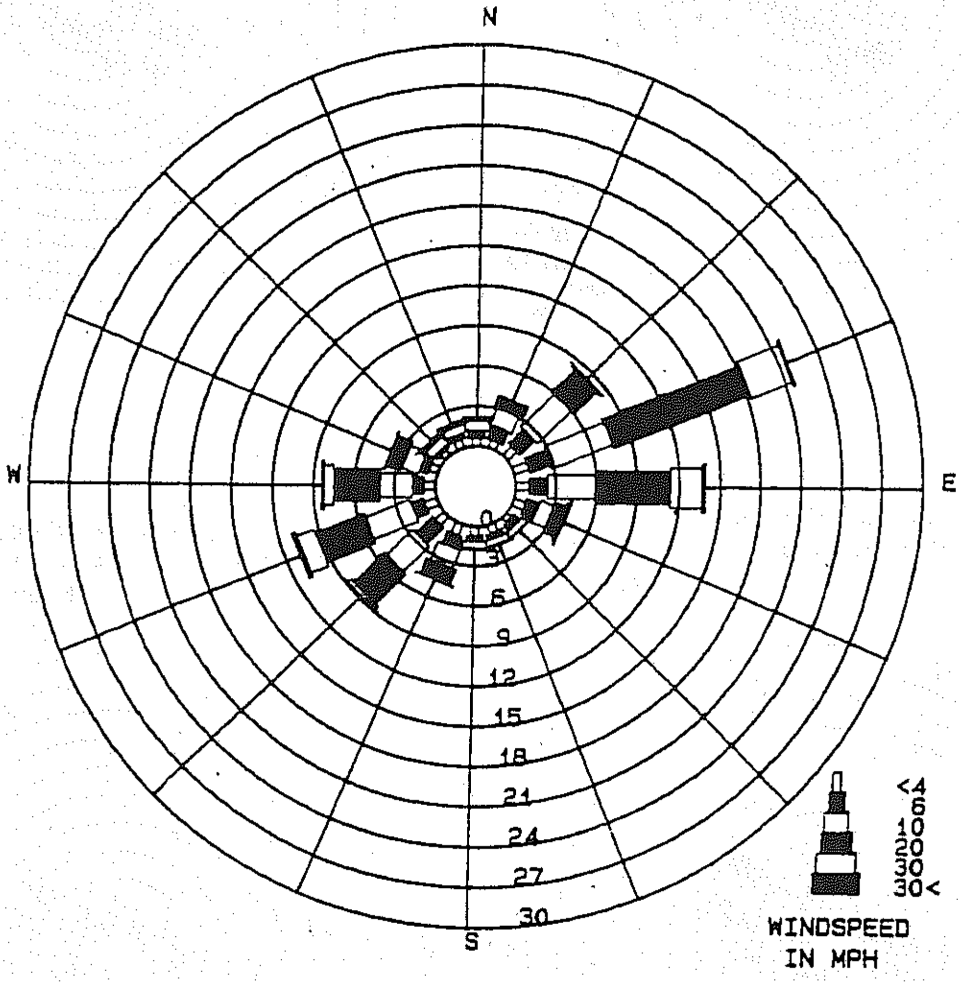


ANNUAL WINDROSE
PRUDHOE BAY, ALASKA - PAD A
JANUARY 1990 - DECEMBER 1990



Job No. : 23086E
Prepared by : W.R.P.
Date : 1/27/93

PRUDHOE BAY WINDROSES AT
THE PAD A MONITORING STATION



Job No.: 23086E	PRUDHOE BAY WINDROSE AT PAD A MONITORING STATION 1991
Prepared by: WRP	
Date: 1/27/93	

Figure 6-3

7.1 MODEL SELECTION

Moisture evaporating from the ocean plays an important role in the overlying boundary layer. Most of the radiative energy input to the water surface goes into evaporation rather than increasing the temperature of the water. What little energy is absorbed gives rise to much smaller variations in temperature than over-land because of the relatively high specific heat of water. The sea surface temperature has a small diurnal range, and over most water surfaces, most of the stability of the boundary layer is due to vertical moisture fluxes rather than sensible heat fluxes. In the absence of advection, the oceanic boundary layer would change little over diurnal time scales (Arya 1988).

Most of the dynamic activity in this boundary layer is driven by the temperature and moisture differentials between the water and the air masses advected over it. Because the properties of these air masses have little to do with local radiation inputs and cloudiness, the Pasquill-Gifford (PG) classification is inappropriate to characterize dispersion over water. Over land, by contrast, diurnal radiative forces play a major role in most instances. This is why the PG system, based on radiation and wind speed, is applied to land masses. As a comparison, the oceanic boundary layer is typically slightly stable during the day, and slightly unstable at night, both occurring in the absence of strong advection. This is the opposite of land-based boundary layers.

Sea ice presents an interesting problem, in that the flux of moisture into the overlying boundary layer ceases. The sea-ice surface then takes on the characteristics of a land mass in terms of modifying the overlying boundary layer. Thus, the interface between the oceanic and land-based boundary layers is effectively removed, and can be assumed to be represented by a land-type boundary layer.

The models described below have been used to assess impacts to general air quality in the modeling domain and increment consumption from the drilling vessels/units, support vessels, ice breakers, and all increment-consuming sources within 50 kilometers of the significance isopleth. The significance impact area is based on the maximum extent of all the significance isopleths.

Based on the unique characteristics of the locale, two different types of drilling vessels/units may be used for exploration operations. One type, commonly referred to as a floating vessel, can only operate during open water and/or broken ice seasons. For modeling the offshore activities during these seasons, the OCD Version 4.1 model was used.

The other type of drilling vessel/unit that may be used during the project is called a bottom-founded unit. This type of drilling unit can operate for a maximum of 365 days per year.

As OCD requires both over water and over land meteorological data sets, and the model is particularly sensitive to the air and sea temperature difference (delta T). During the winter months, pack ice will limit the availability of delta T data in the region. In addition, during the winter months, and most likely for a good part of the year, shoreline fumigation will not occur. Therefore, the Industrial Source Complex Short Term Version 2 (ISC2) was used for both the short-term and long-term averages from the bottom-founded unit during the non-open water/broken ice season (approximately mid-November through mid-July). The OCD model was used to assess short-term and long-term (120 day) averages only during the open water/broken ice season. Any unique over-water boundary layer dynamics will be suppressed by sea ice. The land/water interface during the late fall, winter, spring, and early summer months is completely removed, thus OCD is not the appropriate model to use during these periods. The annualized concentration is weighted and averaged from both models.

Both models were used to assess which of the six cases provided the maximum air quality impact concentrations. The maximum impact case was used to determine the maximum Class II increment consumption and compliance with ambient air quality standards.

7.2 GENERAL DESCRIPTION OF OCD

The OCD model is an hourly, steady-state Gaussian model built on the framework of the U.S. EPA-approved MPTER model (EPA 1980), with appropriate modifications to accommodate the dispersion regime and source characteristics of over water pollutant releases. The model consists of three major components: the over water subroutines which are new algorithms based on over water boundary layer dynamics, the over land subroutines borrowed from the MPTER model to describe dispersion over flat to rolling terrain, and the subroutines borrowed from existing models to describe dispersion in complex terrain. OCD will accept point, line, or area source information as input. OCD also has the ability to model tilted stacks, building plume downwash, shoreline fumigation, and complex terrain.

Differences in mixing depth and stability between the over water and over land boundary layers are important to dispersion processes. The over water mixing depth is relatively shallow due to the lack of strong sensible heat flux from the surface. LeMone (1978) shows that the average mixing depth is about 500 m over low-latitude oceans. In over half of the hours from the tracer studies used to test and develop the OCD model, the mixing depth was observed to be 100 m or less. These limited mixing depths can cause trapping of plumes near the surface.

The other major difference between the over water and over land boundary layers is in the diurnal and annual variation of stability, which is completely unrelated to typical over land behavior. The stability of the marine boundary layer is primarily determined by the amount of sensible and latent heat released to the atmosphere from the water surface. As the sea surface temperature has a small diurnal range, stability in the marine boundary layer is due to vertical moisture fluxes (latent heat) rather than sensible heat fluxes. As a comparison, the oceanic boundary layer is typically slightly stable during the day, and slightly unstable at night, both occurring in the absence of strong advection. This is the opposite of land-based boundary layers.

To develop the initial version of the OCD model (Hanna 1984), the MPTER model was modified to include over water boundary layer dynamics, land-sea mapping required by the differing over land and over water dynamics, and the inclusion of complex terrain subroutines. The modifications are summarized in Table 7-1 and are more fully described in the User's Guide to the OCD Model (MMS 1989) or in Hanna et al. (1985). These two references also explain and document the theoretical and physical bases for the initial OCD model including the assumptions regarding the over-water boundary layer, and provide an extensive discussion of the performance evaluation for the original model.

Since its regulatory approval, Version 3 of the OCD model has been used by the Department of the Interior (DOI), by local agencies, and by the oil and gas industry to determine onshore impacts from OCS activities. Most of the emissions from these facilities are from point sources, such as exhaust vents and stacks for power generation equipment. Estimations of source emission and stack parameters are readily available for the model's input run stream. The offshore meteorological data requirements used in the model can be difficult to acquire, especially when offshore data are sparse. The model has been applied using actual offshore sea surface and air temperature data, along with wind data taken from buoys maintained jointly by the DOI and the National Oceanic and Atmospheric Administration (NOAA), or using worst-case screening assumptions.

The OCD model has been modified based on comments from agency and private users of the model. The focus of these modifications has been streamlining the model code; expansion of the capabilities of the model to assess line, area, and intermittent sources; and incorporation of recent field and theoretical work into the relevant algorithms of the model. Also among the modifications incorporated were the restructuring of the algorithm to more realistically represent the impact of the plume on shoreline terrain and a standardization of the size of the grid cells used in the shoreline mapping routine. Many of the modifications are based on the work of Hanna and DiCristofaro (1988) and are summarized in Table 7-1 along with a comparison of OCD (Version 3) and MPTER.

7.3 GENERAL DESCRIPTION OF ISC2

The Industrial Source Complex Short Term version (ISC2) is a steady-state, multiple-source, Gaussian dispersion model designed for use with stack emission sources situated in terrain where ground-level elevations do not exceed the stack heights of the emission sources. ISC2 also treats complex phenomena such as building-induced plume downwash and the gravitational settling and deposition of particulate matter.

The ISC2 Model is recommended by EPA for use in the applications described here. ISC2 was selected due in part to the flat terrain at the project site. ISC2 is one of several models which are recommended by EPA for such evaluations. ISC2 was preferred for this application because it incorporates algorithms for the simulation of aerodynamic downwash induced by buildings. At the bottom-founded platforms, these effects are of critical importance because many of the emission points are below Good Engineering Practice (GEP) stack height.

ISC2 uses horizontal and vertical dispersion parameters as described in Pasquill (1961) and Gifford (1960). Plume rise is calculated using the methods of Briggs (1969, 1971, 1975). Required meteorological input data include sequential hourly values of wind direction, wind speed, temperature, stability class, and mixing height. The values of wind speed are adjusted to stack height by standard wind shear profile equations and exponents. For this study, the rural exponents given in Table 7-2 were employed. For cases where the effective plume height is below the mixing height, ISC2 assumes the plume is reflected at the mixing height. When the effective stack height (i.e., stack height plus plume rise) is above the mixing height, then the entire plume is assumed to be isolated above the mixing height with no ground-level impact. However, mixing height is not considered in model calculations during stable dispersion conditions.

Technical options selected for the ISC2 modeling are listed in Table 7-3. Use of these options follows EPA (1986, 1987) modeling guidance and/or sound scientific practice. An explanation of these options and the rationale for their selection is provided below. Note that certain selected options are overridden by the model when the building downwash option is selected.

The ISC2 modeling did not employ the gradual plume rise option, which accounts for downwind transport of the plume during the rising phase according to the procedures outlined by Briggs (1972). Gradual plume rise is recommended by EPA (1986, 1987) only when there is significant terrain close to the stacks. Buoyancy-induced dispersion, which accounts for the buoyant growth of a plume, caused by entrainment of ambient air, was included in the modeling because of the relatively warm exit temperature and subsequent buoyant nature of the exhaust plumes. Stack-tip downwash, which adjusts the effective stack height downward following the methods of Briggs (1973) for cases where the stack exit velocity is less than 1.5 times the wind speed at stack top, was also selected as per EPA guidance.

The calm processing option allows the user to direct the program to exclude hours with persistent calm winds in the calculation of concentrations for each averaging period. This option is generally recommended by the EPA (1986, 1987a) for regulatory applications. The ISC2 model recognizes a calm wind condition as a wind speed of 1 meter per second and a wind direction equal to that of the previous hour. The meteorological preprocessor program automatically makes this assignment to calm hours. In addition, any missing hours in the data were assigned as calm. The calm processing option in ISC2 then excluded these hours from the calculation of concentrations.

Past versions of the ISC (ISCST) model used a simplified downwash method to account for the effects of the aerodynamic wakes and eddies produced by plant buildings and structures. The adjustments for plume dispersion were made according to the suggestions of Huber and Snyder (1976) (the Huber-Snyder method). The ISCST model applied either full building wake effect influence or none, creating a physical discontinuity between the zones. The model also used only one set of building dimensions which described the expected downwash condition for the overall site. Thus, the model was constrained due to the limited data and research available.

The ISC2 model has since been modified to include a refined building downwash treatment that uses a method based upon the suggestions of Schulman and Hanna (1986) and Scire and Schulman (1980) (the Schulman-Scire method). If selected, and if the source height is less than or equal to the building height plus one-half the lesser of the building height or maximum projected width, the model performs the Schulman-Scire refined treatment for downwash. Use of the Schulman-Scire algorithm implies use of the following model options: gradual plume rise, no stack tip downwash, and no buoyancy induced dispersion (BID). Otherwise, the Huber-Snyder method is used, as in earlier versions of ISCST. Application of the Huber-Snyder algorithm implies incorporation of gradual plume rise, stack dip downwash, and BID. An exception occurs when the effective plume height from momentum plume rise at two building dimensions downwind is greater than GEP height (the building height plus 1.5 times the lesser of the building height or width). In this case, the building downwash algorithm is not applied when the Huber-Snyder method is selected.

Additional important changes in the Schulman-Scire scheme for building downwash include the application of a linear decay factor as a function of the effective plume height which enhances the vertical dispersion coefficient, σ_z, and modification of the plume rise due to the initial dilution of the plume with ambient air (Scire and Schulman 1980).

When applied, the Schulman-Scire downwash method requires the use of wind-direction specific building dimensions. This allows a more accurate approximation of building effects. The direction-specific dimensions are input for every ten degree sector, and are calculated as the maximum projected cross-sectional width of the overall building for that directional orientation.

7.4 DISPERSION MODELING METHODOLOGY

This section discusses the use of air dispersion modeling to assess the air quality impacts from the Project. The Project is characterized and modeled by six possible cases as discussed in Section 2.0 which will consist of one or two exploratory drilling vessels/units, and up to seven support vessels for each drilling vessel/unit. CO, SO_2, PM, and NO_x emissions from the project have been modeled. The objective of this analysis is to assess project compliance with applicable standards and increments.

Modeling methodologies followed those outlined by the EPA guidance documents for air quality modeling, PSD source review, and in a modeling protocol sent to EPA Region X (WCC, 1992). PSD regulations require that emissions from the facility not cause or contribute to the violation of NAAQS or the PSD increments. The increment limits ground-level concentration increases that are allowed over existing "baseline" concentrations in the area. Available increments are location-specific and, therefore, vary throughout the area where a source is proposed to be located. At any given location, the available increment depends on the amount consumed by sources. Thus, multiple sources can reside in the same general area as long as the increment concentrations at every location are below the increment level and the cumulative impacts do not violate the NAAQS. Significant impact levels, which are much less than increment limits for Class II areas, and state and federal NAAQSs are listed in Table 6-1.

Maximum predicted short-term (24 hours or less) and long-term (annual) impacts from the Project were added to modeled or monitored background concentrations from Prudhoe Bay, and used to represent cumulative pollutant concentrations. The predicted pollutant concentrations were then compared to the federal and state NAAQS to identify whether the proposed facility would comply. In addition to demonstrating compliance with the NAAQS, results of the dispersion modeling were used in computing the expected PSD increment consumption. Air quality impacts were evaluated both onshore and offshore. All air quality modeling methodologies were developed and discussed with EPA Region X.

7.5 RECEPTORS AND LAND-SEA INTERFACE

In order to simulate the transition between marine and land-based environments, the OCD model must be given detailed characterization of the shoreline. Since the Camden Bay shoreline is relatively straight, a rectangular grid was produced to represent the shoreline. This grid has a 1000 meter resolution in both the X and Y directions.

Receptors were placed in a rectangular grid extending 70 km in the east-west direction, and 40 km in the north-south direction, with a resolution of 1000 meters. Receptors included both over water and over land locations. All over water receptors were selected to reflect a three mile radius around each vessel/unit. The three mile radius around each vessel/unit, as discussed and approved by EPA Region X, is considered as "non-ambient" air. This was developed, due in part, to the unique and harsh environment in the Beaufort Sea and to operating stipulations in the MMS Exploration Plan approval.

All modeled sites within the modeling domain are at least 6 miles apart. Receptors were also placed such that there would always be receptors between each site in order to model any cumulative effects. The receptor grids were extended as needed to ensure the entire significance area is included. The maximum extent of the significance isopleth (annual, 24-hour, etc.) was used to represent the impact radius. The bottom founded unit annual impacts were modeled on the coarse grid using ISC2 for the solid ice period (mid-November through mid-July) and OCD for the remaining open water/broken ice season. These identical receptor grids for both models were integrated and the annual concentrations were produced. Short term concentrations were analyzed from both models, with the maximum concentration from either model used to represent the averaging period. A refined receptor grid with 100 meter resolution was placed around the maximum impacts, out 500 meters in all directions.

7.6 SOURCE DATA

All emissions were modeled as a series of point sources. The drilling vessels/units have a variety of point source types (diesel engines, incinerators, small boilers, flares). Since the stack parameters varied, procedures to combine these sources were used, based on the EPA's *Screening Procedures for Estimating the Air Quality Impacts of Stationary Sources* (EPA, 1988). For each combined group of point sources, the total emission rate from each source was summed and used as input into the model. Thus, for a drilling vessel/unit, all pollutants were assumed to exhaust from one centrally located stack, except the flare. Appendix C provides documentation of calculations using the SCREEN model for exit velocity and flame length parameters of the flare emission source. Downwash was included for drilling vessels/units.

Support vessel activity was also modeled as a series of point sources. Ice management vessels used in the vicinity of the drilling vessels/unit are designed to prevent harm to the vessel/unit from ice flow. Several of these vessels are categorized by the U.S. Coast Guard and Canadian Coast Guard as ice-breakers. Two configurations were used to determine worst case concentrations. Short-term averaging periods were modelled by placing support vessels between the drilling vessels/units and the closest shoreline. It is assumed that ice-breakers patrol a 30 degree arc at 5, 2.5, 1, and 0.5 nautical miles from the drilling vessel/unit. Annual averages were modeled by placing the support vessels approximately 0.5 km around drilling vessels/units because it is impossible to predetermine where the ice management will be needed.

Each ice management vessel was modeled as one point source, located at the center of each respective arc. Supply vessels were modeled at the same location as the drilling vessel/unit.

7.7 AIR QUALITY IMPACTS

Several model simulations were made in evaluating the impacts from the Project. Six cases were analyzed to determine the potential annual and short-term impact(s). These cases are described Section 2.1. Based on total potential emissions, two floating drilling vessels would cause the maximum impacts for both the short-term and long-term averaging periods. Case II, IV, and V address two floating drilling vessels at specified distances from shore.

In order to calculate the maximum onshore and offshore impacts, several cases were modeled by positioning the emission sources in "worst-case" configurations. These worst case configurations always involved a six mile modeling separation between the two floating

drilling vessels, since future deviated drilling capabilities and annual reservoir analysis would generally preclude the possibility that exploratory wells would be simultaneously drilled closer than six miles to each other.

Cases I, II, III, and VI were not considered further. Case I with only one floating drilling vessel, clearly showed the lowest emissions, and was not a worst case situation. Case II was not modeled for maximum offshore impacts because alignment of the two sources is not possible along the prevailing northeast wind. Case II was also not modeled for maximum onshore impacts, because the sources in Case V are closer to shore. Both Cases III and VI include one floating drilling vessel and one bottom-founded drilling unit. Neither of these cases were modeled since their total emissions were lower than Cases IV and V, and therefore are not worst case situations.

Onshore Impacts

Case V was examined in closer detail to describe worst case onshore impacts, because in this case, the two floating drilling vessels would be 6 miles from shore, the closest location to shore desired for the Project. For short-term averaging periods, the ice management vessels for this case were placed at locations directly toward shore. The remaining support vessels were modeled by placing them at the same location as the drilling vessels. As described in Section 7.6, annual averages were modeled by placing the ice management vessels approximately 0.5 km around the drilling vessels. The remaining support vessels were modeled by placing them at the same location as the drilling vessels.

Onshore impacts for NO_2 are described in Section 9.0, Air Quality Related Values.

Offshore Impacts

Case IV was studied to determine worst case offshore impacts since this case incorporates one floating drilling vessel 6 miles from shore and a second floating drilling vessel 12 miles from shore. This case allows alignment of the sources along the axis of the prevailing northeast wind. The worst case offshore impact results form the cumulative contribution of the upwind source to the source downwind. For short-term averaging periods the ice management vessels for this case were placed at locations downwind of each vessel, along the axis of the prevailing wind. The remaining support vessels were modeled by placing them at the same locations as the drilling vessels. As described in Section 7.6, annual averages were modeled by placing the ice management vessels approximately 0.5 km around the drilling vessels. The remaining support vessels were modeled by placing them at the same locations as the drilling vessels.

The projected offshore maximum concentrations for short- and long-term averaging times used to determine the impacts are provided in Table 7-4. The maximum concentration is defined as the highest predicted concentration at any receptor point evaluated by the model. The maximum concentrations determined for offshore receptors are also the maximum for the Project. The offshore impacts exceed the onshore impacts.

The location of the maximum annual concentrations is midway between the two floating drilling vessels in the west-southwest direction (240 degrees). The maximum 24-hour SO_2 and PM concentrations are located at the same point as the annual NO_2 maximum impact.

The locations for the 1-hour, 3-hour, and 8-hour pollutant impacts are located 3 miles from the downwind drilling vessel, toward the southwest (230 degrees).

7.8 COMPARISON OF IMPACTS WITH BASELINE AIR QUALITY LEVELS AND APPLICABLE STANDARDS

The primary pollutants assessed in the following analysis include PM, SO_2, NO_x, and CO. Table 7-4 contains the maximum predicted ground level concentrations for the criteria pollutants and the relation of these pollutants to existing background concentrations and current standards. As shown on Table 7-4 all combined impacts are less than the applicable standards. As discussed in the previous section estimated impacts for all averaging times occur 3 miles from the drilling vessels.

When the Project impacts are added to the modeled and monitored ambient concentrations, all maximum total concentrations for the criteria pollutants are predicted to remain below federal standards. Background ambient concentrations of NO_2 and SO_2 were modeled. Background ambient concentrations of PM were assumed to be the same as measurement at CCP. The total annual PM_{10} concentration is 5.88 $\mu g/m^3$, 12 percent of the NAAQS. The

PM_{10} 24-hour total concentration increases slightly to 26 percent of the standard. The annual SO_2 concentration predicted from the Project would add less than 1 $\mu g/m^3$ to the background value of 0.03 ug/m^3, and thus the total SO_2 concentration would be 1 percent of the federal standard. The SO_2 24-hour total concentration would slightly increase to 8 percent of the standard. The total 3-hour SO_2 concentration would be 5 percent of the NAAQS. The project 8-hour CO impact is 83.93 $\mu g/m^3$. The Project 1-hour CO impact is 130.48 $\mu g/m^3$. The Project increases the NO_2 annual value by 22.96 ug/m^3 to 25 percent of the standard.

7.9 COMPARISON OF IMPACTS WITH INCREMENTS

The impact of the Project on PSD increment consumption is addressed in the following section.

7.9.1 Significant Impact Area Analysis

A significant impact area analysis for the increment pollutants with PSD increments. Since the onshore impact area is designated Class II, only the area within the significant impact region need be analyzed to determine increment consumption. If a Class I area was affected, a more thorough analysis would be required. The analysis was confined to sources contributing significantly to the impact area, because the nearest Class I area is approximately 450 miles distant and across the Brooks Range. Any impact upon this Class I area from the Project would not be significant.

Figure 7-1 shows the significant impact area for the annual NO_2 impacts. The annual NO_2 isopleth represents the maximum radius of significant impact. Figure 7-2 shows the extent of the coarse receptor grid.

7.9.2 Comparison With Increments

A comparison of the estimated Project impacts with PSD increments is summarized in Table 7-5.

The contribution from the increment-consuming North Slope sources to the significant impact area has been added to the contribution from the Project for applicable pollutants.

The maximum increment consumption is associated with the annual NO_2 impact (which also has the largest impact area). The annual NO_2 consumption is 92 percent of the increment. The contribution from the Project on the SO_2 increments is shown in Table 7-5, and is 5, 31, and 11 percent of the annual 24-hour and 3-hour increment, respectively.

In general, the Project will result in modest increases in ambient concentrations and will not significantly jeopardize the attainment status of any criteria pollutant. It is also demonstrated that the operation of the Project will not violate PSD increment consumption.

TABLE 7-1

SUMMARY OF DIFFERENCES BETWEEN MPTER, OCD/3, AND OCD/4 MODELS

Component	MPTER	OCD/3	OCD/4
Platform Downwash	Not Considered	BLP or ISC/API Formulas	Petersen (1986) Wind Tunnel Results, with Modifications
TIBL	Not Considered	Hanna (1987) Linear Growth	Hanna (1987) Linear Growth
Fumigation	Not Considered	Deardorff-Willis (1982) Convective Scaling	Turner (1969) Virtual Source
σ_y	Standard EPA	Observed i_y, Briggs f_y	Observed σ_θ, Draxler f_y
σ_z	Standard EPA	Observed i_z	Parameterized i_z
Critical Streamline	Not Considered	Not Considered	RTDM approach
Plume Reflection	Standard EPA	RTDM (ERT, 1982) complex method	Simple TUPOS (Turner et al., 1986) formula
Line and Area Sources	Not Considered	Not Considered	Virtual Source Approach

Definitions:

Definitions:	TIBL:	Thermal Internal Boundary Layer
	i_y, i_z:	Lateral and vertical turbulence intensities
	f_y	Dimensionless function applied to σ_y
	σ_θ	Standard deviation of wind direction fluctuations (in radians)

TABLE 7-2

WIND PROFILE EXPONENTS USED WITH ISC

Stability	Exponent
A - Extremely Unstable	0.07
B - Unstable	0.07
C - Slightly Unstable	0.10
D - Neutral	0.15
E - Slightly Stable	0.35
F - Stable	0.55

TABLE 7-3

TECHNICAL OPTIONS FOR ISC2

Option	ISC
Gradual Plum Rise	No
Stack-Tip Downwash	Yes
Buoyancy-Induced Dispersion	Yes
Building Wake Effects	Yes
Actual Receptor Elevations	No
Concentrations During Calm Wind Conditions Set to Zero	Yes

TABLE 7-4

MAXIMUM PREDICTED CONCENTRATIONS FOR CRITERIA POLLUTANTS FOR THE BEAUFORT SEA EXPLORATION PROJECT

($\mu g/m^3$)

Criteria Pollutant	Interval	NAAQS Standard	Predicted Impact	Ambient Concentration	Total Concentration
PM_{10}	Annual	50	0.88	5[a]	5.88
	24-Hour	150	18.08	21	39.08
SO_2	Annual	80	0.92	0.03[b]	0.95
	24-Hour	365	28.26	0.9	29.16
	3-Hour	1300	57.25	2.74	59.99
CO	8-Hour	10000	83.93	NA[c]	
	1-Hour	40000	130.48	NA	
NO_2	Annual	100	22.96	1.72[b]	24.68

[a] Monitored data from Prudhoe Bay.

[b] Modeled background at ANWR using ISC2.

[c] Modeled concentration below significance levels for CO.

TABLE 7-5

COMPARISON OF PREDICTED POLLUTANT CONCENTRATIONS WITH INCREMENTS FOR THE ARCO ALASKA, INC. BEAUFORT SEA EXPLORATION PROJECT

($\mu g/m^3$)

Pollutant	Averaging Period	PSD Class II Increment	Concentration from PSD Sources	Location (km)	
TSP	Annual	19	0.88		
	24-Hour	37	18.08	549.7	7783.3
SO_2	Annual	20	0.92	549.2	7789.3
	24-Hour	91	28.26	557.0	7795.0
	3-Hour	512	57.25	557.0	7795.0
NO_2	Annual	25	22.96	558.0	7794.1

FIGURE 7.1

ANNUAL NO2 SIGNIFICANCE ISOPLETH

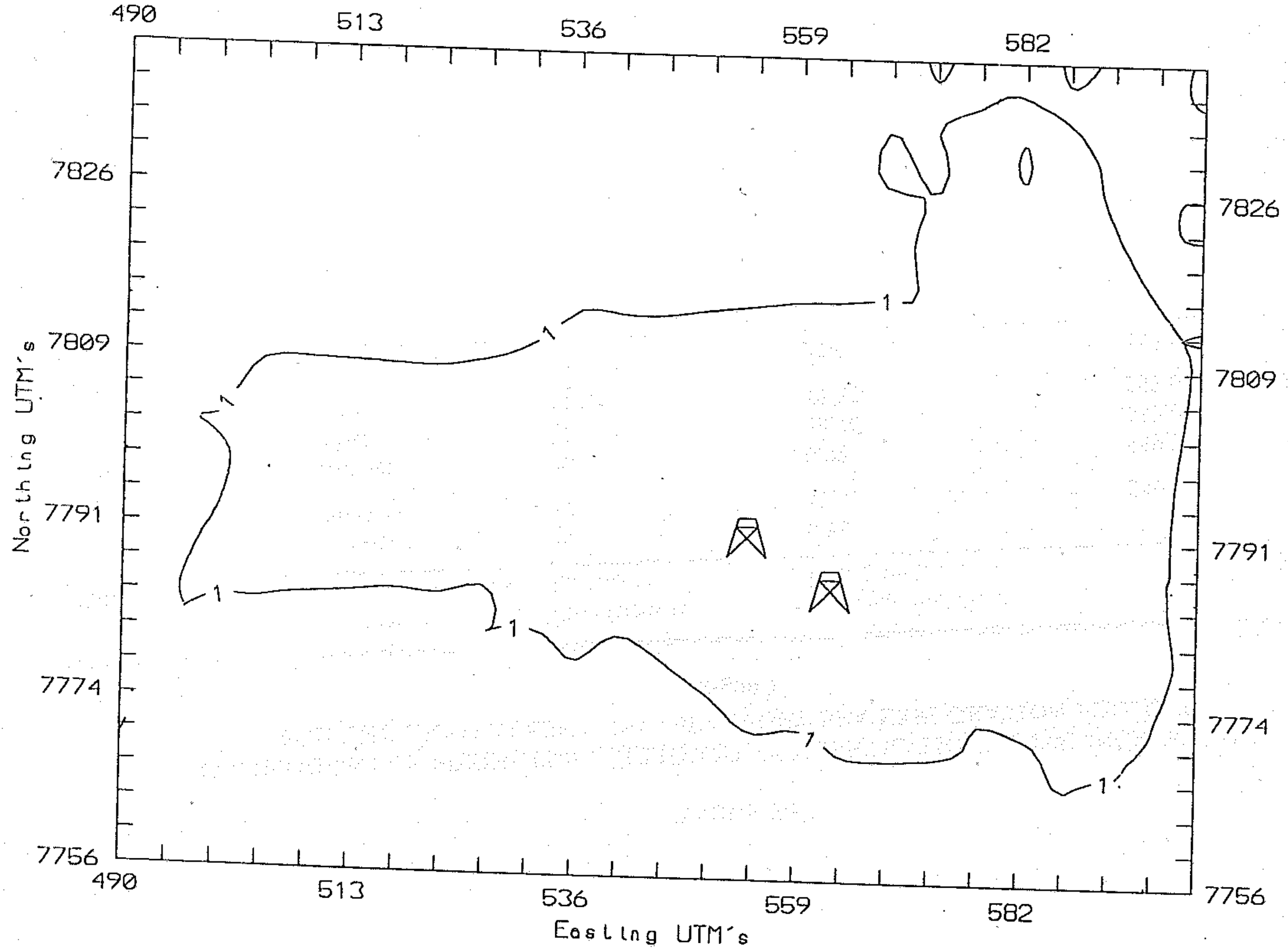
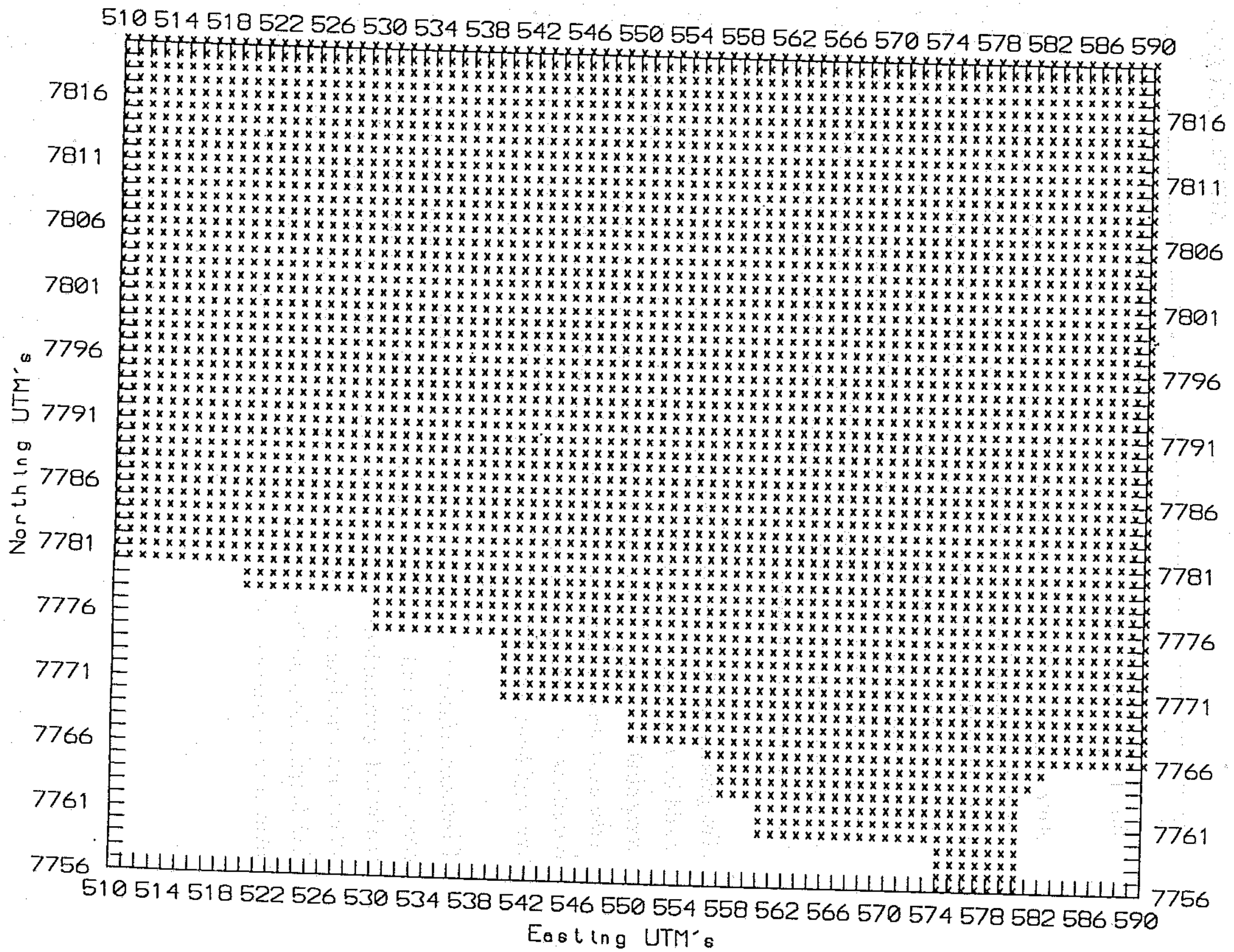


FIGURE 7.2

COARSE GRID RECEPTORS



8.0
AIR TOXICS EVALUATION

8.1 INTRODUCTION

An evaluation of toxic air pollutants (TAPs) from the Project was performed to determine whether potential impacts from TAP emissions would be significant. The procedures used in this evaluation follow those required by the State of Washington's Department of Ecology (WADOE) for new sources, as outlined in their regulation "Controls For New Sources of Toxic Air Pollutants" (Chapter 173-460 Washington Administrative Code). These regulations have been designed to be health protective and apply to compounds that have been identified, or are suspected to be either carcinogenic to humans, or are known to produce non-carcinogenic health effects.

The general WADOE procedure for evaluation of toxics requires identification of TAPs that could be emitted from the source, estimation of project TAPs, estimation of ambient TAP concentrations, and comparison of these concentrations to exposure standards. WADOE calls these exposure standards Acceptable Source Impact Levels (ASILs). If the estimated TAP concentration is less than the ASIL, no additional analyses are needed and the source impacts are considered acceptable.

To estimate ambient TAP concentrations from the Project, air quality dispersion modeling was used. Toxic air pollutant concentrations were estimated at Kaktovik, the nearest (45 miles) residential community to the Project. The air toxic analysis detailed below relied on conservative methods that overpredict actual air toxic impacts. Results predict that potential TAP impacts from the Project will be insignificant. All TAP concentrations are significantly below their respective ASILs.

8.2 IDENTIFICATION AND ESTIMATION OF TAPs

Potential emissions of TAPs from the Project will be primarily from operation of the drilling vessel/unit engines and support vessels. Small amounts of TAPs are generated by engines and other equipment when running on diesel fuel. These emissions include gaseous organic compounds, trace elements, and polycyclic aromatic hydrocarbons (PAHs). The trace elements and PAHs are associated with the particulate matter in the exhaust stream, while the organic compounds would be part of the volatile organic compound (VOC) emissions.

Table 8-1 provides a list of organic compounds, trace elements, and PAHs that have been identified as being emitted from large diesel-fired engines, along with their emission factors from AP-42 (USEPA 1992). Only some of the listed chemicals in diesel engine exhaust are considered to be TAPs by WADOE. These TAPs are identified in Table 8-1.

The emission factors in Table 8-1 are expressed as pounds of chemical emitted per million Btu of heat input (lb/MMBtu) from diesel fuel. These data are based on results of emission source tests of diesel engines. Using these emission factors and the emission factors reported in the source tests for PM_{10} and total organic compounds, the weight fraction of each TAP of either the PM_{10} or total organic compound emissions were computed. Following WADOE procedure, the weight fractions represent that portion of the total emissions of either PM_{10} or organics that the TAP constitutes. The weight fractions for organic TAPs were computed using the source test emission factor for total organics (assuming that VOC are equal to total organics), while the weight fractions of the trace elements and PAHs were computed using the source test PM_{10} emission factor.

Using the TAP weight fraction information, TAP emissions can be computed by multiplying the weight fraction by either the VOC or PM_{10} emission rate, as appropriate. Emission rates of VOCs and PM_{10} for the various Project sources are discussed in Section 3.0. For this TAP analysis, all VOC and PM_{10} emissions from project sources, except the flares, were assumed to be due to diesel fuel combustion, with the TAP speciation profile the same as for large diesel engines.

Toxic air pollutants are not expected to be emitted from the flares associated with the drilling vessels/units. These flares will be burning natural gas, and based on organic speciation information for flare exhaust gases provided in AP-42 (Section 11.3, Table 11.3-3), none of the organics are considered to be TAPs.

8.3 TAP DISPERSION MODELING

Air quality dispersion modeling was performed to evaluate potential impacts from TAP emissions from the Project. Potential TAP concentrations were computed at Kaktovik, the nearest residential community to the Project.

To maximize potential TAP concentrations at Kaktovik, it was assumed that exploration operations would be situated within the modeling domain at a location closest to Kaktovik. From this location the drilling vessels/units would be about 35 miles from Kaktovik. Air dispersion modeling was performed assuming that all Project emission sources were at this single location. Table 8-2 contains the UTM coordinates used in the modeling for the TAP emission sources and Kaktovik.

Two source configuration cases (combination of drilling vessels/units and support vessels) were evaluated as part of the TAP modeling. The first case assumed that two floating drilling vessels with associated support vessels were operating, while the second case assumed that one floating vessel and one bottom-founded drilling unit each with associated support vessels were operating. For both cases, the emissions from the drilling and support vessels were modeled assuming they were emitted from a single source, the drilling vessel. These two cases provide worst-case TAP emission scenarios when compared to the locations for the six cases being considered as part of this permit application. By placing two vessels/units at this location, the maximum TAP concentrations in Kaktovik are overestimated since one vessel/unit would be operating at a greater distance from Kaktovik.

The ISC2 dispersion model was used for all modeling of TAP emissions. In modeling both cases it was assumed that all emission sources would be operating continuously for the entire year for the modeling activity. The maximum short-term emission rates used for modeling are described in Section 3. Using maximum short-term emission rates is an overestimate since some equipment will be operating at less than maximum capacity and/or for fewer than 365 days per year. This assumption particularly overestimates the emissions for the floating vessel since it will be only operating for 120 days of the year. Maximum short-term PM_{10}

and VOC emission rates were used in modeling to obtain maximum 24-hour and annual average concentrations in Kaktovik. Results of the ISC2 modeling are provided in Appendix F.

8.4 EVALUATION OF TOXIC IMPACTS

The concentration of each TAP was computed by multiplying the TAP weight fraction by the modeled maximum PM_{10} and VOC concentrations at Kaktovik. The TAP concentrations are compared to the ASIL to evaluate risk.

For most of the carcinogenic TAPs, the ASILs are based on an annual average concentration, however several are based on a 24-hour average. All non-carcinogen TAPs are based on a 24-hour average concentration. Table 8-3 shows the predicted maximum TAP concentrations for the two floating vessels, along with the ASIL concentration for each of the evaluated TAPs. Table 8-4 contains the same information for the bottom-founded unit and one floating vessel.

All predicted TAP concentrations are well below their respective ASILs. Consequently, the Project will not pose a significant human health risk from TAPs.

TABLE 8-1

ORGANIC COMPOUND, TRACE ELEMENT, AND PAH COMPOUNDS PRESENT IN EXHAUST FROM DIESEL-FIRED ENGINES

Organic Compounds

	Emission Factor (lb/MMBtu)	VOC Weight Fraction (%)	WA DOE Toxic Air Pollutant (Y/n)
Benzene	7.76E-04	3.3021	Y
Toluene	2.81E-04	1.1957	Y
Xylenes	1.93E-04	0.8213	Y
Propylene	2.79E-03	11.8723	Y
Formaldehyde	7.89E-05	0.3357	Y
Acetaldehyde	2.52E-05	0.1072	Y
Acrolein	7.88E-06	0.0335	Y

Trace Elements

	Emission Factor (lb/MMBtu)	PM-10 Weight Fraction (%)	WA DOE Toxic Air Pollutant (Y/n)
Aluminum	1.24E-03	2.5000	Y
Antimony	3.13E-07	0.0006	Y
Arsenic	1.73E-07	0.0003	Y
Barium	1.56E-06	0.0031	Y
Beryllium	1.73E-08	0.0000	Y
Bismuth	1.73E-08	0.0000	Y
Boron	1.94E-05	0.0391	Y
Bromine	8.09E-06	0.0163	Y
Cadmuim	3.29E-06	0.0066	Y
Calcium	1.24E-03	2.5000	Y
Cerium	1.73E-07	0.0003	n
Cesium	1.56E-05	0.0315	Y
Chlorine	4.69E-06	0.0095	Y
Chromium (III)	4.64E-07	0.0009	Y
(VI)**	4.64E-09	0.0000	Y
Cobalt	4.64E-07	0.0009	Y
Copper	1.46E-04	0.2944	Y
Fluorine	8.09E-06	0.0163	Y
Gallium	7.55E-07	0.0015	n
Germanium	1.73E-07	0.0003	Y
Iodine	3.45E-08	0.0001	Y
Iron	4.69E-04	0.9456	n

Trace Elements

	Emission Factor (lb/MMBtu)	PM-10 Weight Fraction (%)	WA DOE Toxic Air Pollutant (Y/n)
Lanthanum	4.64E-07	0.0009	n
Lead	1.62E-06	0.0033	Y
Lithium	1.40E-07	0.0003	n

TABLE 8-1

ORGANIC COMPOUND, TRACE ELEMENT, AND PAH COMPOUNDS PRESENT IN EXHAUST FROM DIESEL-FIRED ENGINES

Magnesium	5.01E-05	0.1010	Y
Manganese	1.24E-05	0.0250	Y
Mercury	1.56E-04	0.3145	Y
Molybenum	1.62E-06	0.0033	Y
Neodyium	4.64E-07	0.0009	n
Nickel	2.64E-05	0.0532	Y
Niobium	1.56E-07	0.0003	n
Phosphorus	1.40E-03	2.8226	Y
Potassium	2.53E-03	5.1008	n
Rubidium	1.40E-06	0.0028	n
Samarium	1.73E-08	0.0000	n
Scandium	1.56E-05	0.0315	n
Selenium	4.64E-05	0.0935	Y
Silicon	6.47E-04	1.3044	n
Silver	2.00E-05	0.0403	Y
Sodium	1.46E-03	2.9435	n
Strontium	3.13E-06	0.0063	n
Tellurium	8.63E-08	0.0002	Y
Tin	1.08E-05	0.0218	Y
Titanium	4.80E-05	0.0968	n
Vanadium	1.56E-07	0.0003	Y
Yttrium	1.56E-07	0.0003	Y
Zinc	1.51E-04	0.3044	Y
Zirconium	1.94E-06	0.0039	Y

TABLE 8-1

ORGANIC COMPOUND, TRACE ELEMENT, AND PAH COMPOUNDS PRESENT IN EXHAUST FROM DIESEL-FIRED ENGINES

Polycyclic Aromatic Hydrocarbons (PAH)	Emission Factor (lb/MMBtu)	PM-10 Weight Fraction (%)	WA DOE Toxic Air Pollutant (Y/n)
Naphthalene	1.30E-04	0.2621	Y
Acenaphthylene	9.23E-06	0.0186	n
Acenaphthene	4.68E-06	0.0094	n
Fluorene	1.28E-05	0.0258	n
Phenanthrene	4.08E-05	0.0823	n
Anthracene	1.23E-06	0.0025	n
Fluoranthene	4.03E-06	0.0081	n
Pyrene	3.71E-06	0.0075	n
Benz(a)anthracene	6.22E-07	0.0013	Y
Chrysene	1.53E-06	0.0031	Y
Benzo(b)fluoranthene	1.11E-06	0.0022	Y
Benzo(k)fluoranthene	2.18E-07	0.0004	Y
Benzo(a)pyrene	2.57E-07	0.0005	Y
Indeno(1,2,3-cd)pyrene	4.14E-07	0.0008	Y
Dibenzo(a,h)anthracene	3.46E-07	0.0007	Y
Benzo(g,h)perylene	5.56E-07	0.0011	n
Total PAH	2.12E-04		

Source: Emission Factor Documentation for AP-42 Section 3.4,
Large Stationary Diesel & All Stationary Dual Fuel Engines

** Emissions of Chromium(VI) assumed to be 0.01 * Chromium(III) [ATSDR/USEPA 1987

TABLE 8-2

UTM COORDINATES FOR SOURCE AND RECEPTOR LOCATIONS USED IN AIR TOXICS MODELING

	UTM Coordinates		
	Easting (km)	Northing (km)	UTM Zone
Drilling Vessels & Support Vessels	572.000	7795.000	6
Kaktovik	400.000	7784.000	7
	627.366	7785.349	6[a]

[a] UTM coordinates were converted to same zone (6) as the drilling vessels and support vessels.

TABLE 8-3

MAXIMUM MODELED TOXIC AIR POLLUTANT CONCENTRATIONS IN KAKTOVIK AND COMPARISON WITH ACCEPTABLE SOURCE IMPACT LEVELS - TWO FLOATING DRILLING VESSELS IN OPERATION

Organic Compounds	VOC Weight Fraction (%)	WA DOE TAP (Y/N)	TAP Type	WA DOE ASIL (µg/m3)	Toxic Impacts (µg/m3)	Exceedance (Y/N)
Benzene	3.3021	Y	A	0.12	0.00218	N
Toluene	1.1957	Y	B	1248.8	0.01711	N
Xylenes	0.8213	Y	B	1448.6	0.01175	N
Propylene	11.8723	Y	B	1165.5	0.16985	N
Formaldehyde	0.3357	Y	A	0.077	0.00022	N
Acetaldehyde	0.1072	Y	A	0.45	0.00007	N
Acrolein	0.0335	Y	B	0.8	0.00048	N

Trace Elements		PM-10 Weight Fraction (%)	WA DOE TAP (Y/N)	TAP Type	WA DOE ASIL (µg/m3)	Toxic Impacts (µg/m3)	Exceedance (Y/N)
Aluminum		2.5000	Y	B	33.3	0.02462	N
Antimony		0.0006	Y	B	1.7	0.00001	N
Arsenic		0.0003	Y	A	0.00023	0.00000	N
Barium		0.0031	Y	B	1.7	0.00003	N
Beryllium		0.0000	Y	A	0.00042	0.00000	N
Bismuth		0.0000	Y	B	33.3	0.00000	N
Boron		0.0391	Y	B	3.3	0.00039	N
Bromine		0.0163	Y	B	2.3	0.00016	N
Cadmuim		0.0066	Y	A	0.00056	0.00000	N
Calcium		2.5000	Y	B	6.7	0.02462	N
Cesium		0.0315	Y	B	6.7	0.00031	N
Chlorine		0.0095	Y	B	10.0	0.00009	N
Chromium	(III)	0.0009	Y	B	1.7	0.00001	N
	(VI)**	0.000009	Y	A	0.000083	0.00000	N
Cobalt		0.0009	Y	B	0.2	0.00001	N
Copper		0.2944	Y	B	3.3	0.00290	N
Fluorine		0.0163	Y	B	6.7	0.00016	N
Germanium		0.0003	Y	B	2.0	0.00000	N
Iodine		0.0001	Y	B	3.3	0.00000	N
Lead		0.0033	Y	B	0.2	0.00003	N
Magnesium		0.1010	Y	B	33.3	0.00099	N
Manganese		0.0250	Y	B	16.7	0.00025	N
Mercury		0.3145	Y	B	0.3	0.00310	N
Molybenum		0.0033	Y	B	16.7	0.00003	N

TABLE 8-3

MAXIMUM MODELED TOXIC AIR POLLUTANT CONCENTRATIONS IN KAKTOVIK AND COMPARISON WITH ACCEPTABLE SOURCE IMPACT LEVELS - TWO FLOATING DRILLING VESSELS IN OPERATION

Nickel	0.0532	Y	C	3.3	0.00052	N
Phosphorus	2.8226	Y	B	0.3	0.02779	N
Selenium	0.0935	Y	B	0.7	0.00092	N
Silver	0.0403	Y	B	0.3	0.00040	N
Tellurium	0.0002	Y	B	0.3	0.00000	N
Tin	0.0218	Y	B	6.7	0.00021	N
Vanadium	0.0003	Y	B	0.2	0.00000	N
Yttrium	0.0003	Y	B	3.3	0.00000	N
Zinc	0.3044	Y	B	16.7	0.00300	N
Zirconium	0.0039	Y	B	16.7	0.00004	N

Polycyclic Aromatic Hydrocarbons (PAH)

	PM-10 Weight Fraction (%)	WA DOE TAP (Y/N)	TAP Type	WA DOE ASIL (µg/m3)	Toxic Impacts (µg/m3)	Exceedance (Y/N)
Naphthalene	0.2621	Y	B	166.5	0.0025808	N
Benz(a)anthracene	0.0013	Y	A	a	0.0000006	-
Chrysene	0.0031	Y	A	a	0.0000014	-
Benzo(b)fluoranthene	0.0022	Y	A	a	0.0000010	-
Benzo(k)fluoranthene	0.0004	Y	A	a	0.0000002	-
Benzo(a)pyrene	0.0005	Y	A	a	0.0000002	-
Indeno(1,2,3-cd)pyrene	0.0008	Y	A	a	0.0000004	-
Dibenzo(a,h)anthracene	0.0007	Y	A	a	0.0000003	-
Total Class A PAHs, as B(a)P				0.0006	0.0000041	N

NOTES:

** Emissions of Chromium(VI) assumed to be 0.01 * Chromium(III) [ATSDR/USEPA 1987]

Type A	carcinogen, annual average
Type B	non carcinogen, 24-hour average
Type C	carcinogen, 24-hour average

a: These compounds are considered PAHs, and have a combined ASIL of 0.0006

TABLE 8-4

MAXIMUM MODELED TOXIC AIR POLLUTANT CONCENTRATIONS IN KAKTOVIK AND COMPARISON WITH ACCEPTABLE SOURCE IMPACT LEVELS - ONE FLOATING VESSEL AND ONE BOTTOM-FOUNDED DRILLING UNIT IN OPERATION

Organic Compounds

	VOC Weight Fraction (%)	WA DOE TAP (Y/N)	TAP Type	WA DOE ASIL (µg/m3)	Toxic Impacts (µg/m3)	Exceedance (Y/N)
Benzene	3.3021	Y	A	0.12	0.00178	N
Toluene	1.1957	Y	B	1248.8	0.01330	N
Xylenes	0.8213	Y	B	1448.6	0.00913	N
Propylene	11.8723	Y	B	1165.5	0.13203	N
Formaldehyde	0.3357	Y	A	0.077	0.00018	N
Acetaldehyde	0.1072	Y	A	0.45	0.00006	N
Acrolein	0.0335	Y	B	0.8	0.00037	N

Trace Elements

	PM-10 Weight Fraction (%)	WA DOE TAP (Y/N)	TAP Type	WA DOE ASIL (µg/m3)	Toxic Impacts (µg/m3)	Exceedance (Y/N)
Aluminum	2.5000	Y	B	33.3	0.01951	N
Antimony	0.0006	Y	B	1.7	0.00000	N
Arsenic	0.0003	Y	A	0.00023	0.00000	N
Barium	0.0031	Y	B	1.7	0.00002	N
Beryllium	0.0000	Y	A	0.00042	0.00000	N
Bismuth	0.0000	Y	B	33.3	0.00000	N
Boron	0.0391	Y	B	3.3	0.00031	N
Bromine	0.0163	Y	B	2.3	0.00013	N
Cadmuim	0.0066	Y	A	0.00056	0.00000	N
Calcium	2.5000	Y	B	6.7	0.01951	N
Cesium	0.0315	Y	B	6.7	0.00025	N
Chlorine	0.0095	Y	B	10.0	0.00007	N
Chromium (III)	0.0009	Y	B	1.7	0.00001	N
(VI)**	0.000009	Y	A	0.000083	0.00000	N
Cobalt	0.0009	Y	B	0.2	0.00001	N
Copper	0.2944	Y	B	3.3	0.00230	N
Fluorine	0.0163	Y	B	6.7	0.00013	N
Germanium	0.0003	Y	B	2.0	0.00000	N
Iodine	0.0001	Y	B	3.3	0.00000	N
Lead	0.0033	Y	B	0.2	0.00003	N
Magnesium	0.1010	Y	B	33.3	0.00079	N
Manganese	0.0250	Y	B	16.7	0.00020	N
Mercury	0.3145	Y	B	0.3	0.00245	N
Molybenum	0.0033	Y	B	16.7	0.00003	N

TABLE 8-4

MAXIMUM MODELED TOXIC AIR POLLUTANT CONCENTRATIONS IN KAKTOVIK AND COMPARISON WITH ACCEPTABLE SOURCE IMPACT LEVELS - ONE FLOATING VESSEL AND ONE BOTTOM-FOUNDED DRILLING UNIT IN OPERATION

Nickel	0.0532	Y	C	3.3	0.00042	N
Phosphorus	2.8226	Y	B	0.3	0.02203	N
Selenium	0.0935	Y	B	0.7	0.00073	N
Silver	0.0403	Y	B	0.3	0.00031	N
Tellurium	0.0002	Y	B	0.3	0.00000	N
Tin	0.0218	Y	B	6.7	0.00017	N
Vanadium	0.0003	Y	B	0.2	0.00000	N
Yttrium	0.0003	Y	B	3.3	0.00000	N
Zinc	0.3044	Y	B	16.7	0.00238	N
Zirconium	0.0039	Y	B	16.7	0.00003	N

Polycyclic Aromatic Hydrocarbons (PAH)

	PM-10 Weight Fraction (%)	WA DOE TAP (Y/N)	TAP Type	WA DOE ASIL (µg/m3)	Toxic Impacts (µg/m3)	Exceedance (Y/N)
Naphthalene	0.2621	Y	B	166.5	0.00205	N
Benz(a)anthracene	0.0013	Y	A	a	0.000000	-
Chrysene	0.0031	Y	A	a	0.000001	-
Benzo(b)fluoranthene	0.0022	Y	A	a	0.000001	-
Benzo(k)fluoranthene	0.0004	Y	A	a	0.000000	-
Benzo(a)pyrene	0.0005	Y	A	a	0.000000	-
Indeno(1,2,3-cd)pyrene	0.0008	Y	A	a	0.000000	-
Dibenzo(a,h)anthracene	0.0007	Y	A	a	0.000000	-
Total Class A PAHs, as B(a)P				0.0006	3.43E-06	N

NOTES:

** Emissions of Chromium(VI) assumed to be 0.01 * Chromium(III) [ATSDR/USEPA 1987]

Type A	carcinogen, annual average
Type B	non carcinogen, 24-hour average
Type C	carcinogen, 24-hour average

a: These compounds are considered PAHs, and have a combined ASIL of 0.0006

9.0
AIR QUALITY RELATED VALUES (AQRV)

This section addresses the potential effects on soils and vegetation in the Arctic National Wildlife Refuge (ANWR) from NO_x emitted from the Project. This pollutant was selected for evaluation since it is emitted in the largest quantity, as well as its ability to affect soils and vegetation. The Project will be located approximately twelve miles offshore (Brownlow Point) of ANWR. ANWR is a Class II Area located approximately 75 miles east of Prudhoe Bay on the North Slope of Alaska.

To assess potential effects from the Project on ANWR, this analysis provides background information on soils, vegetation, and air quality at ANWR, along with modeled NO_2 concentrations resulting from the Project and background emission sources. The analysis then compares modeled NO_2 concentrations to published threshold values for injury to soils and vegetation.

9.1 EXISTING ENVIRONMENT

The topography of the nineteen million acre ANWR includes flat coastal plains along the northern coast, and to the south rolling hills, foothills, and mountainous terrain covering over two-thirds of the Refuge. There are many creeks and ice-filled depressions in the rolling terrain. Circumpolar tundra ecosystems cover ANWR, which are cold, treeless, and underlain by up to 2,000 feet of permafrost. Permafrost is a condition of the earth's surface where the temperature is below freezing for two or more years. Only the top 2 to 3 feet thaws and freezes with the seasons.

9.1.1 Soils

Arctic tundra soils are generally poorly drained and poorly aerated due to the underlying permafrost. Soil is formed by mechanical break-up of parent material caused by the continual thawing and freezing. Parent material for coastal tundra soils is often derived from marine sediments. A major component of arctic tundra soils is undecayed organic matter since the cold temperatures inhibit decomposition.

The seasonal thawing and freezing of arctic soils causes the creation of polygonal shaped land forms on plains areas. The polygons are created as soils contract and expand during the freeze and thaw cycle. The cracks between the polygons are filled with wedge-shaped masses of ice. As the wedges expand, they compress the soil in the polygons causing elevation of either the center or the edges of the polygons. The polygon landforms create microtopography changes which influence the distribution of plant communities.

9.1.2 Vegetation

Several tundra vegetation and landform types occur within the region, including thaw lake plains, hilly coastal plains, foothills and flood plains. The following paragraphs contain written descriptions of the land forms and vegetation found at ANWR.

Polygonal patterned ground characterizes the thaw lake plains in ANWR, and creates shallow and drained lakes. Aquatic and wet tundra species that grow in the shallow and drained lake basins include pendant grass, aquatic sedges, cottongrass, and herbaceous plants and mosses.

Gently rolling hill topography and poorly developed polygons characterize the hilly coastal plains in ANWR. Typical vegetation species for the hilly coastal plains includes sedges, mosses, lichens, and prostrate shrubs. Tussuck tundra occurs in the relatively well-drained soils of the hilly plain. Examples of tussuck tundra vegetation species are cottongrass and several species of dwarf prostate shrubs, such as dwarf birch, Labrador tea, and several varieties of willows.

Hills separated by drainage channels characterize the foothills in ANWR. Tussocks and dwarf shrubs grow on the foothills, and dwarf shrub willow, birch and alders grow on the slopes.

Barren deltas, braided river channels, terraces, and alluvia deposits characterize the river flood plains in ANWR.

An arctic tundra species of concern is the fruticose lichen. Lichens are highly susceptible to atmospheric pollutants since the entire surface area of the lichen is able to intake nutrients that are dissolved in water. Lichens are also able to concentrate substances in excess of physiological needs. These two traits enable lichens to easily absorb and concentrate atmospheric pollutants, and therefore make lichens good indicators of air pollution (Olson 1982).

Lichens are a major source of wintertime food for caribou. Birds use lichen for nest building, camouflage, and feeding. Caribou consume three to five kilograms of lichens per day and lichens may exceed fifty percent of their winter diet (Richardson and Young 1977).

9.1.3 Air Quality

Ambient NO_2 levels are unknown for ANWR. The nearest ambient NO_2 measurements were taken at two monitoring stations, Pad A and CCP, located approximately seventy-five miles west of ANWR at Prudhoe Bay. Table 6-2 presents ambient air quality data at these stations from 1986 through 1991. The ambient annual NO_2 averages measured during 1991 was 19 $\mu g/m^3$ at CCP and 10 $\mu g/m^3$ at Pad A which are below the Federal annual NO_2 standard of 100 $\mu g/m^3$.

The measured data show much higher NO_2 concentrations at the CCP station compared to the PAD A station. The Pad A station is relatively isolated from major NO_x emission sources while the CCP station is intentionally located immediately downwind of various NO_x emission sources at Prudhoe Bay to characterize maximum impact location. The higher NO_2 concentrations at the CCP station reflect the influence of these emissions (ENSR 1991). Because the Pad A station is relatively isolated from emission sources it is probably more representative of air quality at ANWR than the CCP station. ANWR is by far more isolated from NO_x sources than the Pad A station; therefore, ambient NO_2 levels at ANWR can be expected to be lower than levels at the Pad A station. The Pad A monitoring data are used in this analysis since the data are more representative of ANWR than the CCP station.

9.2 ANALYSIS

To estimate potential effects at ANWR, air quality modeling was performed using ISC2 and OCD models. Estimated maximum NO_2 concentrations at ANWR from Project operations and from background sources were computed. These concentrations are given below.

The Project proposes several different operating cases. The case which would produce the greatest impact to ambient air quality at ANWR is operation of two floating drilling vessels/units within six miles of shoreline (Case V, described in Section 7.7). The models calculated the background NO_2 and the maximum NO_2 concentration increase at ANWR from Project operations.

The models calculated an annual background NO_2 concentration of 1.72 $\mu g/m^3$. The maximum modeled annual average NO_2 concentration increase in ANWR due to the Project is 12 $\mu g/m^3$. Therefore, the maximum annual average NO_2 concentration at ANWR, background plus Project emissions, would be 13.72 $\mu g/m^3$.

9.2.1 Impacts to Soils

This section provides background information on how NO_x affects soils, calculates the increase of nitrogen deposition attributed to the Project, and estimates potential impacts from Project emissions on soils of ANWR.

9.2.1.1 Mechanisms for NO_x Impacts to Soils

Nitrogen oxides may be transferred from the atmosphere to the soil by a variety of mechanisms, including chemical reaction, absorption (including plant uptake and assimilation), and wet and dry deposition. Of the different transfer mechanisms, research and literature focuses on nitrogen deposition.

Although research on nitrogen deposition effects on arctic tundra soils is limited, research has been conducted on soils in more temperate regions. Soil pH is usually dependent upon the parent material and its buffering capacity. The arctic tundra soils have a low buffering capacity since the permafrost condition does not allow acidified water to percolate past soil. Furthermore, both tundra peat and surface waters have very low buffer capacities.

9.2.1.2 Potential Effects on Soils

The current background nitrate wet deposition rate for ANWR is unknown. A method of estimating nitrogen deposition associated with a project is provided in the Forest Service

Handbook: Air Resource Management Handbook. Project and background deposition calculations are based on the predicted annual average NO_2 concentration from the Project of 12 $\mu g/m^3$ and 1.72 $\mu g/m^3$, respectively.

$$d = C \times Vd \times F \times R(86{,}400 \text{ sec./day})(365 \text{ day/yr.})(10^{-9} \text{ kg}/\mu\text{g})(10^4 \text{ m}^2/\text{ha})$$

d = is the dry deposition in kg./ha-yr.
C = concentration of NO_2 as appropriate in $\mu g/m^3$ for annual.
Vd = deposition velocity =.0045 m/s for NO_2(Taylor et al., 1987)
F = frequency of occurrence of the maximum concentration
= 1.0 for an annual average concentration
R = nitrogen ratio of element to total compound weight
= 14/46 = .3 for nitrogen from NO_2

The dry deposition rate is assumed to be approximately one-half of the total deposition rate, and thus, the number obtained from the equation is multiplied by two to provide an estimate of the total deposition rate.

Based on this analysis, the highest potential addition of nitrogen deposition due to the Project would be 10.22 kg N/ha-y. The total deposition, Project plus Denali National Park background would be 11.68 kg N/ha-y.

9.2.2 Effects on Vegetation

This section provides background information on how NO_x affects vegetation, threshold dosages of pollutants for vegetation, and potential effects from the Project on arctic tundra at ANWR.

9.2.2.1 Mechanisms for NO_2 Effects On Vegetation

The NO_x pollutant group includes six chemical species: nitric oxide (NO), nitrogen dioxide (NO_2), nitrous oxide (N_2O), nitrogen sesquioxide (N_2O_3), nitrogen tetroxide (N_2O_4), and nitrogen pentoxide (N_2O_5). Of these, only two are important as air pollutants: NO and NO_2. Plants absorb gaseous NO_2 more rapidly than NO (Bennett and Hill 1975), primarily because

NO_2 reacts rapidly with water and NO is nearly insoluble. Overall, NO is much less phytotoxic than NO_2 (Smith 1990).

Vegetation can be injured by contact with high ambient concentrations of NO_2 and by nitrogen deposition, or acid deposition. Following absorption of NO_2 through the leaf stomata (openings in the leaf epidermis through which gases are exchanged), the gas reacts with water on the moist surfaces of the mesophyll cells to form nitrous acid (HNO_2) or nitric acid (HNO_3). NO_2 injury to plants may occur either because of acidification or by conversion of NO_2 to nitrate (NO_3) or nitrite (NO_2) (Zeevaart 1976). NO_3 and NO_2 are toxic to plants; however, NO_2 is more toxic than NO_3 (Mudd 1973).

Research indicates NO_x and its products, NO_3 and NO_2, produce many biochemical and physiological effects in plants, including inhibition of amino acid and protein formation, fatty acid and lipid production, carbon fixation (photosynthesis), and increased respiration (Treshow 1984). The possible result is suppressed growth or tissue injury.

9.2.2.2 Threshold Dosages of Ambient Nitrogen Dioxide and Nitrogen Deposition

The threshold value for annual ambient NO_2 effects to vegetation (EPA 1980; ADEC 1990) are 94-188 $\mu g/m^3$ for intermediate plants. These threshold values represent the minimum ambient concentrations at which adverse growth effects or tissue injury in exposed vegetation have been reported. The predicted total annual NO_2 concentration is 13.72 $\mu g/m^3$. The predicted annual NO_2 concentration resulting from the Project is well below the threshold value for effects on vegetation.

The Boyce-Thompson Institute for Plant Research at Cornell University has conducted extensive research at the request of Prudhoe Bay Unit owners to evaluate the effects of ambient air quality on indigenous vegetation at Prudhoe Bay. This research was conducted using actual ambient concentrations of pollutants measured at stations at Prudhoe Bay and at a network of vegetation monitoring plots at Prudhoe Bay. In addition, controlled experiments were conducted on specimens of arctic willow in laboratories with simulated arctic conditions using representative ambient and elevated pollutant levels.

The multi-year research program began in 1989 and the Institute releases findings in annual reports. The results of field and laboratory studies completed in 1992 did not provide any indication that air quality at Prudhoe Bay had produced measurable deleterious impacts on tundra vegetation. Annual ambient NO_2 levels at Prudhoe Bay, 9 $\mu g/m^3$ (0.0050 ppm) at Pad A and 16 $\mu g/m^3$ (0.010 ppm) at CCP, were below the levels considered detrimental to arctic tundra. The treatment levels of NO_2 used in the laboratory studies were 564 $\mu g/m^3$ (0.3 ppm) for three hours daily for seven of nine consecutive days. The concentration and duration of NO_2 exposure in the laboratory exceed those believed to occur in the field, and therefore, represent an extreme acute level of actual pollutant exposure. Laboratory exposure to NO_2 was shown not to cause detriment to arctic willow.

Besides effects on vegetation from ambient air quality, effects can be caused by nitrogen deposition/or acid deposition. Results of Boyce-Thompson studies do not provide any indication that nitrogen deposition at Prudhoe Bay has caused injury to tundra vegetation.

9.2.2.3 Potential Effect to Vegetation at ANWR

The modeled annual ambient NO_2 concentrations of 13.72 $\mu g/m^3$ projected for ANWR due to Project operation and background is below the threshold known to cause negative effects to vegetation. Based on this information, emissions generated from Project operation would not cause inhibited growth or injury to vegetation at ANWR.

The modeled concentration of 13.72 $\mu g/m^3$ for Project operation and background is below the ambient level of 19 $\mu g/m^3$ recorded at Prudhoe Bay, which was found by Boyce-Thompson not to cause injury to vegetation. Based upon this information, emissions generated from Project operation would not cause inhibited growth or injury to vegetation at ANWR.

The modeled concentrations for Project operation are far lower than the extreme dosages (564 $\mu g/m^3$) used in the laboratory studies that were shown not to cause injury to arctic willow. Based upon this information, emissions generated from Project operation would not cause inhibited growth or injury to vegetation at ANWR.

Vegetation at Prudhoe Bay did not exhibit any signs of injury from nitrogen deposition during studies completed by the Boyce-Thompson Institute. Although the nitrogen deposition rate