Emissions, Meteorological Data, and Air Pollutant Monitoring for Alaska's North Slope

prepared for

Alaska Department of Environmental Conservation
Division of Air Quality
410 Willoughby Ave., Suite 303
Juneau, AK 99811-1800

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prepared by

MACTEC

MACTEC Engineering & Consulting
Research Triangle Park, NC

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ABBREVIATIONS / ACRONYMS

AAAQS..................................Alaska ambient air quality standards
ADEC....................................Alaska Department of Environmental Conservation
AFWA...................................Air Force Weather Agency
ANWR ....Arctic National Wildlife Refuge
APSC....................................Alyeska Pipeline Service Company
AQRV ....Air Quality Related Value
ASOS ....Automated Surface Observation System
BCON ....CMAQ Boundary Conditions Processor
BLM......................................U.S. Bureau of Land Management
BOEMRE...............................U.S. Bureau of Ocean Energy Management, Regulation and Enforcement
BPXA....................................BP Exploration (Alaska), Inc.
CAMx ....Comprehensive Air Quality Model with Extensions
CCTM ....CMAQ Chemical-Transport Model
CFD.......................................Computational Fluid Dynamics
CMAQ...................................Community Multiscale Air Quality
COARE.................................Coupled Ocean-Atmosphere Response Experiment
CPAI ....ConocoPhillips Alaska, Inc.
DOD......................................U.S. Department of Defense
DOI ....U.S. Department of the Interior
EPA.......................................U.S. Environmental Protection Agency
EU ....Emission Unit
FAA.......................................FAA
FWS ......................................U.S. Fish and Wildlife Service
FSL..Forecast Systems Laboratory
GHG......................................Greenhouse Gas
GMT......................................Greenwich Mean Time
ICON.....................................CMAQ Initial Conditions Processor
ISCST3..................................Industrial Source Complex Short Term
JPROC...................................CMAQ Photolysis Rate Processor
LULC ....Land Use/Land Cover

MCIP......................................CMAQ Meteorology-Chemistry Interface Processor
MOU ....Memorandum of Understanding
MM5 ....Penn State/NCAR Mesoscale Model
MMIF......................................Mesoscale Model Interface
MMS ....Minerals Management Service
NAAQS..................................National Ambient Air Quality Standards
NAM/Eta................................North American Mesoscale Model
NCAR ....National Center for Atmospheric Research
NCDC ....National Climatic Data Center
NCEP ....National Centers for Environmental Prediction
NDBC ....National Data Buoy Center
NEI..National Emission Inventory
NEPA ....National Environmental Policy Act
NOAA ....National Oceanic and Atmospheric Administration
NODC ....National Oceanographic Data Center
NPRA.....................................National Petroleum Reserve – Alaska
NPS ....U.S. National Park Service
NRC ....National Research Council
NRL..Naval Research Laboratory
NWS.......................................U.S. National Weather Service
OCD ....Offshore and Coastal Dispersion
OCS..Outer Continental Shelf
OPEI.......................................U.S. EPA Office of Policy, Economics, and Innovation
PiG ....Plume-in-Grid
PSD ....Prevention of Significant Deterioration
RFP ....Request for Proposals
RUC ....Rapid Update Cycle
TAPS......................................Trans-Alaska Pipeline System
TAR..Technical Analysis Report
USDA.....................................U.S. Department of Agriculture
USGS ....United States Geological Survey
WBAN ....Weather Bureau Army-Navy
WEA ....Western Energy Alliance
WMO ....World Meteorological Organization

WRF.......................................Weather Research and Forecasting

Units of Measure

°C ....degrees Celsius
°F...degrees Fahrenheit
km ....kilometer
km^2 ....square kilometers
m/s...meters per second
tpy ....tons per year
$\mu g/m^3$.....................................micrograms per cubic meter

Pollutants

CAPS.....................................Criteria Air Pollutants
CO ....Carbon Monoxide
H_2S ....Hydrogen Sulfide
HAPS ....Hazardous Air Pollutants
HNO_3.....................................Nitric Acid
NO...Nitric Oxide
NO_2 ....Nitrogen Dioxide
NO_3^-.......................................Nitrate
NO_X.......................................Oxides of Nitrogen
O_3 ....Ozone
PM-2.5 ....Particulate Matter (diameter less than 2.5 microns)
PM-10 ....Particulate Matter (diameter less than 10 microns)
SO_2 ....Sulfur Dioxide
$SO_4^=$.......................................Sulfate
VOC ....Volatile Organic Compound

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EXECUTIVE SUMMARY

The Alaska Department of Environmental Conservation (ADEC) received a grant from the U.S. Environmental Protection Agency (EPA) to prepare a report summarizing current air pollutant monitoring, emission, and meteorological data for Alaska's North Slope to provide an assessment of cumulative industrial impacts. This assessment includes:

- Identifying emission sources, including industrial point sources, area sources, mobile sources (onroad, nonroad, and marine), and natural sources (wildfires and biogenic/geogenic);
- Assessing the quality of existing data;
- Determining data gaps (temporal, spatial, or pollutant);
- Summarizing emission data with considerations for preparing data for potential model input; and
- Recommending an approach for modeling regional impacts related to industry on the North Slope.

This assessment serves two interests:

1. Regulatory compliance demonstrations for individual facilities and
2. Assessing cumulative, regional impacts resulting from a cluster or larger group of facilities.

The impetus for this assessment is the increasing industrial activity on the North Slope primarily related to the oil and gas industry. As demand for energy continues to increase in the United States and worldwide, there is an increased drive for the development of new energy sources, particularly oil and gas. With increased development come increased effects on many areas of the environment, including air quality. This assessment will aid Federal and State agencies in evaluating the impact of current activities on the North Slope, as well as plan and prepare for future activity so potential impacts to the environment and human health can be minimized.

Modeling analyses require, at a minimum, information on emissions sources, meteorological conditions, and ambient background concentrations. This assessment reviews dispersion models applicable to the assessment interests, as well as input data needed for analyses. ADEC provided files associated with permitting activities, meteorological data, and ambient monitoring on the North Slope. This information was reviewed and compiled to gain a comprehensive understanding of the current data available required to perform near-field and far-field dispersion modeling to address the purposes of this assessment. A valuable outcome of this assessment was the identification of gaps in emissions, meteorology, and ambient air quality data.

Dispersion models applicable for accomplishing the dual modeling purposes identified above were reviewed with recommendations as to appropriate models to use and a brief examination of the input data requirements. The complexity and input requirements of the various models range from simple to very complex and extensive. The AERMOD modeling system, the current model approved by EPA for regulatory compliance applications, is recommended for near-field impacts (less than 50 kilometers of a facility). For impacts beyond 50 kilometers and out to several hundred kilometers, the CALPUFF modeling system is recommended. Two versions of the CALPUFF modeling system exist: the version accepted by EPA for regulatory applications and an updated version that is not accepted by EPA for regulatory applications. The version of CALPUFF to use will depend on the purpose of the modeling application. To assess impacts on a regional basis, where travel distances are great, and to account for long-range transport from areas outside the North Slope and chemical transformations associated with these long distances, a photochemical grid model is recommended. Both the Community Multiscale Air Quality (CMAQ) model and the Comprehensive Air Quality Model with Extensions (CAMx) are appropriate, but a decision on which is more appropriate has been deferred to allow further analysis of the physics and input requirements. Photochemical grid models require the most extensive input to assess cumulative region-wide impacts.

The focus on emissions was on stationary point sources. ADEC identified 38 stationary sources in the North Slope as major sources requiring a Federal Title V permit and 37 sources requiring a Title I permit. Major sources account for 96% of the total potential emissions in the North Slope. The major sources are largely concentrated in and around the Prudhoe Bay area and westward to Alpine, a lateral span east to west of only about 100 km. All other source types including minor, synthetic minor, synthetic minor-80%, and two non-classified sources make up the remaining 4% of the total potential emissions. Industrial activities in the North Slope are largely related to oil production and transport which account for about 58% of the permitted sources. Electric power generation plants account for approximately 21%, and the balance, about 20%, are primarily related to the seafood and construction industries. Emission units found in permit applications but not contained in the ADEC emissions inventory system were identified.

Much of the data for major sources exists in ADEC's inventory, including source parameters (e.g., stack height and diameter), while very little exists for other source types (e.g., minor, synthetic minor). Of the 38 major sources, 36 are represented in ADEC's emission inventory and account for all but 0.2% of the total potential emissions of the 38 major sources. Of the 37 non-major sources, only two were found to exist in the emission inventory. The 34 non-major sources that are not represented in the emission inventory account for 3% of the total potential emissions across all 74 permitted sources.

The availability of North Slope meteorological data was reviewed. Information was tabulated from several sources: hourly weather observations routinely archived at the National Climatic Data Center (NCDC); a large study conducted by the Bureau of Ocean Energy Management; Regulation and Enforcement (BOEMRE, formerly the Minerals Management Service (MMS)) of site-specific data collected by entities on the North Slope; additional data collected by oil and gas companies and other facilities on the North Slope generally in support of dispersion modeling; and meteorological files that are archived in the ADEC AirFacs database.

Regulatory modeling requires five consecutive years of recent data unless site-specific data is used, in which case only one year is required, though five years is still preferred. Data collected by public sources such as the NWS are sparse though relatively evenly spaced along the coastline, while site-specific data collected at industrial sites are concentrated in and around the Prudhoe Bay area and westward to Alpine. The representativeness of the data for the site where the dispersion model is applied is an important consideration during the data selection process. The sparse geographic coverage of the meteorological data makes it difficult to find data that is representative of a site for which no site-specific data has been collected. Coverage by stations recording hourly weather data is fairly good, but the availability of data above the surface (up to tens of kilometers) is limited to a single station at Barrow, Alaska. This limitation can create difficulties for modeling if data from Barrow are not available. The temporal coverage of the site data and the quality of the data is more problematic. Some sites have been collecting data for a short period of time, others for much longer periods. Some data are from the 1980's and 1990's. ADEC requires that meteorological data used for regulatory compliance demonstrations meet Prevention of Significant Deterioration (PSD) requirements. Although the BOEMRE/MMS report suggests the data catalogued and archived under that program are of sufficient quality for use in modeling, ADEC has reservations about the usefulness of the data in a compliance demonstration. More recently collected site data undergo rigorous reviews to determine if the data are of PSD quality, which is required for permit modeling. While some data are of PSD quality, other data are not, making the spatial and temporal availability of data even sparser.

In a compliance demonstration designed to determine if a source will meet national ambient air quality standards (NAAQS) and Alaska ambient air quality standards (AAAQS) for a criteria pollutant, background concentrations are required. This information usually comes from ambient air quality monitoring sites operated by a regulatory agency or, in this case, industrial facilities operating on the North Slope. Monitoring sites are less numerous as you move westward toward Alpine from Prudhoe Bay, and virtually non-existent west of Alpine across the interior regions of the North Slope. Data are available for this purpose for 8 sites, with only one site outside the area around Prudhoe Bay. Most monitoring results are from 2001 and later and multiple years are available at some sites. While the availability of monitored data for most criteria pollutants is reasonable, there is a scarcity of ambient PM-2.5 data.

There are also stringent criteria with regard to the siting, setup, and the maintenance of the monitoring equipment in addition to screening criteria applied to the data. Data must pass data screening criteria on a quarterly basis. Much of the data collected at industrial sites is limited to less than five years. Some data that spans five years or more do not meet all the quality assurance requirements and cannot be used for regulatory compliance demonstrations.

While most pollutants at the sites are well below the NAAQS, the value for the 1-hr NO_2 standard is exceeded at two sites and the value for the 24-hr PM-2.5 standard is exceeded at one site. These monitored measurements do not necessarily indicate a violation of the NAAQS. The exceedences were recorded before the new standards for these pollutants were established. In addition, the 1-hr NO_2 values reported are maximum values and have not been computed to represent the ambient concentration based on the definition of the standard (e.g., 98^{th} percentile of the 3-yr average).

1. INTRODUCTION

As demand for energy continues to increase in the United States and worldwide, there is an increased drive for development of new energy sources, particularly oil and gas. With the increased development come increased effects on many areas of the environment, including air quality. The demand for energy and resulting oil and gas development must be tempered with a concern for the environment and maintaining a quality of life not only for the human population but also wildlife and vegetation.

The Alaska Department of Environmental Conservation (ADEC) received a grant from the EPA to prepare a report summarizing current air pollutant monitoring, emission, and meteorological data for Alaska's North Slope to provide an accurate assessment of cumulative industrial impacts. This assessment requires identifying emission sources, including industrial point sources, area sources, mobile sources (onroad and nonroad and marine), and natural sources (wildfires and biogenic/geogenic); assessing the quality of existing data; determining data gaps (temporal, spatial, or pollutant); recommending methods to fill data gaps and filling those gaps if possible; summarizing and analyzing emission data with considerations for preparing data for potential model input; recommend an approach for modeling regional impacts related to industry on the North Slope; and begin work to gather model inputs and put them into appropriate model ready formats.

This assessment of air quality data and modeling serves two purposes: 1) regulatory permitting demonstrations for individual facilities and 2) assessing cumulative, region-wide impacts resulting from a cluster or larger group of facilities on the North Slope of Alaska, which contains some of the most pristine and undisturbed land in the nation.

A June 2011 Memorandum of Understanding (MOU)[1] among several federal agencies stated that "[i]n facilitating oil and gas development, we must ensure that public health, safety, and environmental quality standards are met efficiently, transparently, and in a well-coordinated fashion. … [T]he U.S. Department of Agriculture (USDA), the U.S. Department of the Interior (DOI), and the U.S. Environmental Protection Agency (EPA) (Signatories) commit to a clearly

[1] Memorandum of Understanding among the U.S. Department of Agriculture, U.S. Department of The Interior, and U.S. Environmental Protection Agency, Regarding Air Quality Analyses and Mitigation for Federal Oil And Gas Decisions Through the National Environmental Policy Act Process, June 2011.

defined, efficient approach to compliance with the National Environmental Policy Act (NEPA) regarding air quality and air quality related values (AQRVs), such as visibility, in connection with oil and gas development on Federal lands. The MOU charts a path to protect air quality and AQRVs as we move forward with responsible oil and gas development on Federal lands."

While the above referenced MOU addresses issues at a federal level, several areas within the United States are also addressing air quality issues related to gas and oil development. One that is affected by increased activity is the North Slope of Alaska. Another region is in the western United States and includes Utah, Colorado, and Wyoming. Issues and concerns over air quality that affect these regions may provide insights into similar issues and concerns on the North Slope.

The Utah Department of Environmental Quality has established the Oil and Gas Air Quality Partnership to evaluate impacts and develop management approaches for the Uintah Basin with the following goals:

- Ensure the health and welfare of the citizens of Utah;
- Manage economic and natural resources;
- Improve technical understanding of the current air quality in oil and gas producing areas of the state, how air quality will be affected by oil and gas development, and the impact of growth on regional air quality goals;
- Work with others to coordinate and collaborate on oil and gas studies in the region; and
- Address future air quality issues before they become a problem.

Several projects are being undertaken to help Utah and surrounding states and regions characterize the impact of oil and gas development on air quality.

The Western Energy Alliance (WEA) undertook the Uintah Basin Air Quality Study, a comprehensive modeling study that provides quantitative estimates of air quality in the Uintah Basin. The study, focused on summertime conditions, provided a comprehensive analysis of cumulative air quality impacts using conservative modeling assumptions from natural gas and oil activities to provide public land managers and regulators with a worst-case scenario in the basin.

Utah, Colorado, Wyoming, EPA, U.S. Bureau of Land Management (BLM) and the U.S. Forest Service are participating in a pilot project – the Three-State Study. The project will provide a regional assessment of air quality conditions focused on the oil and gas development. The pilot project focuses on the following activities:

1. Expand air quality monitoring to establish baseline conditions, track trends, and evaluate model performance;
2. Create a data warehouse to store, manage, and share data among state/federal agencies, industry and their contractors to support modeling of air pollutants; and
3. Perform regional scale air quality modeling of current and projected conditions.

The results of this study will provide quantitative information about the air quality impacts of oil and gas that can be used for air shed management, and ultimately provide a framework for making project-by-project cumulative NEPA analyses.

EPA produced a draft report to assist the Office of Policy, Economics, and Innovation (OPEI) assess environmental impacts associated with oil and gas production in Region 8 (EPA, 2008). The report intended to serve as a technical resource for policy makers, environmental managers, and other stakeholders focused on oil and gas production. The analysis was commissioned by OPEI to meet the following objectives:

- Facilitate a general understanding of oil and gas production, related environmental releases, and associated environmental implications in EPA Region 8;
- Identify policy issues, program initiatives, and stewardship opportunities related to regional oil and gas production, focusing on air, water, and land issues;
- Assess environmental releases to air, water, and land resulting from current and projected oil and gas production in the region; and
- Lay the groundwork for future action to reduce environmental impacts associated with current and projected production in Region 8 and nationally.

Section 2 of this assessment provides an overview of the North Slope including geography, demographics, Federal lands, the oil and gas industry on the North Slope, and climatology. Section 3 focuses on the air dispersion models – types of models and applicability, recommended models, and a summary of model input requirements. Emission sources and source characteristics are presented in Section 4, existing meteorological data available for the North Slope is discussed in Section 5, and ambient monitoring data are presented in Section 6.

As part of the effort, a bibliography was developed to identify various sources of information that could be used in this assessment and is included in APPENDIX A. In APPENDIX B, two tables from the June 2011 MOU describe general approaches to air quality modeling. APPENDIX C presents tabulated information on data gaps in the ADEC emission inventory for major sources.

1.1 REFERENCES

U.S. EPA, 2008: *An Assessment of the Environmental Implications of Oil and Gas Production: A Regional Case Study (Working Draft)*, September 2008.

2. OVERVIEW OF NORTH SLOPE

This overview section provides a summary of the unique physical, human, and biological environments of the North Slope. More detailed information can be found in the North Slope Borough *Background Report of the Comprehensive Plan* and the North Slope Borough web site at: http://www.north-slope.org.

2.1 GEOGRAPHY

The North Slope Borough is located at the northern perimeter of Alaska, entirely above the Arctic Circle. It is the largest borough in Alaska with over 15 percent of the state's total land area. The Borough encompasses the entire northern coast of Alaska along the Arctic Ocean and contains approximately 89,000 square miles of land and 5,900 square miles of water.

The southern boundary runs in an east - west direction at 68° North latitude, about 105 miles north of the Arctic Circle. The Borough extends east to the border with Canada, west to the Chukchi Sea, and north to the Beaufort Sea.

The North Slope includes three regions with different geographic characteristics. Moving from south to north, these regions are:

- The Brooks Range is an east-west trending range that represents the northern extension of the Rocky Mountains. The highest point on the North Slope is Mount Chamberlin (9,020 feet) in the eastern Brooks Range.

- The Brooks Range Foothills are characterized by gently rolling hills and broad exposed ridges that form the northern flank of the Brooks Range. The region is characterized by rolling, treeless tundra and large river basins.
- The arctic coastal plain extends southward from the shoreline approximately 30 miles into the coastal lowlands. Freshwater lakes cover approximately 26 percent of the arctic coastal plain. The arctic coast is the terminus for many river deltas emptying to the open sea, and is generally low-lying except for occasional bluffs and sea cliffs.

Permafrost underlies the entire region. On the Arctic Coastal plain, permafrost starts between 1 to 2 feet below the surface and has been found at depths of 2,000 feet.

There are several protected lands on the North Slope:

- Arctic National Wildlife Refuge (78,050 km^2),
- Gates of the Arctic National Park and Preserve (39,460 km^2),
- Gates of the Arctic Wilderness (29,320 km^2),
- Mollie Beattie Wilderness (32,375 km^2),
- Noatak National Preserve (26,300 km^2), and
- Noatak Wilderness (26,000 km^2).

In addition the North Slope includes one unit of the Alaska Maritime National Wildlife Refuge, which extends from Cape Lisburne on the Chukchi Sea to the rainforests of southeast Alaska.

2.2 COMMUNITIES – POPULATION AND ECONOMY

The North Slope Borough had a permanent population of 9,430 in 2010 according the 2010 Census. This is a 27.7 percent increase from the 2000 population of 7,385. The projected population for 2025 is 9,765 (North Borough Comprehensive Transportation Plan, 2005). The Borough is sparsely populated. The population density is only 0.1 persons per square mile, compared to the Alaskan population density of 1.2 persons per square mile. A high percentage of the permanent population is classified as American Indian or Alaska Native persons.

Most of the permanent population resides in one of seven coastal villages. A general description of each of these villages follows, moving from east to west along the coastline:

- **Kaktovik** is 90 miles west of the Canadian border on the northern shore of Barter Island and the edge of the 20-million-acre Arctic National Wildlife Refuge. In 2003, there were 286 residents and a labor force of 98. Eighty-eight percent of residents are Iñupiat Eskimo. Fifty-seven percent of the working residents are employed by the North Slope Borough or School District. Thirty-seven percent are employed in the private sector, primarily by Native corporations and their affiliates. Like other communities in the region, subsistence hunting, fishing and whaling play a major role in the local economy.
- **Nuiqsut** is located about 18 miles south of the Colville River headwaters at the Beaufort Sea. In 2003, there were 416 residents in Nuiqsut and a labor force of 169. Approximately 92 percent of residents are Iñupiat Eskimo. Like all North Slope villages, Nuiqsut's economy is based primarily on subsistence hunting, fishing and whaling.
- **Barrow** is the economic, transportation and administrative center for the North Slope Borough. Located on the Chukchi Sea coast, Barrow is the northernmost community in the United States. Barrow has 4,429 residents, of which approximately 61 percent are Iñupiat Eskimo. Although Barrow is a modern community, subsistence hunting, fishing and whaling are still very important to the local economy. Many residents who work full- or part-time continue to hunt and fish for much of their food. In 2003, approximately one-third of the working population of 1,935 was employed in the private sector. Only a few work for oil companies at Prudhoe Bay. The Borough employs 46 percent of the work force and the School District employs another 19 percent.
- **Atqasuk** is located inland from the Arctic Ocean on the Meade River, about 60 miles southwest of Barrow. Atqasuk has a population of 250 residents and a work force of 72 as of 2003. Iñupiat Eskimos comprise 91 percent of the population. Atqasuk's economy is largely based on subsistence caribou hunting and fishing.
- **Wainwright** sits on a wave-eroded coastal bluff of a narrow peninsula which separates Wainwright Inlet from the Chukchi Sea. Wainwright is about 70 miles southwest of Barrow. Wainwright is the third largest village in the North Slope Borough, and in 2003 had a population of 556 and work force of 221. Ninety-four percent of the residents are Iñupiat Eskimo. Wainwright has a larger private sector than most villages: 38 percent of

the work force is employed by private businesses, primarily the village and regional corporations.

- **Point Lay** is perched on the Chukchi Sea coast 150 miles southwest of Barrow. Point Lay had a population of 260 residents in 2003, with a work force of 98. Eighty-six percent of residents are Iñupiat Eskimo.
- **Point Hope** is located near the end of a triangular spit jutting 15 miles into the Chukchi Sea, 250 miles southwest of Barrow. Point Hope is the second largest city on the North Slope with a population of 764 and a labor force of 293. The local economy is largely based on subsistence hunting, fishing and whaling.
- **Deadhorse** is an unincorporated community in the North Slope Borough. The town consists mainly of facilities for the workers and companies that operate at the nearby Prudhoe Bay oil fields. Deadhorse is accessible via the Dalton Highway from Fairbanks, or the Deadhorse Airport. The permanent population is variously listed as being between 25 and 50 residents. Temporary residents (employed by various firms with local interests) can range as high as 3,000. Companies with facilities in Deadhorse service Prudhoe Bay, nearby oil fields, and the Trans-Alaska Pipeline System (TAPS), which brings oil from Prudhoe Bay to Valdez on the south-central Alaska coast.

2.3 FEDERAL LANDS

The federal government is a predominant landholder within the North Slope Borough, with interests in surface and subsurface estates in the area. Federal agencies responsible for land management include the BLM, U.S. Fish and Wildlife Service (FWS), National Park Service (NPS), and Department of Defense (DOD). The areas designated in the map to the right as the National Petroleum Reserve-Alaska and the Arctic National Wildlife Refuge contain some Alaska Native lands. Similarly, the area titled “Mostly State Lands” also contains some Alaska Native lands. Finally, the area on the far left portion of the map labeled “Mostly Native Lands” also includes some state and federal lands. TAPS extends from Prudhoe Bay to Valdez, Alaska.

The National Petroleum Reserve – Alaska (NPRA) contains over 23 million acres and is primarily managed by the BLM for a competitive oil and gas leasing program. The North Slope Borough communities of Atqasuk, Nuiqsut, and Barrow physically are located within the NPRA or have corporation lands that are located within NPRA. Residents of other Borough communities use lands within NPRA for subsistence and other traditional uses.

The Arctic National Wildlife Refuge (ANWR) is located on the east side of the Borough and units of the Alaska Maritime National Wildlife Refuge are located along the west coast of the Borough. The refuges are managed by the FWS. The community of Kaktovik is located within the boundaries of ANWR and the community of Point Hope is situated between two units of the Alaska Maritime National Wildlife Refuge. Residents from other Borough communities use lands within both refuges for subsistence and other traditional uses.

Both the Gates of the Arctic National Park and Preserve and the Noatak National Preserve are also partially located within the North Slope Borough. These two units are located along the southern border of the Borough in the Brooks Range.

There are numerous DOD sites throughout the Borough. However, many of the sites are being closed and facilities dismantled.

North of the coastal plain lies the Outer Continental Shelf (OCS), federal submerged lands that lie seaward of the states' jurisdiction (generally three nautical miles from the shoreline). The Chukchi and Beaufort Seas of the Arctic Ocean are the primary marine waters associated with the OCS area. Sea ice formation in the Chukchi and Beaufort Seas begins in October, and the ice pack persists through late June, although the ice begins to melt and break up in April.

2.4 OIL AND GAS INDUSTRY

Since the opening of the 800-mile-long Trans-Alaska Pipeline in 1977, more than 13 billion barrels of oil have flowed from thousands of oil wells on the North Slope to international and domestic markets. During this period, North Slope oil has contributed about 20 percent of the United States' annual domestic production.

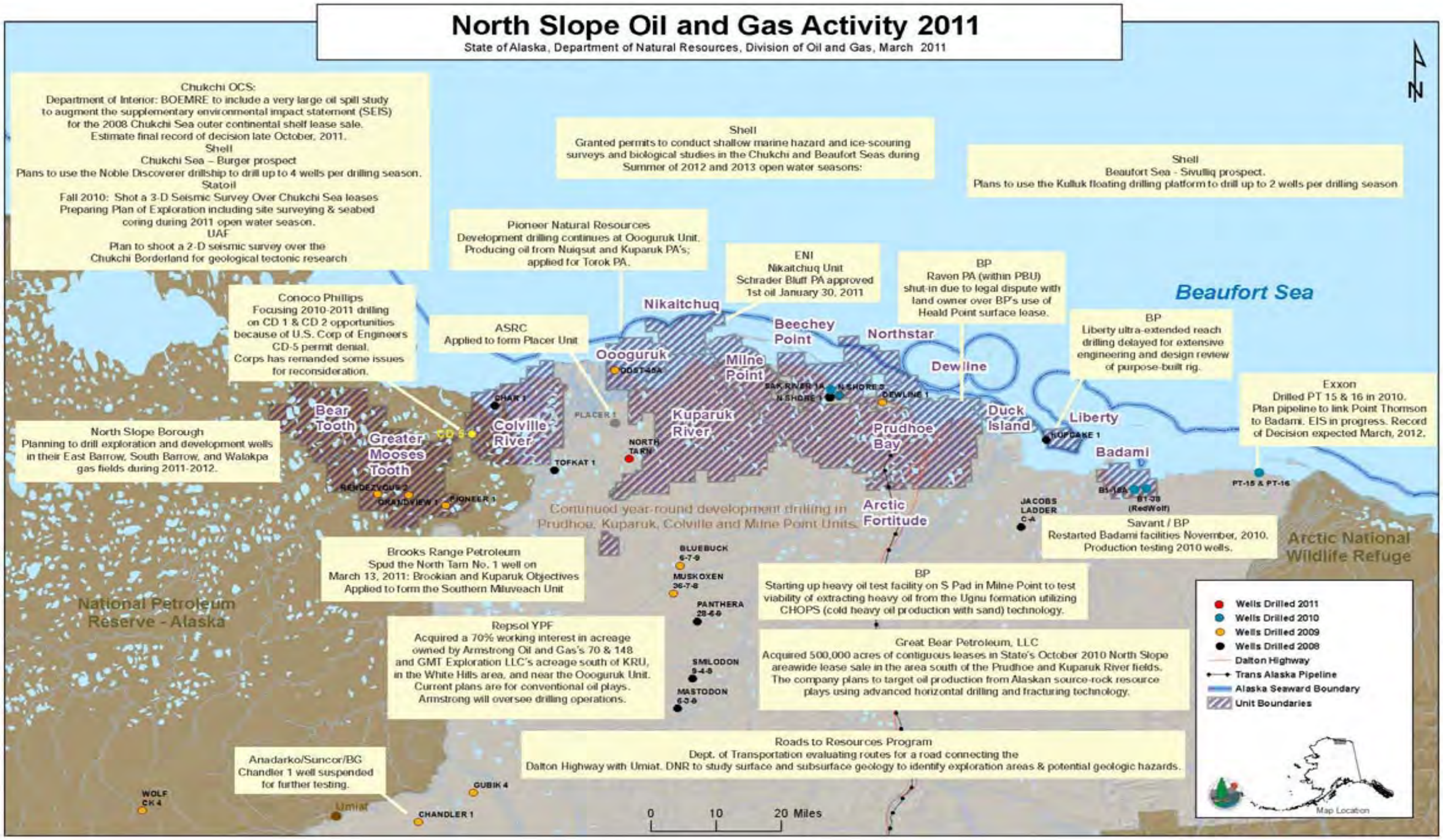
Currently, most oil production on the North Slope takes place on state lands in the general vicinity of Prudhoe Bay, which, in 1968, was the site of the largest oil field ever discovered in North America.

Oil companies and the state of Alaska are looking to federal lands for future oil development on the North Slope. These lands include the NPRA, the OCS, and the coastal plain of the ANWR.

- Active oil exploration is underway in the NPRA, a 23-million-acre tract located west of Prudhoe Bay. The BLM manages the NPRA for both oil resources and natural values.
- The Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) regulates oil activities on the Outer Continental Shelf, defined as 3 or more miles from shore.
- The Congress has not determined whether to open portions of the federally owned ANWR, east of Prudhoe Bay, to oil and gas development activities. The refuge was created in 1960 and expanded in 1980 to its present size of 19 million acres—of these, about 8 million acres have been designated as wilderness. A 1.5-million-acre coastal section of the refuge (known as the "1002 Area") was set aside in 1980 for study of its fish and wildlife resources as well as for possible oil and gas development, but the Congress would need to specifically authorize oil and gas development activity.

Figure 2.1 provides an overview of North Slope oil & gas activity in 2011.

Figure 2.1: Oil and Gas Activity, North Slope, 2011



http://www.dog.dnr.alaska.gov/products/publications/northslope/northslope_tabbed_042209.html#nswiomap

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2.5 CLIMATOLOGY

A dry, polar climate dominates the arctic coastal plain throughout the year, with short, cool summers and long, cold winters. Temperatures on the arctic coastal plain are typically below freezing from mid-October into May. Temperatures vary across the arctic coastal plain, depending on the proximity to the coast. In general, February is the coldest month with an average temperature of about -21 degrees Fahrenheit (°F). July is typically the warmest month, with an average temperature of 46°F. Temperature extremes can range from -56°F during winter months to as high as 78°F in mid-summer. The nearby Arctic Ocean and abundant sea ice contribute to the cool, frequently foggy, summers.

Annual precipitation (both rainfall and snowfall) is low and mostly falls as snow during the winter. Precipitation varies somewhat across the arctic coastal plain. Kaktovik, located on Barter Island in the eastern portion of the Borough, receives approximately 5 inches of precipitation during the summer months and approximately 20 inches of snow during the winter months. Point Hope, located on the western end of the Borough, receives approximately 10 inches of precipitation annually, with snowfall of about 36 inches.

South of the arctic coastal plain are the Brooks Range Foothills and the Brooks Range. There is a change in the climate conditions as the elevation increases. Air temperatures decrease rapidly with rising elevation. Anaktuvuk Pass, located in the north-central portion of the Brooks Range, has more of a continental climate. Due to the higher elevation, summers are cool. The average temperature in January is about -14°F, and the average summer temperature is about 50°F. Extremes have been recorded from -56 to 91°F. Anaktuvuk Pass receives approximately 11 inches of precipitation in the summer months, and receives an average of 63 inches of snowfall per year.

Prevailing winds blow cold air off the Arctic Ocean and are strongest during winter, often creating blizzard conditions. The prevailing wind direction is typically northeasterly to easterly, and southerly winds may break this pattern on occasion. The average annual wind speed in the region is approximately 12 miles per hour.

Figure 2.2 and Figure 2.3 show wind roses for the Endicott facility for January 2001-2005 and July 2001-2004 (MMS, 2006). Each ring represents 4% with the outermost ring representing 20%. The multi-colored bars indicate the direction the wind is blowing from, with the length of each color proportional to the percentage in that wind speed category. Wind speed categories are (from black to light blue) are 0.5-2.1 meters/second (m/s), 2.1-3.6 m/s, 3.6-5.7 m/s, 5.2-8.8 m/s, 8.8-10.8 m/s, and >10.8 m/s.

Figure 2.2: Wind Rose for January 2001-2005 at Endicott

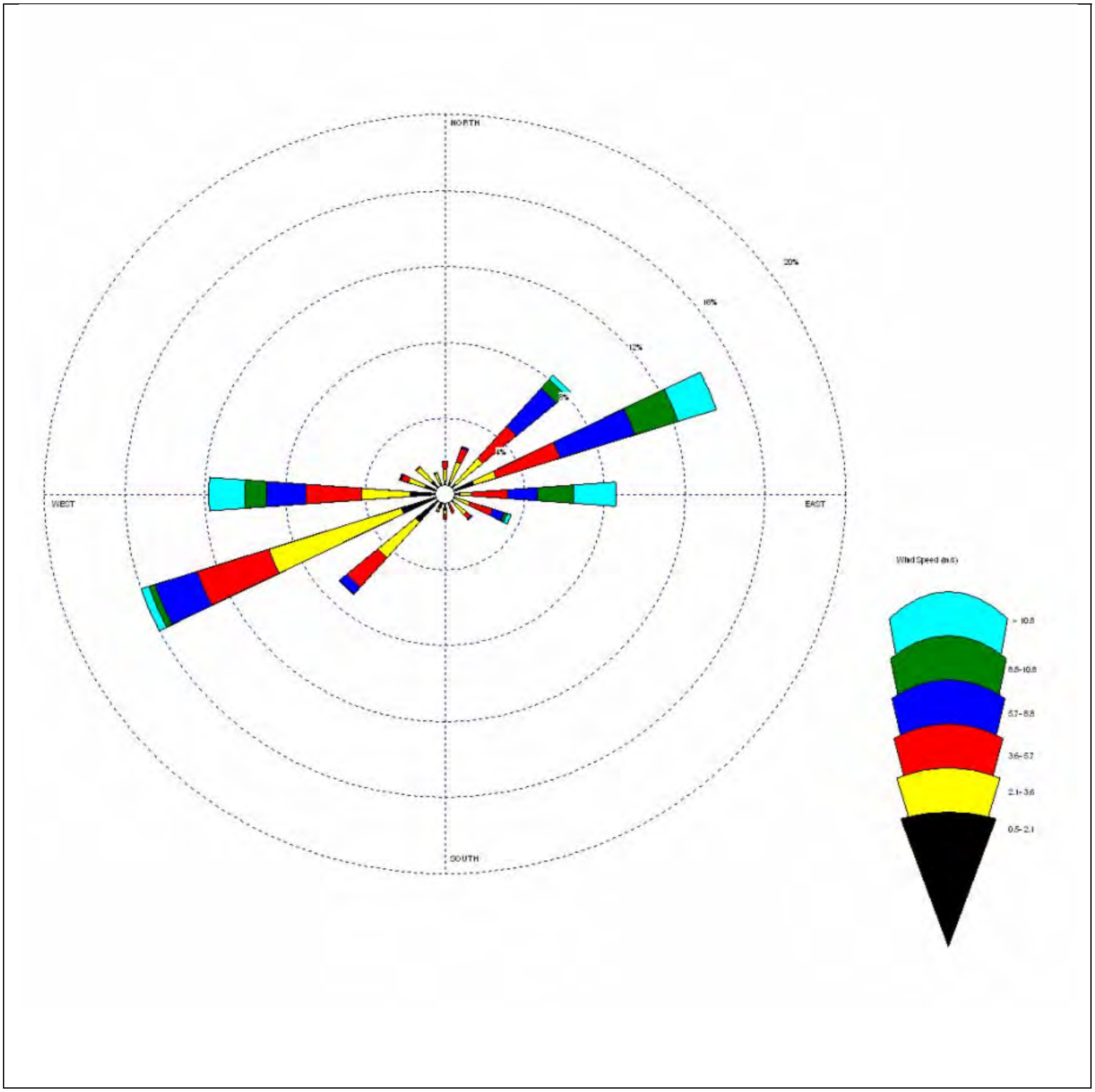
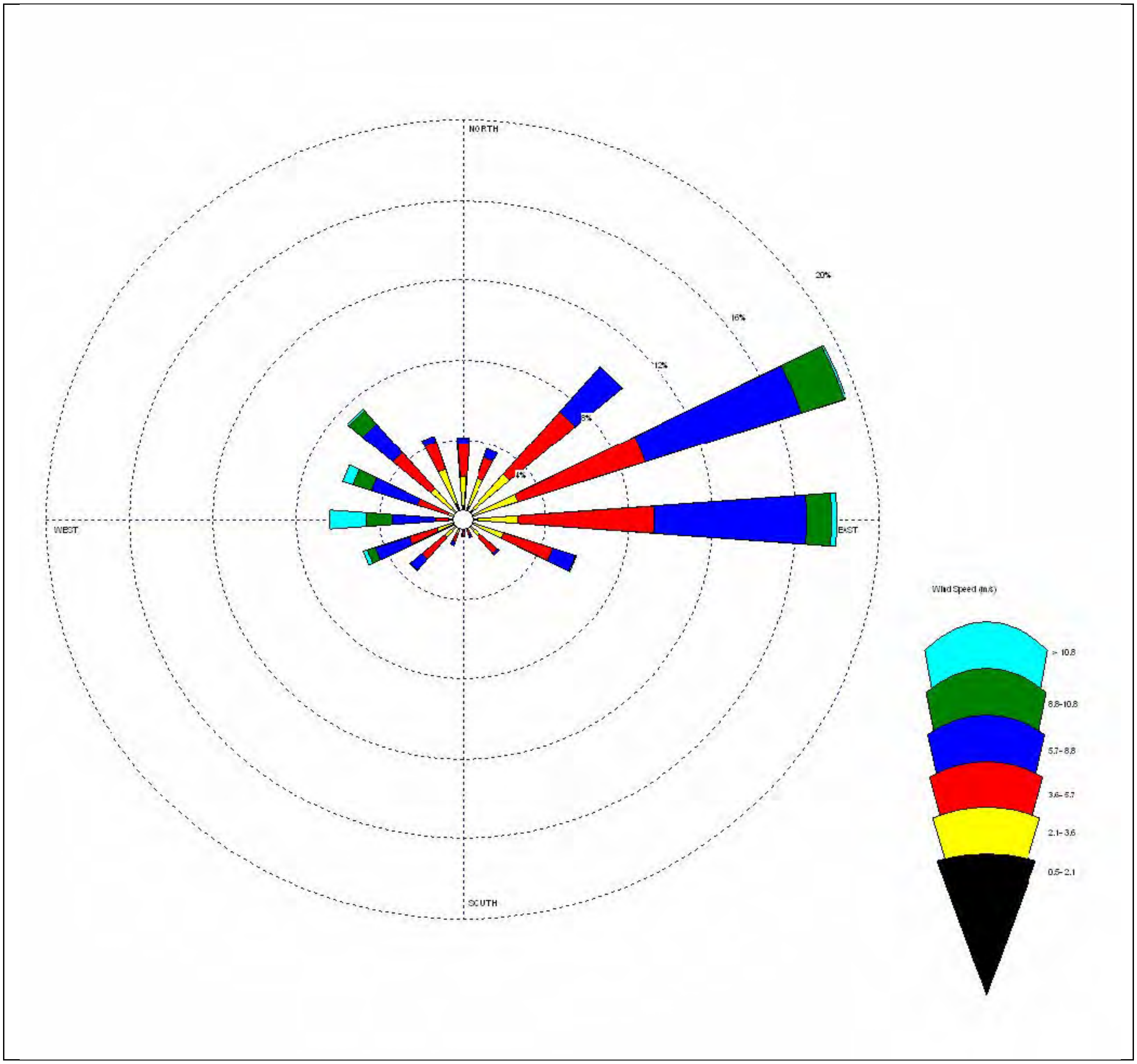


Figure 2.3: Wind Rose for July 2001-2004 at Endicott



Due to low temperatures, permafrost is continuous across the region, except under large rivers and thaw lakes. Permafrost and frost processes contribute to a large variety of surface features such as pingos, ice-wedge polygons, and oriented thaw lakes. The presence of permafrost prevents surface drainage so soils typically are saturated and have thick organic horizons.

Sea ice typically forms on the Beaufort and Chukchi Sea in November and remains through early June. The formation of first-year sea ice along the coast signals the start of freeze-up. During the first part of freeze-up, nearshore ice is susceptible to movement and deformation by winds and ocean currents. By late winter, the first-year sea ice is about 6 to 7 feet thick. The ice freezes to the seafloor and forms the bottomfast-ice subzone of the landfast-ice zone. The landfast-ice zone may extend from the shore out to depths of 45 to 60 feet.

Rivers and lakes start freezing in September. Some rivers and lakes freeze to the bottom, other maintain flow under the ice or have deep pools, which are critical to both the survival of fish and as a source of water for community and industrial uses (such as ice roads). Along the Beaufort Sea coast, breakup of the rivers and lakes generally begins in late May but may occur as late as mid-June. River ice begins to melt before the sea ice and, during the early stages of breakup, water from rivers may temporarily flood ice that has formed on the deltas.

Storms are a major factor in weather on the North Slope, and a consideration for all types of offshore and onshore human activity. Offshore storms can create hazards for residents pursuing subsistence activities, and create wave and ice conditions that are hazardous to oil exploration and production offshore structures. Storms also contribute to coastal erosion and ice override hazards. Onshore, storms can bring transportation to a halt, endanger people traveling between communities, and cause snow drifting that buries facilities and roads.

2.6 AIR QUALITY

According to a 2003 National Research Council (NRC) report on the effects of oil and gas activities on the North Slope (NRC, 2003), air quality on the North Slope meets the Alaska ambient air quality standards (AAAQS) and the national ambient air quality standards (NAAQS). Monitored values collected at several sites on the North Slope as part of ambient air monitoring programs by oil/gas and other interests are presented in Section 6 and tend to support the assertion regarding air quality standards. One possible exception is the 1-hr NO_2 standard, although this standard was not in effect in 2003. The highest 1-hr NO_2 values exceed the standard at two sites for several different years. It is important to note that the 1-hr NO_2 values reported in Section 6 are maximum values and have not been computed to represent the ambient concentration based on the definition of the standard (e.g., 98^{th} percentile of the 3-yr average).

Emissions from local facilities result in observable haze, increased atmospheric turbidity, and decreased visibility (NRC, 2003). At the time of the NRC report, widespread Arctic haze, which occurs at higher elevations, and locally produced smog are the most apparent air quality problems on the North Slope. Lack of a pre-development baseline on air quality hampers an assessment of current and future activities, both local and distant, on North Slope air quality.

The NRC (2003) found that

- "The only area-wide monitoring program on the North Slope has been for priority pollutants as defined by the Clean [Air] Act, from 1986 through 2002, at a limited number of sites. … No large-scale, long-term monitoring system has been established to provide a quantitative baseline of spatial or temporal trends in air quality on the North Slope."
- "The quantity of air contaminants reaching the North Slope from distant sources is unknown."
- "Little is known about the nature or extent of interactions between locally produced and globally transported air contaminants on the North Slope."

They recommend "… monitoring should be implemented to distinguish between locally derived emissions and those that arrive by long-range transport, to determine how they interact, and to monitor potential human exposure to air contaminants."

The effects of air quality on vegetation near industrial facilities on the North Slope appear minimal and NO_X and SO_2 monitoring through 1994 revealed no effects on vegetation that could be attributed to pollution. Recommendations for continued monitoring of NO_X and SO_2 were made; however, such monitoring is not being conducted. Lichens are vulnerable to SO_2 and concentrations as low as 12 $\mu g/m^3$ for short periods can depress photosynthesis in several species, with damage occurring at 60 $\mu g/m^3$. As seen in Table 6.1, the highest 1-,3-, and 24-hr monitored values for SO_2 exceed 12 $\mu g/m^3$ at most sites for most years for which monitored data are available, and exceed the 60 $\mu g/m^3$ threshold for a few of the site-years. The NRC report concludes that "… even though air quality meets National Ambient Air Quality Standards, it is not clear that those standards are sufficient to protect arctic vegetation."

2.7 VEGETATION

Tundra, which refers to the rolling, treeless plains of arctic regions and dominates the terrestrial vegetation of the North Slope Borough, is categorized into three types: alpine, moist, and wet.

Alpine tundra vegetation is found in the well-drained mountainous range areas and consists mainly of low, mat-forming vegetation communities including heather and blueberry, interspersed with willow and dwarf birch. Outcrops and talus slopes that are exposed to harsh environmental conditions support cushion forming herbaceous vegetation such as mosses, and lichens that serve as food for caribou.

Moist tundra vegetation dominates the vegetation community of the foothills region, and consists of cotton grass, between which mosses, lichens, and herbs thrive. Dwarf scrub (woody vegetation) communities consisting of willow, dwarf birch, Labrador tea, and crowberry are also present.

The moist tundra is divided by the numerous river drainages found in the area, the floodplains of which support a different vegetation community consisting of high shrubs. Undisturbed areas of this community support willows, mosses and lichens, and occasionally alders and cottonwood trees. Disturbed areas closest to the streambed are colonized by horsetail, dwarf fireweed, and alpine bluegrass.

The wet soil conditions in the arctic coastal plain support wet tundra herbaceous communities dominated by sedges or grasses. Dwarf scrub communities are found where soil conditions are dryer, such as at thaw lake margins, along river bluffs, or other more elevated, well-drained areas.

2.8 WILDLIFE

As with all areas within Alaska, the North Slope region supports a wide range of wildlife. During the season when the North Slope is thawed, the inland and shoreline areas are a haven for migratory waterfowl and other birds. Residents of the North Slope primarily engage in a subsistence lifestyle and are heavily dependent on the availability of the resources in the area.

Native Alaskans in coastal communities rely on marine mammals and other coastal resources for food sources, whereas inland communities rely on caribou and other resources. Mammals are present in concentrated areas during certain times of the year. Polar bears roam the ice pack during the winter, but come ashore during the summer when the sea is free of ice.

2.9 REFERENCES

MMS, 2006: *Study Final Report for the Beaufort Sea Meteorological Monitoring and Data Synthesis Project.* Minerals Management Service, Anchorage, Alaska, July 2006.

North Slope Borough Background Report of the Comprehensive Plan, Adopted by the North Slope Borough Assembly on October 11, 2005. Prepared for the North Slope Borough. Prepared by URS Corporation. October 2005.

North Slope Borough Comprehensive Transportation Plan. Prepared for the North Slope Borough. Prepared by ASCG Incorporated. August 2005.

NRC, 2003: Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope. National Research Council, National Academies Press, Washington, DC.

3. AIR QUALITY MODELS AND RECOMMENDATIONS

Before developing the input to an atmospheric dispersion model, the appropriate model to use for the particular application must be determined. Considerations when selecting a dispersion model include the purpose of the modeling (e.g., impacts on local and federal standards, risk assessment, and the OCS) and the complexity of the modeling (e.g., terrain considerations, availability of meteorology). In this section the modeling approach is examined.

3.1 TYPES OF MODELS AND APPLICABILITY

Models can range from simple screening models to refined Gaussian models to regional scale Eulerian and Lagrangian photochemical grid models. Except for the simplest of models, many models share common general concepts of atmospheric processes, such as dry and wet deposition, although the parameterization and numerical solution of those processes are likely different from model to model. Generally, regional scale models are much more complex, include atmospheric chemistry mechanisms, and model more atmospheric processes than a simpler refined model, but as a result, also require much more input from the user.

3.1.1. Screening Models

Screening models estimate concentration impacts that are equal to or greater than what is expected from a refined modeling analysis. Impacts from screening models usually are based on a matrix of meteorological conditions that have no directional dependence, simplified terrain, and likely apply only to a single source in a model run, requiring results from several model runs be combined in some manner for multiple sources. These models generally transport pollutant emissions downwind. In a regulatory permitting application, passing at a screening level may not require modeling with a refined model.

3.1.2. Refined Models

Refined models incorporate more advanced physical processes of the atmosphere, utilize regularly observed meteorological data, incorporate a more complex treatment of terrain, apply to one or more emission sources, process multiple source types (such as point, area, and volume), model extent is 50-kilometers (near-field), but may be limited to single pollutants and impacts from close to emission sources to a few hundred kilometers. The models may be limited to primary (e.g., PM-10, SO_2, NO_X, CO, and hazardous air pollutants), non-reactive pollutants or have simplified chemical processes, such as the exponential decay found in AERMOD. Plumes may be parameterized using (bi-)Gaussian models, a combination of Gaussian and probability density function (pdf), or puff models.

These models are used primarily for regulatory permitting purposes where a dense network of receptors is needed to determine if a facility complies with ambient air quality standards. The input requirements are more complex than for screening models, but can vary greatly from model to model.

3.1.3. Photochemical Grid Models

Photochemical grid models are large-scale air quality models intended to depict how air pollution forms, accumulates, and dissipates by simulating changes of pollutant concentrations and interactions of pollutants in the atmosphere as well as the transport into and out of a region. These models are applied at multiple spatial scales from local, regional, national, and up to global scales; employ complex chemistry mechanisms/transformations applicable to multiple pollutants; and can be applied to study greenhouse gases (GHGs) and the formation of secondary pollutants (PM-2.5, O_3). Photochemical models are more applicable to assessing the cumulative impact of pollutants.

There are two types of photochemical grid models commonly used in air quality assessments: the Lagrangian trajectory model that employs a moving frame of reference, and the Eulerian grid model that uses a fixed coordinate system with respect to the ground. Most of the current operational photochemical air quality models have adopted the three-dimensional Eulerian grid modeling mainly because of its ability to better and more fully characterize physical processes in the atmosphere and predict the species concentrations throughout the entire model domain. The models operate on a grid of cells, both horizontally and vertically, with cell size ranging from a few kilometers to tens of meters or more horizontally, and tens of levels vertically. They can also nest one or more grid networks of different cell resolution within the domain.

Traditionally, photochemical models incorporated a plume uniformly and instantaneously into the entire volume of a grid cell. To resolve finer scale (sub-grid) emissions in these models, plume-in-grid (PiG) models were developed, which are Lagrangian plume models embedded in the grid model.

Photochemical grid models generally are meant more for regulatory and policy assessments. They are routinely used for regulatory analysis and attainment demonstrations. Due to the resources required (data, computational requirements, time) to run a photochemical grid model, it is not practical to use a photochemical model to demonstrate compliance.

3.1.4. Coastal Process Models

With the Beaufort and Chukchi Seas making up the coastline of the North Slope, an important category of models for the North Slope applies to offshore sources, coastal processes and fumigation. Coastal fumigation occurs when a pollutant is released into a stable layer, is transported onshore and encounters an unstable thermal layer over land, leading to the rapid downward mixing of pollutants and high ground level concentrations.

3.1.5. Other Models

Another category of models are computational fluid dynamic (CFD) models. These models are useful in areas with numerous buildings (such as urban street canyons) and other complex urban geometries where refined modeling cannot resolve the turbulence associated within and between structures. CFD models are also useful in regions that are sharply affected by topographically-induced turbulence. CFD modeling is not considered in this assessment.

There are many specialized models used for a very specific purpose, such as open burn/ detonation, hazardous spills, near-road, accidental releases, and emergency response. These specialized models are not applicable for this assessment.

3.1.6. Additional Model Considerations

Some models are considered as near-field vs. far-field models, steady state vs. non-steady state, or Gaussian-plume vs. puff models. Near-field generally refers to distances from a facility fenceline to about 50 kilometers (km) whereas the far-field represents distances from about 50 km to a few hundred kilometers.

When the pollutant is released from the source in refined modeling, it can be modeled as a Gaussian plume with a structure described by a Gaussian probability distribution in the vertical, horizontal, or both. Emissions also can be modeled as a puff. Puffs respond to the meteorology immediately surrounding it, allowing puffs to be tracked across multiple sampling periods until it is either completely diluted or has tracked across the modeling domain and out of the computational area.

In a steady-state model, there is no time-dependency, conditions are assumed uniform over the entire region of interest, and do not take into account time for a pollutant to travel across the domain of interest. A steady-state model has no 'memory' of prior atmospheric conditions (unless special methods are used to save the state of the atmosphere from the previous hour). The plume is transported in a straight line in the direction the wind is blowing. In a non-steady state puff model, the pollutant emissions/puffs are tracked from hour to hour until the puff exits the computational domain or is too diluted (ground level concentrations would be too small). For cases with a high degree of spatial variability of the flow within the boundary layer, such as along a winding valley, the straight-line steady state assumption may not be valid and a puff model may be more appropriate.

3.2 EXISTING MODELS FOR THE NORTH SLOPE AND RECOMMENDATIONS

Not only are models developed by both public and private for-profit concerns in the United States, but models that perform the same function are developed in other countries. Those models may parameterize physical processes differently or include/exclude other atmospheric process. For this assessment, however, we will limit our recommendation(s) to models that are available in the United States and are freely available. Also, the recommended models are generally accepted by EPA in regulatory and assessment applications.

The Appendix in the 2011 Memorandum of Understanding[2] between USDA, DOI, and EPA contained an overview matrix of air quality modeling. It is repeated here as Table 3.1 since it contains several of the models discussed below. It is important to note that the range of costs does not include preparation of the meteorological input. Development of 3-dimensional meteorology for a model such as CALPUFF can easily add $10,000 or more depending on the amount of data needed for the application and whether or not gridded meteorology is used as part of the input.

[2] Memorandum of Understanding among the U.S. Department of Agriculture, U.S. Department of The Interior, and U.S. Environmental Protection Agency, Regarding Air Quality Analyses and Mitigation for Federal Oil And Gas Decisions Through the National Environmental Policy Act Process, June 2011

Table 3.1: Overview of Air Quality Model Characteristics (Memorandum of Understanding, June 2011)

	Near Field (<50km)			Long Range Transport (>50km) & Photochemical Models		
	AERSCREEN	VISCREEN/PLUVUE II	AERMOD	CALPUFF	SCIPUFF**	CMAQ/CAMX
Description	A conservative single-source *screening* model based on AERMOD for NAAQS and PSD permitting.	Plume blight models for AQRVs and PSD permitting. Visual impacts are estimated by detailing change in color and contrast along a specific view.	*Refined* single/cumulative regulatory model for NAAQS, toxics, and PSD. Used for non-reactive criteria pollutants.	*Refined* long range transport model for AQRVs, NAAQS, and PSD Increment. Contains simplified chemical processes.	*Refined* (alternative) long range model for NAAQS and PSD Increment. Contains more advanced chemical processes.	*Refined* photochemical model with full chemistry. Urban to regional scale model capable of single source or cumulative impact assessments.
Advantages	Quick, easy to setup, and simple operation.	VISCREEN: Quick, easy operation and results. PLUVUE II: Complex blight analysis.	Most widely accepted regulatory model. Extensive documentation/guidance for appropriate use.	Ability to simulate pollutant transport that varies in time and space. Addition of simple chemistry and deposition.	Ability to simulate pollutant transport that varies in time and space. Addition of advanced chemistry.	Primary models for ozone and secondary particulate matter impact. Includes most realistic chemistry.
Disadvantages	Conservative modeling assumptions and results.	Single purpose models with lack of robust guidance.	Not suitable for ozone or AQRV impact analyses.	Numerous model control options, difficult validation, and long run times.	Not widely available and not extensively documented.	Complex setup and operation. Advanced computing requirements.
Required computer resources	Light (laptop)	Light (laptop)	Light/Moderate (PC)	Moderate (robust PC)	Moderate (robust PC)	Heavy (UNIX, cluster)
Required model input data	Pre-set meteorology.	Pre-set meteorology or National Weather Service observations.	National Weather Service or on-site observations.	3-Dimension meteorology	3-Dimensional meteorology	3D meteorology, heavy emissions processing.
*Range of costs**	In-house to minimal	In-house / $10K - $75K	$10K – $30K	$10K - $50K	$10K - $75K	$50K - $100K
Factors affecting costs	None	None/Multiple runs	runtime	Meteorology, runtime	Meteorology, runtime	Multiple inputs, runtime
Time to set up, run model	Minutes	Minutes / 1-2 weeks	1-2 Weeks	Days to weeks	Weeks	Weeks to months
Model Developer	EPA	EPA/EPA	EPA	TRC	Lakes Environmental	EPA/Environ
Background, references	40CFR51AppxW	FLAG, 40CFR51AppxW	40CFR51AppxW	FLAG, 40CFR51AppxW	Private	EPA SIP guidance

* Does not include development of baseline emissions (present or future), meteorological inputs, or contract management. Initial development costs may be more.
** SCIPUFF is considered an alternative model under 40 CFR 51 Appx. W but may be considered for long range transport use on a case-by-case basis.

3.2.1. Screening Models

Several screening models are approved by EPA for regulatory applications. The most common is AERSCREEN, the screening version of AERMOD, which replaced SCREEN3 in March 2010 as the recommended screening model. There are several other screening models available including CTSCREEN and RTDM (both can be used for complex terrain) and TSCREEN (toxics screening). All but AERSCREEN are older models that have not been updated in many years.

AERSCREEN (EPA, 2011a) generates estimates of "worst-case" 1-hour concentrations, without the need for hourly meteorological data, for a single source using the refined model AERMOD. AERSCREEN includes conversion factors to estimate "worst-case" 3-hour, 8-hour, 24-hour, and annual concentrations.. AERSCREEN is intended to produce concentration estimates that are equal to or greater than the estimates produced by AERMOD with a fully developed set of meteorological and terrain data, but the degree of conservatism will vary depending on the application. Table 3.1 indicates that pre-set meteorology is used for AERSCREEN. That statement is not completely true, depending on the interpretation of 'pre-set'. Rather than an internal, static set of meteorological conditions (as in SCREEN3), AERSCREEN develops a site-specific worst-case set of meteorology based on input from the user such as wind speed, temperature, and surface characteristics (albedo, Bowen ratio, surface roughness). As with AERMOD (discussed in the next section), AERSCREEN is for near-field applications.

3.2.2. Refined Models

Refined dispersion models listed in 40 CFR 51 Appendix W are required to be used for State Implementation Plan (SIP) revisions for existing sources and for New Source Review (NSR) and Prevention of Significant Deterioration (PSD) programs. The refined models in this category include CTDMPLUS (EPA, 1989); AERMOD (EPA, 2004c; EPA, 2004d) and preprocessors AERMET (EPA, 2004a; EPA, 2006) and AERMAP (EPA, 2004b; EPA, 2009); Offshore and Coastal Dispersion (OCD) model (Department of the Interior, 1997), AERMOD with Coupled Ocean-Atmosphere Response Experiment (COARE) algorithms, CALPUFF (v. 5.8) (Scire et al., 2000) and CALPUFF (v. 6.42) with COARE algorithms. AERMOD, CTDMPLUS, and OCD are applicable for transport distance less than 50 km. CALPUFF and CALPUFF-COARE are for transport distances from 50 km to several hundred kilometers, unless a compelling reason to use CALPUFF closer than 50 km can be demonstrated for specific applications (EPA, 2008b). Both

AERMOD-COARE and CALPUFF-COARE are non-guideline models, and the determination of the applicability of these two models is on a case-by-case basis.

Complex Terrain Dispersion Model PLUS Algorithms for Unstable Situations (CTDMPLUS)

Another near-field model for flat and complex terrain is CTDMPLUS. Developed in the late 1980's, CTDMPLUS is a Gaussian air quality model for use in all stability conditions for complex terrain. Terrain features are parameterized as idealized shapes (closed ellipses), which requires a great deal of effort to incorporate terrain information into the model (the user must digitize contours from topographic maps). Each receptor is associated with a particular hill (unless modeling is conducted as flat terrain). CTDMPLUS can use a vertical profile of site-specific meteorological data in its estimates of pollutant impacts.

AERMOD Modeling System

AERMOD is the preferred regulatory near-field, steady state model from EPA for modeling industrial sources. Model development began in 1993 (development of the meteorological preprocessor, AERMET, began in 1992) with the objective of having methods that capture the essential physics, provide plausible concentration estimates, and demand reasonable model inputs while remaining as simple as possible. After extensive review and comment, evaluations, and updates, AERMOD was promulgated in 2005, succeeding EPA's workhorse model of 30 years, the Industrial Source Complex Short Term (ISCST3). AERMOD includes state-of-the-art modeling concepts that incorporate air dispersion based on planetary boundary layer (PBL) turbulence structure and scaling concepts, including treatment of both surface and elevated sources, and both simple and complex terrain. AERMOD handles the computation of pollutant impacts in both flat and complex terrain within the same refined modeling framework, unlike ISCST3 in which complex terrain modeling was based on COMPLEX1, a screening level model.

AERMOD is a steady-state plume model. In the stable boundary layer (SBL), it assumes the concentration distribution to be Gaussian in both the vertical and horizontal. In the convective boundary layer (CBL), the horizontal distribution is also assumed to be Gaussian, but the vertical distribution is described with a bi-Gaussian probability density function (pdf). Additionally, in the CBL, AERMOD treats “plume lofting,” whereby a portion of plume mass, released from a buoyant source, rises to and remains near the top of the boundary layer before becoming mixed into the CBL. AERMOD also tracks any plume mass that penetrates into the elevated stable layer, and then allows it to re-enter the boundary layer when and if appropriate. For sources in both the CBL and the SBL, AERMOD treats the enhancement of lateral dispersion resulting from plume meander.

AERMOD characterizes the PBL through both surface and mixed layer scaling. AERMOD constructs vertical profiles of wind speed, wind direction, turbulence, temperature, and temperature gradient using similarity (scaling) relationships that are based on calculations from AERMET and all available meteorological observations. These profiles are used to extract point values at designated heights and layer-averaged meteorology for AERMOD's transport and dispersion calculations. AERMOD accounts for the vertical inhomogeneity of the PBL in its dispersion calculations. This is accomplished by "averaging" the parameters of the actual PBL into "effective" parameters of an equivalent homogeneous PBL.

AERMET uses hourly observational data (National Weather Service and site-specific) and information provided by the user about the underlying surface to develop boundary layer parameters that are passed to AERMOD for its transport and dispersion modeling calculations. These data are discussed in more detail below.

OCD

Developed by MMS, the Offshore and Coastal Dispersion (OCD) model is applicable to coastal projects which include offshore sources of air emissions that impact onshore areas of flat terrain. For example, oil development projects that include emissions from one or more offshore platforms, associated mobile sources such as tankers or supply boats, and coastal processing facilities would use the OCD model for all offshore emissions and for all onshore point source emissions within one kilometer of the coastline. Offshore mobile sources, such as vessels and barges, can be simulated as a line source with OCD or as a series of point sources. Fugitive hydrocarbon emissions from offshore sources are also to be simulated as multiple point sources

OCD is a straight line Gaussian model developed to simulate the effects of offshore emissions from point, area, or line sources on the air quality of coastal regions and includes special algorithms that account for overwater plume transport and dispersion, as well as changes that take place as the plume crosses the shoreline and interacts with the over land environment by means of a virtual point source treatment.

The model was developed in the 1980's with a minor update in the 1990's for a more robust model when following the plume trajectory. Model options allow OCD to differentiate the meteorological situation over the land and the sea, account for offshore platform downwash, evaluate the partial penetration of the plume when a temperature inversion is present, and compute fumigation episodes based on overwater and overland stability differences. In addition, the user has the option to input turbulence intensities directly into the model.

In addition to modeling offshore sources, OCD can model onshore sources in the same model run. The overland scenarios are based on EPA's MPTER model (Pierce and Turner, 1980; Chico and Catalano, 1986) for dispersion over a flat to rolling terrain, and the subroutines based on RTDM (Paine and Egan, 1987) model to consider dispersion in complex terrain where receptors are above stack top. However, EPA's *Guideline on Air Quality Models* in 40 CFR 51, Appendix W (EPA, 2005) states that "… OCD is not recommended for use in air quality impact assessments for onshore sources." When fumigation conditions are expected to occur from a source or sources with tall stacks located on or just inland of a coastline, EPA's Shoreline Dispersion Model (SDM) may be applied on a case by case basis. SDM was released in 1990 and has not been updated since. Information is scarce on the physics and data requirements for SDM. When sources are further from the shoreline or coastal fumigation is not expected, AERMOD may be the preferred model for over land simple and complex terrain applications.

A graphical user interface and a control file similar to the one for CALPUFF were implemented for OCD, along with some other updates to the code that do not include changes to the dispersion algorithms. Hourly meteorological data are needed from both offshore (air-sea temperature difference and over-water wind speeds) and onshore locations and uses the same meteorological input as the ISCST3 model for the onshore location. OCD has simplified chemistry via monthly decay rates.

When compared to AERMOD, OCD lacks some of the more recent advances in dispersion modeling. These include the PRIME downwash algorithms, Plume Volume Molar Ratio Method (PVMRM) for estimating NO_2, and plume meander for improved estimates under light wind conditions. Additionally, for downwash, a single structure width and height at or near the stack location that is the primary influence on downwash effects is specified rather than the direction dependent parameters specified in models such as AERMOD and CALPUFF.

AERMOD-COARE

AERMOD is generally applied for onshore regulatory applications, whereas OCD is an approved regulatory model for offshore applications. The AERMOD Coupled Ocean-Atmosphere Response Experiment (COARE) model, developed by Environ Corporation International (Environ), is an alternative approach to modeling nearshore impacts where overwater influences may be important. The model bypasses the AERMOD meteorological preprocessor and uses the COARE air-sea flux algorithm and overwater meteorological measurements to account for the influence of overwater transport on plume dispersion.

The rationale for the approach, assemblage of the meteorological data, and evaluation of the AERMOD-COARE approach is described in a report by Environ (2010). The argument is that there is no preferred regulatory model for offshore applications. The alternative approach is that replacing AERMET with COARE provides a meteorological input file that is more consistent for marine applications. Environ's assumption is that "given an appropriate characterization of meteorology conditions over water, the diffusion algorithms within AERMOD should perform in a fashion similar to the results found in the many field studies that lead to it becoming the EPA Guideline model over land. AERMOD would be used for the dispersion model predictions and would be applied in a manner consistent with new source review procedures over land."

Pursuant to Section 3.2.2.e of Appendix W in 40 CFR 51, EPA Region 10 on April 1, 2011 approved the use of AERMOD-COARE by Shell in their 2011 modeling assessments conducted in support of the Discovery and Kulluk OCS permit applications (EPA, 2011b). The use of AERMOD-COARE was limited to ice free (open water) conditions and AERMOD with AERMET was used when sea ice was present. The Office of Air Quality Planning and Standards concurred with the EPA Region 10 on May 6, 2011 (EPA, 2011c).

While EPA Region 10 allowed the use of AERMOD-COARE for the Shell OCS projects, it is still considered as an alternative model under Section 3.2.2.e of Appendix W in 40 CFR 51. Therefore, further use in a regulatory application would still require case-by-case approval under the regulation.

CALPUFF Modeling System

The far-field model approved by EPA for regulatory applications is CALPUFF and its components. CALPUFF is a multi-layer, multi-species non-steady-state time- and space-dependent Gaussian puff model intended for use on scales from tens of meters from a source to hundreds of kilometers. CALPUFF includes parameterized gas phase chemical transformation of SO_2, $SO_4^{=}$, NO, NO_2, HNO_3, NO_3^{-}, and organic aerosols. For regional haze analyses, sulfate and nitrate particulate components are explicitly treated. CALPUFF can treat primary pollutants such as PM-10, toxic pollutants, ammonia, and other passive pollutants. The model includes a resistance-based dry deposition model for both gaseous pollutants and particulate matter. Wet deposition is treated using a scavenging coefficient approach. The model has detailed parameterizations of complex terrain effects, including terrain impingement, side-wall scrapping, and steep-walled terrain influences on lateral plume growth. A subgrid-scale complex terrain module based on a dividing streamline concept divides the flow into a lift component traveling over the obstacle and a wrap component deflected around the obstacle.

The meteorological fields used by CALPUFF are produced by the CALMET meteorological model. CALMET includes a diagnostic wind field model containing objective analysis and parameterized treatments of slope flows, valley flows, terrain blocking effects, and kinematic terrain effects, lake and sea breeze circulations, and a divergence minimization procedure. CALMET contains interfaces to prognostic meteorological models such as the Penn State/NCAR Mesoscale Model (e.g., MM5; Section 13.0, ref. 94), as well as the Regional Atmospheric Modeling System (RAMS) and North American Mesoscale (NAM/Eta) models.

There are multiple versions of CALPUFF: 1) a regulatory-approved version (5.8) and 2) an updated version (6.4.2), which has not been approved for regulatory applications, but incorporates several updates to the modeling system. CALPUFF can be applied in the near-field in regulatory applications, but only if other near-field models are not appropriate. Determination on the applicability of CALPUFF in the near-field is on a case-by-case basis. It is up to the user to make a compelling argument that CALPUFF should be used to estimate near-field impacts in a regulatory application otherwise EPA will not approve its use (EPA, 2008). CALPUFF is recommended for far-field impacts – beyond 50 km. Without a rigorous analysis on each application of CALPUFF, the model cannot be recommended for near-field regulatory applications.

CALPUFF-COARE

The CALPUFF modeling system was updated to include an option to use COARE algorithms in CALMET (Scire et al., 2005). A new buoy preprocessor was introduced that creates revised

SEA.DAT files for CALMET with wave data for the COARE overwater flux option. The new processor can read data files readily obtained from the National Oceanographic Data Center (NODC) and National Data Buoy Center (NDBC) web sites.

In addition, CALPUFF (v. 6.42) was updated to include a building downwash adjustment for elevated (platform) structures with an open area between the surface and the bulk of the structure. These and other enhancements are available in the recent CALPUFF modeling system versions, but are not part of the system approved for regulatory applications (model version 5.8).

3.2.3. Regional Photochemical Grid Models

According to the EPA, "These models are typically used in regulatory or policy assessments to simulate the impacts from all sources by estimating pollutant concentrations and deposition of both inert and chemically reactive pollutants over large spatial scales." Although EPA states that these models can be used in a regulatory assessment, the models in this section are more complex than what would normally be used in a regulatory permitting application.

Community Multiscale Air Quality (CMAQ) Modeling System

The CMAQ (Byun and Ching, 1999) modeling system is designed to model multiple air quality issues, including tropospheric ozone, fine particles, toxics, acid deposition, and visibility degradation. CMAQ is designed to handle scale dependent meteorological formulations and affords a large amount of flexibility. The CMAQ modeling system simulates various chemical and physical processes important for understanding atmospheric trace gas transformations and distributions. The CMAQ modeling system contains three types of modeling components: a meteorological modeling system for the description of atmospheric states and motions, emission models for man-made and natural emissions that are injected into the atmosphere, and a chemistry-transport modeling system for simulation of the chemical transformation and fate. CMAQ is designed to handle scale dependent meteorological formulations and a large amount of flexibility.

CMAQ has a "one atmosphere" perspective that combines the efforts of the scientific community. The CMAQ system is designed to have a flexible community modeling structure based on modular components. Improvements will be made to the CMAQ modeling system as the scientific community further develops the state-of-the-science. In other words, contributions to the science in CMAQ are not limited to one person, group, or agency. Rather it is a collaborative effort of the scientific community.

The CMAQ modeling system consists of several processors and the chemical-transport model:

- Meteorology-chemistry interface processor (MCIP)
- Photolysis rate processor (JPROC)
- Initial conditions processor (ICON)
- Boundary conditions processor (BCON)
- CMAQ chemical-transport model (CCTM)

__C__omprehensive __A__ir Quality __M__odel with E__x__tensions (CAMx)

CAMx (Environ Corp., 2010) is a publicly available modeling system for the integrated assessment of photochemical and particulate air pollution. Since air quality issues reach beyond the urban scale, CAMx is designed to evaluate the impacts of air pollution over many geographic scales from suburban to continental, be computationally efficient, and be easy to use. CAMx incorporates two-way grid nesting which means that pollutant concentration information propagates into and out of all grid nests during model integration. Any number of grid nests can be specified in a single run, while grid spacing and vertical layer structures can vary from one grid nest to another. Low-level (gridded) emissions are released into the lowest (surface) layer of the model, and elevated stack-specific (point) emissions with buoyant plume rise can be emitted into any model layer.

According to the CAMx User's Guide, "CAMx inputs are developed using independent third-party models and processing tools that characterize meteorology, emissions, and various other environmental conditions (land cover, radiative/photolysis properties, and initial/boundary conditions). Interface programs are needed to translate the products of each of these models/processors into the specific input fields and formats required by CAMx. After the air quality simulation is completed, additional programs are used to post-process the concentration fields, develop model performance statistics and measures, manipulate Probing Tool output into various reportable formats, and further translate raw results into forms necessary for regulatory purposes" (Environ, 2010).

3.2.4. Recommendations

APPENDIX B shows two tables from the June 2011 Memorandum of Understanding[1] that provide guidelines addressing models to consider based on the purpose for performing an air quality modeling analysis. There are a few models in those tables that are not discussed above and several models are discussed above that are not included in the MOU tables. The recommendations below are based on the models presented above.

For assessing impacts on the North Slope, refined models and regional scale models are the preferred candidates. Although fumigation is an important process, it is limited to coastal areas and may not be appropriate for assessing impacts for inland areas further from the coast. For assessing cumulative impacts, regional/photochemical grid models and possibly a refined model are appropriate, depending on the nature of the assessment and size of the domain under consideration. For regional scale modeling for which the domain is defined as the entire North Slope, the photochemical grid models are preferable, whereas for large sub-areas within the North Slope a refined model that can be applied out to several hundred kilometers may be more applicable.

A consideration in selecting an appropriate model for regulatory or cumulative assessments is the computational effort required to run a model and the model run time. Screen models require the least amount of computer power and usually run in a few seconds to a few minutes. Refined models can generally run on desktop computers available today, but may take a long period of time to run depending on the number of sources and number or receptors modeled. Photochemical grid models have the most rigorous computing requirements.

With its state-of-the science algorithms and relative simplicity of applying the model, AERMOD and its components and supporting tools (collectively known as the AERMOD Modeling System) are recommended for near-field impacts on the Alaska North Slope and inland regulatory assessments.

For far-field impacts and possibly cumulative impacts that do not extend across the entire North Slope, the CALPUFF model is recommended. If the assessment is for a regulatory application, then version 5.8 should be used. For other assessments, and with approval from appropriate regulatory agencies, version 6.42, and the associated preprocessors should be considered.

For near-shore assessments where the waters and atmosphere of the Beaufort and Chukchi Seas may have an influence, either AERMOD-COARE or CALPUFF-COARE (which is contained in version 6.42) is recommended. Neither of these models is approved for regulatory applications, and should be used only for non-regulatory assessments or when a compelling argument to use one or the other in a regulatory application can be made. While the OCD model may also be considered for regulatory applications, the algorithms represent older methods for dispersion.

If a cumulative assessment across the entire North Slope is to be performed, then a photochemical grid model is recommended to account for long-range transport of pollutants into the region and chemical transformations. There are two models: CMAQ and CAMx. A more detailed analysis is required to determine which model to use.

3.3 SUMMARY OF MODEL INPUT REQUIREMENTS FOR RECOMMENDED MODELS

The input requirements for the different models can vary widely. Screening models generally require very little input and the estimates, by design, are very conservative. Screening models can be useful for a single source where impacts are not expected to exceed local or national standards. Input requirements for refined modeling are more intensive and as the refined model becomes more complex, so do the inputs. Here we provide a description of the input requirements for AERMOD and CALPUFF.

3.3.1. Near Field - AERMOD

AERMOD is a straight-line, steady-state plume dispersion model that incorporates planetary boundary layer turbulence structure and scaling concepts, including treatment of both surface and elevated sources, and both simple and complex terrain.

Figure 3.1 shows a flow diagram for the AERMOD dispersion modeling system. The primary inputs are meteorological data (AERMET) which requires land use data (AERSURFACE), terrain data (AERMAP), building information for downwash calculations (BPIPPRM), and a control file (not shown) that directs the calculations in AERMOD.

For North Slope applications, meteorological data may be the most problematic to obtain. A requirement for meteorological data for any dispersion modeling effort is that the data must be representative of the site being modeled. AERMET is the meteorological processor for

AERMOD and can use National Weather Service (NWS) data (surface weather observations and upper air data), site-specific data, and hour averages of 1-minute Automated Surface Observation System (ASOS) data.

Figure 3.2 shows the input requirements and processing for AERMET.

Figure 3.1: Components of the AERMOD Modeling System

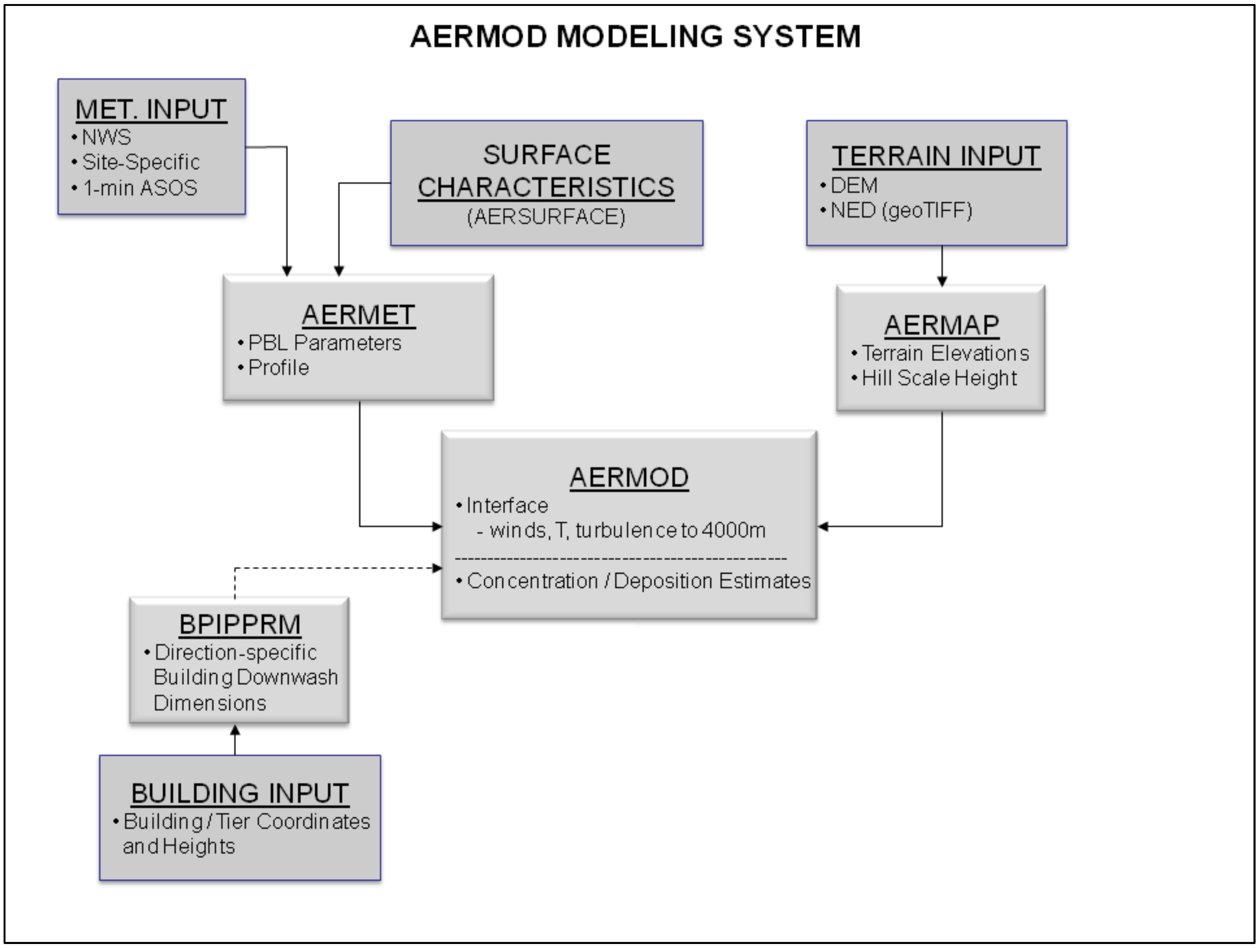
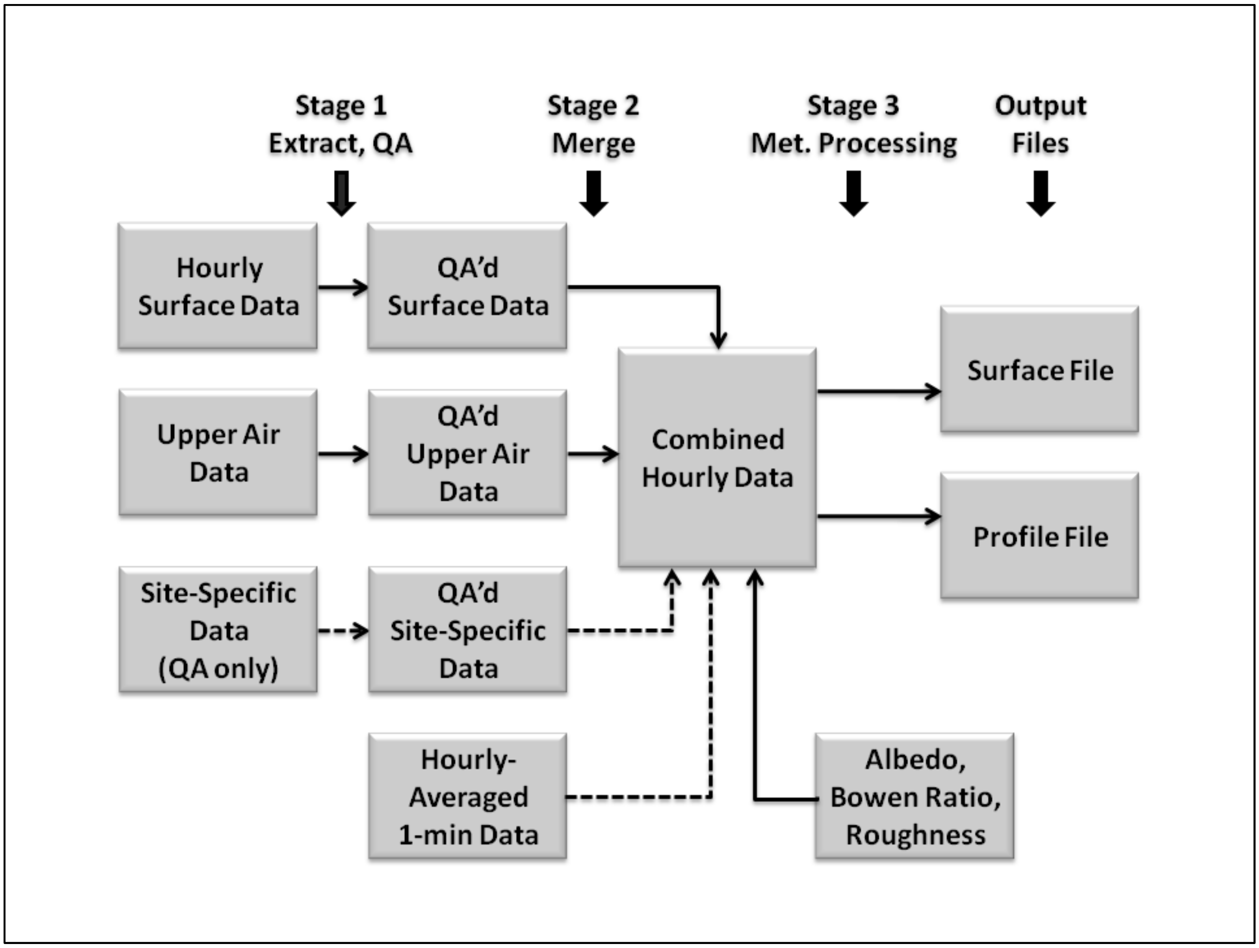


Figure 3.2: AERMET Input and Processing



While AERMET is designed to operate with NWS data only, the scarcity of hourly surface NWS observations on the North Slope makes site-specific data a necessity. Facilities on the North Slope, as well as all over Alaska, collect hourly meteorological data from instrumented towers. The minimum site-specific parameters, in lieu of NWS data, required to run AERMET are wind speed and direction (usually near 10 meters), temperature at two levels (usually 2 and 10 meters), and solar radiation. Other parameters that may be collected are barometric pressure and precipitation. For site-specific data to be used in a model, the data must be deemed as PSD quality. AERMET also requires twice-daily upper air soundings (vertical profiles of the atmosphere from the surface up to several tens of thousands of feet), usually at or near 0000 Greenwich Mean Time (GMT) and 1200 GMT. Upper air data are not collected by the facilities, and modeling with AERMET requires use of NWS data for this purpose. The only NWS site on the North Slope that collects upper air data is at Barrow, Alaska.

In addition to the NWS or site-specific data, AERMET requires an estimate of several parameters that describe the surface conditions surrounding the measurement site. These are the albedo (a measure of light reflected by the earth's surface), Bowen ratio (a measure of the moisture content), and roughness length (a measure of the roughness over which the wind is blowing). A tool developed by EPA, AERSURFACE (EPA, 2008a), processes land use/land cover (LULC) data from the United States Geological Survey (USGS) to determine these parameters. The publicly available version of AERSURFACE (version 08009) is limited to the continental United States since the program currently only processes 1992 USGS data, which does not have LULC data for Alaska. To overcome this limitation, a procedure was developed by ADEC to determine these parameters via hand calculations (ADEC, 2009).

3.3.2. Far Field/Regional - CALPUFF

CALPUFF is a multi-layer, non-steady state puff dispersion model. Unlike AERMOD where meteorological conditions are assumed uniform for the hour and across the modeling domain, CALPUFF simulates the effects of time- and space-varying meteorological conditions on pollution transport, chemical transformation, and removal.

CALPUFF was developed under contract to the U.S. EPA, but remains in the private sector. There are multiple versions of CALPUFF: 1) a regulatory-approved version (5.8) and 2) a publicly available (version 6.42) but not approved for regulatory applications. Note that the version numbers refer to the dispersion model. The components in the CALPUFF modeling system have a different version number and those components have been updated as well.

The main differences between version 5.8 and 6.42 of the dispersion model are an option to use an alternative method to compute the convective mixing heights and use of sub-hourly time steps for near-field applications. An analysis performed by a private consultant confirmed that when both versions are run with 1-hr time steps and other options and assumptions are identical, the results from the two versions are equivalent (to 3 decimal digits). There are some differences between the two versions in CALMET, but they are virtually the same.

The CALPUFF modeling system requires more information than AERMOD as seen in Figure 3.3, although many of the input files are optional. Only two files are required to run the dispersion model - the control file and the meteorology (bold italic in Figure 3.3). Output from CALPUFF requires use of CALPOST, a postprocessor used to obtain the desired information from the output file(s).

CALMET is the meteorological processor for CALPUFF. The input requirements and options are more complex than for AERMOD (see Figure 3.4). Most of the files are required, with only a few optional files. Although CALMET can process multiple hourly NWS files, it cannot process directly site-specific data. In order to use site-specific data, whether it is one file or multiple files, the file must be converted to an NWS format recognized by CALMET.

Developing the input files for CALMET is a resource-consuming exercise. A simple set of meteorological data with only a few stations can require over 100 hours to prepare the meteorological data, depending on the complexity of the application, availability of data, and assumptions made. A large part of this effort is checking the quality of the data before and after a model run. There can be failed model runs that are due to problems with the meteorology that do not become apparent before running the model.

3.3.3. Photochemical Grid – CMAQ or CAMx

Both CMAQ and CAMx are very complex, input intensive photochemical grid models. Based on the initial review of these models, there is no compelling reason to select one model over the other. CMAQ is supported by EPA, whereas CAMx is privately developed but publicly available. For that reason, CMAQ may be the preferred model for this type of analysis.

Before recommending one model over the other, though, further investigations of these two models are needed.

Figure 3.3: CALPUFF Modeling System

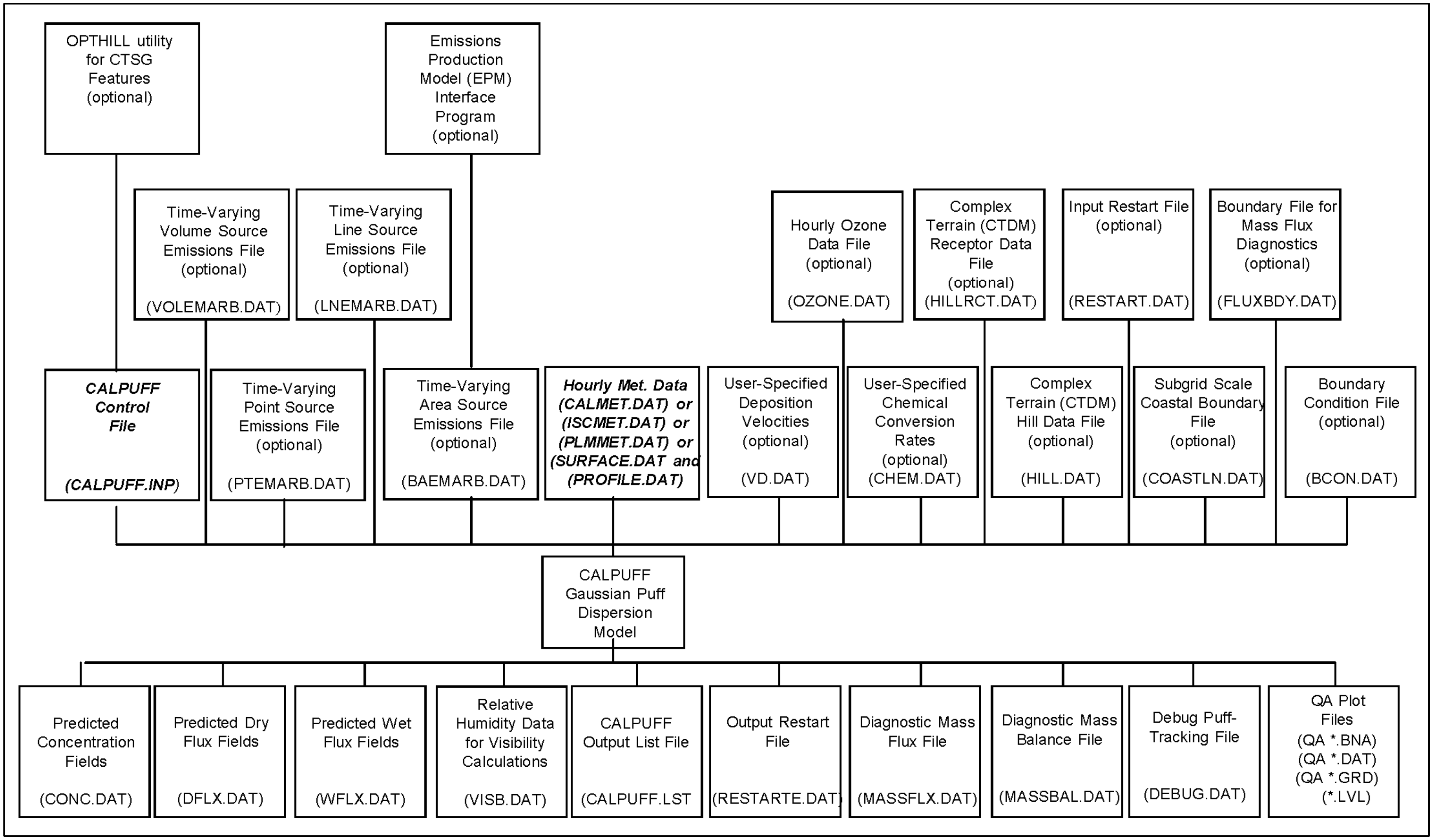
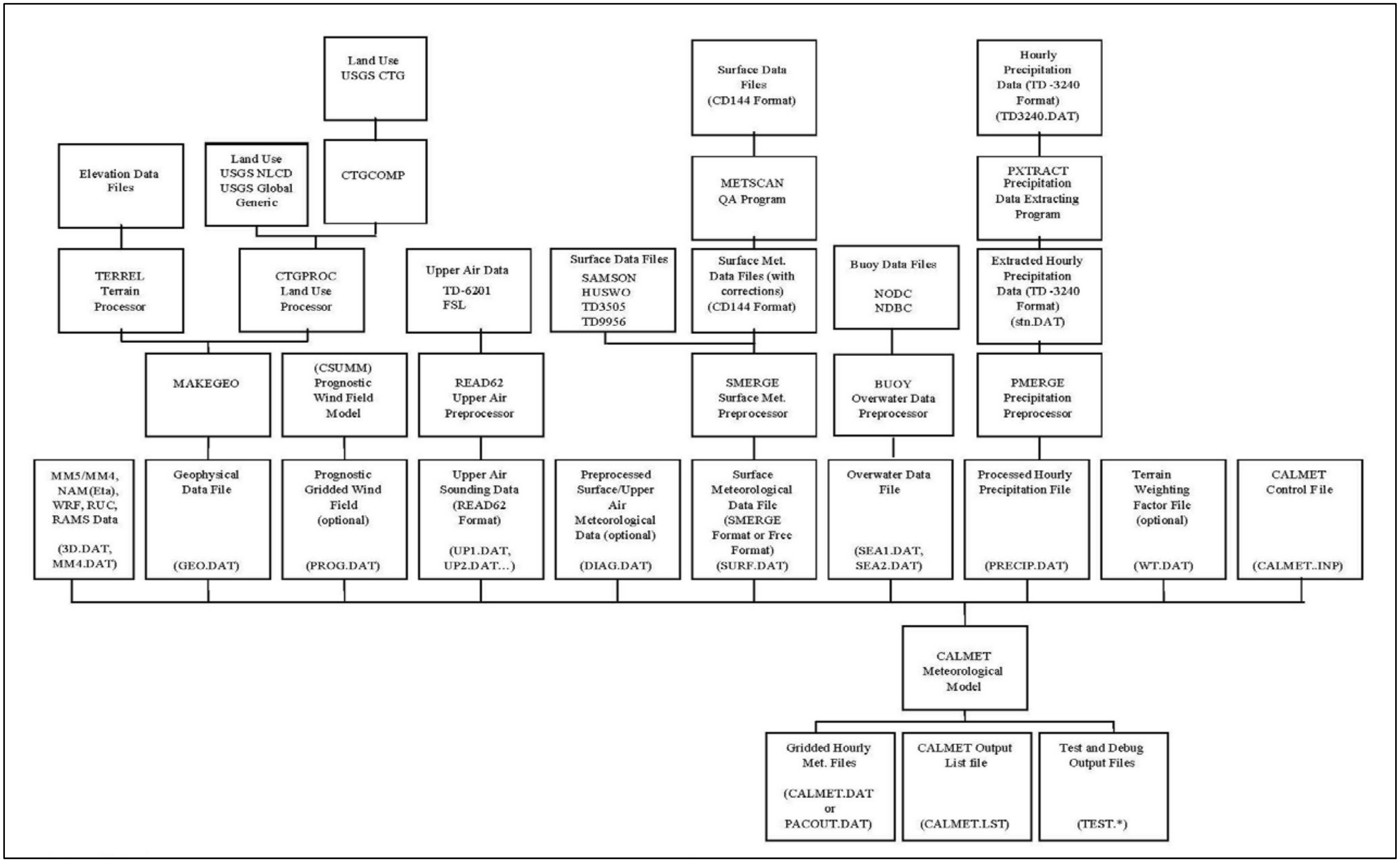


Figure 3.4: CALMET Flow Diagram



3.4 REFERENCES

ADEC, 2009: *ADEC Guidance re AERMET Geometric Means*, Alaska Department of Environmental Conservation, Air Permits Program, April 7, 2009.

Byun, D. and J. Ching, 1999: *Science Algorithms of the EPA Models-3 Community Multiscale Air Quality (CMAQ) Modeling System*. EPA/600/R-99/030, Office of Research and Development, Washington DC, March 1999.

Chico, T. and J.A. Catalano, 1986. *Addendum to the User's Guide for MPTER*. U.S. Environmental Protection Agency, Research Triangle Park, NC, NC 27711

Department of the Interior, 1997: *User's Guide for Offshore and Coastal Dispersion (OCD) Model Version 5*. Minerals Management Service, Gulf of Mexico OCS Region, November 1997.

Environ Corp., 2010: *User's Guide Comprehensive Air Quality Model with Extensions, version 5.30.* Environ International Corporation, Novato, CA.

EPA, 1989: *User's guide to the Complex Terrain Dispersion Model Plus Algorithms for Unstable Situations (CTDMPLUS): Volume 1. Model Description and User Instructions*. EPA/600/8-89/041, U.S. Environmental Protection Agency, Atmospheric Research and Exposure Assessment Laboratory, Research Triangle Park, NC 27711, March 1989.

EPA, 2004a: *User's Guide for the AERMOD Meteorological Preprocessor (AERMET).* EPA-454/B-03-002, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711.

EPA, 2004b: *User's Guide for the AERMOD Terrain Preprocessor (AERMAP)*. EPA-454/B-03-003. U.S. Environmental Protection Agency, Research Triangle Park, NC 27711.

EPA, 2004c: *AERMOD User's Guide*. EPA-454/B-03-001, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, September 2004.

EPA, 2004d: *AERMOD: Description of Model Formulation*. EPA-454/R-03-004, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, September 2004.

EPA, 2005: Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions; Final Rule, 40 CFR, Part 51, Appendix W, November 9, 2005.

EPA, 2006: *Addendum - User's Guide for the AERMOD Meteorological Preprocessor (AERMET)*. EPA-454/B-03-002, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711.

EPA, 2008a: *AERSURFACE User's Guide*. EPA-454/B-08-001, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, January 2008.

EPA, 2008: *Clarification of Regulatory Status of CALPUFF for Near-field Applications.* U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, 27711.

EPA, 2009: *Addendum - User's Guide for the AERMOD Terrain Preprocessor (AERMAP).* EPA-454/B-03-003. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711.

EPA, 2011a: *AERSCREEN User's Guide*. EPA-454/B-11-001, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, 27711, March 2011.

EPA, 2011b: *Memorandum - COARE Bulk Flux Algorithm to Generate Hourly Meteorological Data for Use with the AERMOD Dispersion Program; Section 3.2.2.e Alternative Refined Model Demonstration.* U.S. Environmental Protection Agency, Region 10, Seattle, WA 98101, 1 April 2011.

EPA, 2011c: *Memorandum – Model Clearinghouse Review of AERMOD-COARE as an Alternative Model for Application in an Arctic Marine Ice Free Environment.* U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, 27711, 6 May 2011.

Paine, R., and B. Egan, 1987: User's Guide to the Rough Terrain Dispersion Model (RTDM) (Rev. 3.20). EPA/SW/MT-88/041A, U.S. Environmental Protection Agency, Research Triangle Park, NC.

Pierce, Thomas D. and D. Bruce Turner, 1980. User's Guide for MPTER. EPA-600/8-80-016, U.S. Environmental Protection Agency, Research Triangle Park, NC.

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

Scire, J., D. Strimaitis, and R. Yamartino, 2000: *A User's Guide for the CALPUFF Dispersion Model (Version 5)*. Earth Tech, Inc., Concord, MA.

Scire, J., D. Strimaitis, and F. Robe, 2005: *Evaluation of Enhancements to the CALPUFF Model for Offshore and Coastal Applications*. 10th Conference on Harmonization within Atmospheric Dispersion Modeling for Regulatory Purposes, Sissi, Crete, October 17-20, 2005.

4. EMISSION SOURCES/SOURCE CHARACTERISTICS ON THE NORTH SLOPE

In this section, a general description of various pollutants of interest, activities producing pollution and a compilation of industrial point sources are presented.

4.1 POLLUTANTS OF INTEREST

In 1970, Congress created the Environmental Protection Agency and passed the Clean Air Act, giving the federal government authority to clean up air pollution in this country. Since then, EPA and states, tribes, local governments, industry, and environmental groups have worked to establish a variety of programs to reduce air pollution levels across America.

Air pollution negatively impacts our environment and leads to significant environmental issues to contend with such as smog, acid rain, the greenhouse effect, and "holes" in the ozone layer. Each of these problems has serious implications for our health and well-being, as well as for the environment. Through the years, there have been a variety of regulatory schemes and voluntary initiatives to reduce the harmful effects of air pollution. Examples include command-and-control regulations, cap-and-trade programs, fuel economy standards, and pollution prevention activities.

The Clean Air Act is arguably the most complex piece of environmental legislation in the world. Table 4.1 identifies how air pollutants are classified under the Clean Air Act, briefly describes the health and environmental impacts of each class of pollutants, and summarizes the regulatory schemes that have been developed to reduce the impacts on health and the environment. For further information, refer to EPA's *Plain English Guide to the Clean Air Act* (EPA, 2007) which can be viewed online at: http://www.epa.gov/air/caa/peg.

Table 4.1: Health and Environmental Impacts of Pollutants and Regulatory Activities

Air Pollutant Category	Health and Environmental Effects	Overview of Regulatory Framework
National Ambient Air Quality Standard (NAAQS) / **Criteria Air Pollutant (CAP)** Carbon Monoxide Lead Nitrogen Dioxide Ozone (ground level) Coarse Particulate Matter (PM-10) Fine Particulate Matter (PM-2.5) Sulfur Dioxide Volatile Organic Compounds (VOCs)	•Long-term exposure is linked to lung cancer, heart disease, asthma attacks, increased mortality and other health problems. •Short-term exposure has been linked to headaches and nausea, increased hospital visits for asthma and respiratory problems, and eye irritation. •People with lung disease, children, older adults, and people who are active can be affected when ozone and fine particle levels are unhealthy. •Some CAPs can also have effects on aquatic life, vegetation, and animals.	**U.S. EPA** sets NAAQS based on "Criteria Documents" that lay out the latest scientific evidence of the adverse effects to human health and public welfare. **U.S. EPA** establishes national emission standards for new source and mobile sources. **State and local agencies** monitor ambient air quality to determine whether an area violates the NAAQS and develop state implementation plans (SIPs) to ensure healthy air. **State agencies** and **U.S. EPA** issue permits to **facilities** to ensure that new and modified sources utilize state-of-the-art pollution controls and do not significantly deteriorate air quality **State and local agencies** monitor compliance with pollution control requirements.
Hazardous Air Pollutant (HAP) Includes 188 chemicals, such as arsenic, benzene, formaldehyde, mercury, and dioxins.	•Some HAPs are known or suspected to cause cancer. •Other HAPs may cause respiratory effects, birth defects, and reproductive and other serious health effects. •Some HAPs can even cause death or serious injury if accidentally released in large amounts.	**U.S. EPA** developed "technology based" regulations - MACT standards - requiring sources to meet specific emissions limits based on emissions levels already achieved in practice by similar sources. **U.S. EPA** may use a "risk-based" approach to implement additional standards to address any significant remaining, or residual, health or environmental risks.
Haze and Visibility Precursors Particulate Matter and precursors (including sulfur dioxide and oxides of nitrogen which react in the air to form sulfate and nitrate particles)	•These pollutants absorb and scatter light, reducing the clarity and color of what we see. •Scenic and historic vistas in urban areas, national parks and wilderness areas can be obscured during certain times of the year by a veil of white or brown haze.	**Regional Planning Organizations (RPOs) and State agencies** are putting together plans to reduce regional haze in national parks and wilderness areas. These are the first steps in meeting the national goal of eliminating the manmade pollution that impairs visibility.
Acid Deposition (Acid Rain) Precursors Including sulfur dioxide and oxides of nitrogen which react in the air to form sulfate and nitrate particles)	•Acid rain causes acidification of lakes and streams and contributes to the damage of trees at high elevations and sensitive soils. •Acid rain accelerates the decay of building materials and paints, including irreplaceable buildings, statues, and sculptures that are part of our nation's cultural heritage.	**U.S. EPA** set up a cap-and trade system for power plant emissions. Allowances may be bought, sold, or banked. However, regardless of the number of allowances a source holds, it may not emit at levels that would violate federal or state limits set to protect public health.
Greenhouse Gases Primarily carbon dioxide, methane and black carbon	•Some observed changes include shrinking of glaciers, thawing of permafrost, earlier break-up of ice on rivers and lakes, lengthening of growing seasons, shifts in plant and animal ranges and earlier flowering of trees.	**U.S. EPA** now requires reporting by major sources and greenhouse gases trigger permits for the Prevention of Significant Deterioration (PSD) of air quality. **State and local agencies** are beginning to develop Action Plans to reduce emissions
Ozone Depleting Chemicals Chemicals such as CFCs, halons, and methyl chloroform	•Ozone depletion causes increased UV radiation to reach the Earth which can lead to more cases of skin cancer.	**U.S. EPA** has established regulations to phase out ozone-depleting chemicals in the United States.
Indoor Air Quality Pollutants Asbestos, mold, lead, radon, second hand smoke	•Exposure can result in allergic reactions, asthma, and other respiratory complaints similar to effects from CAPs and HAPs.	**U.S. EPA** and **State and local agencies** jointly administer a variety of programs to reduce exposure to indoor air pollution.

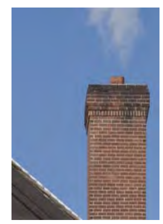
For further information, see: http://www.epa.gov/air/basic.html

4.2 SOURCE ACTIVITIES PRODUCING POLLUTION

There are numerous human activities and natural events that generate air pollution. Sources of air pollution are generally categorized into five major sectors. These are:

Point Sources are comprised of stationary facilities that emit pollutants above a certain threshold, from a stack, vent or similar discrete point of release. Air quality permits are issued to industries and facilities to ensure that these emissions do not harm public health or cause significant deterioration in areas that presently have clean air. The permit also ensures that facilities make adequate provisions to control their emissions.

Area Sources are sources of air pollutants that are diffused over a wide geographical area. Area sources include sources that in and of themselves are insignificant, but in aggregate may comprise significant emissions. Examples would be emissions from small dry cleaners, home heating boilers, and VOCs volatizing from house painting or consumer products. The fuels used mainly for heating in Alaska include wood, propane, and fuel oil.



Mobile Onroad Sources are sources of air pollution from internal combustion engines used to propel cars, trucks, buses, and other vehicles on public roadways. Exhaust emissions are typically estimated using EPA emission factor models such as MOBILE6 or MOVES and counts of vehicle miles traveled. Emissions are typically calculated by road type, vehicle type, and fuel type. One of the major sources of PM-10 and PM-2.5 emissions is fugitive dust from unpaved roadways typical in rural Alaska.

Mobile Nonroad Sources are sources of air pollution from internal combustion engines used to propel trains, airplanes, and marine vessels, or to operate equipment such as forklifts, lawn and garden equipment, portable generators, etc. The EPA NONROAD model calculates emissions from approximately 80 different types

of nonroad equipment, and categorizes them by technology type (i.e., gasoline, Diesel, LPG, CNG, 2-stroke, and 4-stroke) and horsepower range. Emissions from nonroad equipment can be estimated using either total fuel use or hours of operation. Emissions from trains, airplanes, and marine vessels are calculated using methodologies unique to those types of sources.

Natural Sources create emissions from biogenic and geogenic processes associated with vegetation, soils, wildfires, sea salt and volcanoes. The sharp scent of pine needles, for instance, is caused by monoterpenes, which are among the group of VOCs. The EPA has developed models that estimate emissions of biogenic VOCs from vegetation for natural areas, crops, and urban vegetation. ADEC and the Division of Forestry track the time periods, size and location of wildfires throughout the State on a yearly basis, and use emission factors to estimate particulate emissions from each fire.

Available Emission Inventory Data

The following references have quantified emissions for most of the inventory sectors discussed above:

- **ADEC Point Source Inventory**. ADEC is required by Federal Regulations 40 CFR 51.321 to submit a statewide point-source emission inventory to the EPA every three years. ADEC requires individual facilities to provide detailed process-level emissions for criteria pollutants and information regarding stack characteristics and location. See Section 4.2.1 for a detailed analysis of the ADEC industrial point source inventory. The ADEC point source inventory can be accessed online at: https://myalaska.state.ak.us/dec/air/airtoolsweb/EmissionInventory.aspx.

- **EPA National Emission Inventory (NEI)**. The NEI is based primarily upon emission estimates and emission model inputs provided by State, Local, and Tribal air agencies, supplemented by data developed by the EPA. The NEI is developed on a 3-year cycle, with the current version based on 2008 data and commonly referred to as the NEI2008. Most of the NEI2008 point source inventory is based on data provided directly from the ADEC point source inventory described above. Other NEI2008 inventory sectors (onroad mobile, nonroad mobile, and area sources) are based on data, methods, and models that were developed primarily for use in the lower 48 States and may not be entirely representative of the conditions in the North Slope Borough. Additional information about the NEI and NEI2008 can be found online at: http://www.epa.gov/ttn/chief/net/2008inventory.html#inventorydoc.

- **Alaska Rural Communities Emission Inventory**. The NEI2008 for non-point sectors may not accurately estimate emissions in Alaska, especially in rural areas. ADEC and Sierra Research, Inc. developed calendar year 2005 area, onroad, and nonroad emission inventories that were representative of rural areas in Alaska (Sierra Research, 2007). The basic approach used to estimate emissions from the rural communities consisted of: (1) collecting information on 2005 seasonal activity and fuel use from 13 representative rural communities in the state using surveys; (2) developing emissions inventories for those representative rural communities; extrapolating those results to other communities based on similarities in geography, location, and size. The full report that describes the Alaska Rural Communities Emission Inventory can be downloaded online at: http://www.epa.gov/region10/pdf/tribal/wrap_alaska_communities_final_report.pdf.

- **2009 Alaska Wildfire Emissions Inventory**. ADEC is responsible for collecting, reviewing, tracking, and summarizing statewide fire data and preparing the annual Alaska Enhanced Smoke Management Plan emission inventory reports. ADEC prepared a summary of the 2009 fires, their type, start and end dates, locations, and acreages using data to DEC by the Division of Forestry. Emission factors (tons of pollutant per acre) are used for the various vegetation types with the Division of Forestry data to estimate emissions (ADEC, 2011). The complete report describing the 2009 Alaska Wildfire Emissions Inventory can be downloaded online at: http://fire.ak.blm.gov/content/admin/awfcg_committees/Air%20Quality%20and%20Smoke%20Management/6_2009%20AK%20WF%20EI%20rpt%20050411.pdf.

Table 4.2 summarizes the NEI2008 information for the North Slope Borough. Emissions were quantified for a variety of point, area, onroad, and nonroad categories. The emissions from point sources clearly dominate the inventory. This is as expected because of the sparse population and limited road network on the North Slope. Urban areas with great population density and traffic, such as Fairbanks or Anchorage, tend to have emissions roughly distributed equally among the four sectors, depending on the pollutant.

According to Alaska Department of Transportation (as referenced on http://www.prudhoebay.com/), the average daily volume of traffic is about 200 vehicles in the Prudhoe Bay area. The amount of land area in Prudhoe Bay is nearly 90 square kilometers while the amount of surface water is 31 square kilometers. Thus, twenty-five percent of the total surface area of Prudhoe Bay is water. North of the Brooks Range, there is limited traffic, and most of it consists of commercial vehicles. The Prudhoe Bay / Deadhorse area is focused on oil production, transport, and supporting services, and is not set up to handle tourism. The permanent population of Prudhoe Bay is approximately 47 and the number of families is 0 (PrudhoeBay.com).

Table 4.2: NEI2008 Emission Summary for the North Slope Borough

	2008 Annual Emissions (tons/year)					
Category	**CO**	**NO_X**	**PM-10**	**PM-2.5**	**SO_2**	**VOC**
Fuel Comb - Electric Generation - Natural Gas	830	3,477	94	93	109	50
Fuel Comb - Electric Generation - Oil	126	570	9	9	95	11
Fuel Comb - Industrial Boilers, ICEs – Nat. Gas	6,379	31,511	642	639	706	261
Fuel Comb - Industrial Boilers, ICEs – Oil	137	428	21	18	35	50
Fuel Comb - Industrial Boilers, ICEs – Other	1	<1	1	<1	<1	<1
Industrial Processes - Oil & Gas Production	2,242	1,140	162	95	130	431
Industrial Processes - Petroleum Refineries	93	17	7	6	1	16
Industrial Processes - Storage and Transfer			<1	<1		2
Point Source Subtotal	**9,807**	**37,143**	**936**	**862**	**1,076**	**820**
Point Source % of Total	**77%**	**99%**	**94%**	**96%**	**98%**	**60%**
Fuel Comb - Comm/Institutional - Natural Gas	22	26	2	1	1	1
Fuel Comb - Comm/Institutional – Oil	<1	<1	<1	<1	<1	<1
Miscellaneous Non-Industrial NEC						6
Waste Disposal	41	8	21	16	4	6
Mobile – Aircraft	341	35	4	1	5	28
Mobile - Commercial Marine Vessels	1	12	1	1	7	<1
Mobile - Nonroad Equipment – Diesel	85	61	4	4	8	7
Mobile - Nonroad Equipment – Gasoline	1,133	25	7	6	<1	312
Mobile - Nonroad Equipment – Other	9	2	<1	<1	<1	<1
Mobile – Onroad Diesel Heavy Duty Vehicles	14	46	2	1	<1	3
Mobile – Onroad Diesel Light Duty Vehicles	<1	<1	<1	<1	<1	<1
Mobile – Onroad Gasoline Heavy Duty Vehicles	32	5	<1	<1	<1	2
Mobile – Onroad Gasoline Light Duty Vehicles	1,342	64	1	1	1	117
Gas Stations					<1	39
Solvent - Consumer & Commercial Solvent Use						28
Solvent - Dry Cleaning						2
Solvent - Industrial Surface Coating & Solvents						<1
Construction Dust			18	2		
Area, Onroad, Nonroad Subtotal	**2,997**	**259**	**58**	**32**	**26**	**544**
Area, Onroad, Nonroad % of Total	**23%**	**1%**	**6%**	**4%**	**2%**	**40%**
Total North Slope Borough	**12,804**	**37,402**	**993**	**894**	**1,101**	**1,364**

Table 4.3 compares the NEI2008 emissions to the ADEC Rural Communities emissions for the North Slope Borough. The emissions of NO_X and SO_2 are reasonably comparable between the two inventories. However, the ADEC Rural Communities inventory reports significantly greater amounts of CO, PM-10, PM-2.5, and VOC.

Based on our experience with inventories in other areas, there are two possible explanations for the larger emission estimates in the Rural Communities inventory. The ADEC Rural Communities inventory did not provide emission estimates for subcategories such as home heating or onroad vehicles. One explanation may be differences in assumptions made about residential wood combustion. In other inventories CO, PM and VOC emissions from residential wood combustion can be quite large and may be underestimated in the NEI2008. On the other hand, woody vegetation is not readily available for home heating on the North Slope, so the Rural Communities inventory may overestimate emissions for residential wood combustion. Second, fugitive dust emissions from vehicle travel on paved and unpaved roads vary considerably based on both traffic and climatic factors. There may be significant differences in the methodologies between the two inventories and the assumptions made for calculating fugitive dust emissions from paved and unpaved roads. As stated in the Executive Summary of the Rural Communities inventory report, the Rural Communities inventory was developed with the goal to "quantify emissions from smaller rural communities in Alaska using information collected locally or from similar communities in the state." For this reason it is believed the Rural Communities inventory is a more accurate representation of North Slope emissions than the existing Alaska statewide inventory developed by EPA which relies on "source-surrogates and temporal and spatial relationships developed from 'lower 48' studies that produce large inaccuracies and inconsistencies when applied to a vast, complex state like Alaska" (Sierra, 2007).

Table 4.3: Comparison of NEI2008 and ADEC Rural Communities Inventories for the North Slope Borough (Excludes Point Sources, Commercial Marine and Aviation)

	Annual Emissions (tons/year)					
Inventory	CO	NO_X	PM-10	PM-2.5	SO_2	VOC
EPA NEI2008	2,655	211	53	30	14	515
ADEC Rural Communities 2005	8,934	293	2,493	824	12	6,068

The 2009 Alaska wildfire emissions inventory estimated that during the summer of 2009 there were 527 wildfires, of which 331 were human caused and 196 were caused by lightning. A total of 2,951,593 acres burned. The acreage burned was the third highest of the last 10 years. The fire season began at the end of April, with the majority of reported fires occurring May through August in the northern half of the state. PM-2.5 emissions were estimated to be 1,597,149 tons in 2009. Emissions from wildfires vary significantly from year to year and also geographically across the State. For example, PM-2.5 emissions from fires were estimated to be only 93,450 tons in 2006. The exact locations of the fires were not provided in the ADEC report, but presumably this information is available in ADEC files. On the North Slope one would expect most of the fires to be limited to the southern part of the Borough in the Brooks Range since there is limited woody vegetation north of the Brooks Range. However, it is not known whether PM-2.5 emissions from fires in the Brooks Range and central portion of the State would be transported north to the Arctic Coastal regions. Further investigation is warranted.

According to the USGS, Alaska has more than 40 active volcanoes, and the state has experienced, on average, two significant eruptions every year since 1945. Volcanic eruptions are an important source of fine particulates. The effects of eruptions on air quality are both local and long range. Particulates can reach high into the atmosphere and travel long distances. Degassing by the volcanoes between eruptions also introduces pollutants into the atmosphere.

Other sources of pollution that affect air quality on the North Slope include sea salt and the long range transport of fine particulates from Asia, Canada, and other distant regions. Andrews et al. (2006) looked at a 2002 event that transported dust from Asia and monitored at Barrow, Alaska. While the effects on air quality were not quantified, they found that 1) Asian dust is regularly recorded at an observatory in Barrow, Alaska, 2) dust/pollution has been observed at the surface and in the vertical column above the observatory, and 3) differences in optical properties of dust events suggest a variety of sources, transport mechanisms, and chemical transformations.

Further investigations are needed to quantify the particulates and gases that affect the North Slope from volcanoes, sea salt, and long-range transport.

4.2.1. Industrial Point Sources

ADEC identified 38 stationary sources in the North Slope as major sources requiring a Federal Title V permit and 37 sources requiring a Title I permit. Major sources account for 96% of the total potential emissions in the North Slope. All other source types including minor, synthetic minor, synthetic minor-80%, and two non-classified sources make up the remaining 4% of the total potential emissions. Table 4.4 lists the permitted sources in the North Slope, categorized by source type and sorted by total potential emissions.

Industrial activities in the North Slope are largely related to oil production and transport which account for about 58% of the permitted sources. The majority of those sources are owned and operated by either BP Exploration (Alaska), Inc. or ConocoPhillips Alaska, Inc. Electric power generation plants account for approximately 21%, and the balance, about 20%, are primarily related to the seafood and construction industries.

As Figure 4.1 and Figure 4.2 illustrate, the major sources are largely concentrated in and around the Prudhoe Bay area and westward to Alpine, a lateral span east to west of only about 100 km. The Prudhoe Bay oil field, incidentally, is the largest oil field in North America. In addition, there are a few sources south of Prudhoe Bay including pump stations along the Trans-Alaska Pipeline, as well as a few power plants located along the western coast at Barrow, Wainwright, and Point Hope. As would be expected, the non-major sources are located in a pattern similar to the major sources.

Figure 4.1: Location of Major Permitted Sources in the North Slope Borough

Figure 4.2: Concentration of Major Permitted Sources in the Prudhoe Bay Area

Table 4.4: Permitted Facilities Located in the North Slope Borough, Grouped by Source Type, Sorted by Total PTE

Owner / Facility (By Source Type)	Total PTE (tpy)*
Major	**117,510**
BP Exploration (Alaska) Inc. / Central Compressor Plant (CCP)	16,719
BP Exploration (Alaska) Inc. / Central Gas Facility (CGF)	13,485
BP Exploration (Alaska) Inc. / Gathering Center #1 (GC 1)	6,507
ConocoPhillips Alaska, Inc. / CPF 1, Kuparuk Central Production Facility #1	6,259
BP Exploration (Alaska) Inc. / Flow Station #3 (FS 3)	5,653
BP Exploration (Alaska) Inc. / PBU Central Power Station (CPS)	5,462
BP Exploration (Alaska) Inc. / Endicott Production Facility	5,175
BP Exploration (Alaska) Inc. / Flow Station #2 (FS 2)	4,989
ConocoPhillips Alaska, Inc. / Kuparuk River Unit Transportable Drilling Rigs	4,588
BP Exploration (Alaska) Inc. / Lisburne Production Center (LPC)	4,094
BP Exploration (Alaska) Inc. / Flow Station #1 (FS 1)	4,075
ConocoPhillips Alaska, Inc. / CPF 2, Kuparuk Central Production Facility #2	3,986
ConocoPhillips Alaska, Inc. / Alpine Central Processing Facility	3,905
BP Exploration (Alaska) Inc. / Gathering Center #3 (GC 3)	3,794
ConocoPhillips Alaska, Inc. / CPF 3, Kuparuk Central Production Facility #3	3,355
BP Exploration (Alaska) Inc. / Gathering Center #2 (GC 2)	3,208
BP Exploration (Alaska) Inc. / Seawater Injection Plant East (SIPE)	2,888
Alyeska Pipeline Service Company / TAPS Pump Station 01	2,743
Alyeska Pipeline Service Company / TAPS Pump Station 04	2,646
BP Exploration (Alaska) Inc. / Northstar Production Facility	2,261
BP Exploration (Alaska) Inc. / Milne Point Production Facility (MPU)	1,904
Alyeska Pipeline Service Company / TAPS Pump Station 03	1,757
BP Exploration (Alaska) Inc. / Base Operations Center (BOC)	1,595

Table 4.4: Permitted Facilities Located in the North Slope Borough, Grouped by Source Type, Sorted by Total PTE

Owner / Facility (By Source Type)	Total PTE (tpy)*
BP Exploration (Alaska) Inc. / Badami Development Facility	1,548
BP Exploration (Alaska) Inc. / Seawater Treatment Plant, Prudhoe Bay Unit (STP)	776
TDX North Slope Generating, Inc. / North Slope Generating Power Plant	636
ConocoPhillips Alaska, Inc. / Kuparuk Seawater Treatment Plant (STP)	534
Barrow Utilities & Electric Cooperative, Inc. / Barrow Power Plant	458
Halliburton Energy Services, Inc. / Deadhorse Facility	380
Alaska Interstate Construction, LLC / Deadhorse Soil Remediation Unit	314
BP Exploration (Alaska) Inc. / Transportable Drilling Rigs (Drill Rigs)	308
BP Exploration (Alaska) Inc. / Prudhoe Bay Operations Center / Main Construction Camp (PBOC/MCC)	219
Delta Leasing, LLC / Atigun Camp	175
North Slope Borough / Nuiqsut Power Plant	151
BP Exploration (Alaska) Inc. / Crude Oil Topping Unit (COTU)	116
North Slope Borough / Wainwright Power Plant	101
North Slope Borough / Point Hope Power Plant	101
Minor	**1,800**
Eni US Operating Co. Inc. / Nikaitchuq Development	741
BP Exploration (Alaska) Inc. / Northstar Caribou Crossing Compressor Facility	208
North Slope Borough / Service Area Ten Incinerator Plant	173
Knik Construction / Astec Mobile Asphalt Plant #1	160
Alyeska Pipeline Service Company / TAPS Pump Station 02	146
North Slope Borough / Barrow TOS Facility	98
Schlumberger Technology Corporation / Deadhorse Bulk Facility	74
Brechan Enterprises / AESCO Madsen DM7228 Drum Mix Asphalt Plant (Bells Flats)	70
BP Exploration (Alaska) Inc. / Hot Water Plant (HWP)	40

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Table 4.4: Permitted Facilities Located in the North Slope Borough, Grouped by Source Type, Sorted by Total PTE

Owner / Facility (By Source Type)	Total PTE (tpy)*
BP Exploration (Alaska) Inc. / Grind and Inject Facility (G & I)	34
Bicknell Inc / AEDCO Hot Plant	30
BP Exploration (Alaska) Inc. / Northstar Pipeline Heater (Tie-In at PS 01)	26
Synthetic Minor	**661**
BP Exploration (Alaska) Inc. / Milne Point Unit C-PAD (MPU C-Pad)	232
North Slope Borough / Kaktovik Power Plant	100
BP Exploration (Alaska) Inc. / Drill Site 16 – Generator	99
US Air Force / Oliktok LRRS	61
Baroid Drilling Fluids (Halliburton) / Prudhoe Bay Mud Plant	60
BP Exploration (Alaska) Inc. / Nabors Alaska Drilling - Wrangell Camp	40
BP Exploration (Alaska) Inc. / Nabors Brooks Camp	40
US Air Force / Point Barrow LRRS	15
US Air Force / Barter Island LRRS	15
Synthetic Minor - 80%	**1,644**
ConocoPhillips Alaska, Inc. / Alpine Satellite Drill Pad CD5	277
City of Galena / Galena Airport (formerly USAF, Galena AS)	265
BP Exploration (Alaska) Inc. / BPXA Transportable Drill Rig Camps	141
Icicle Seafoods, Inc. / P/V Arctic Star	101
North Slope Borough / Anaktuvuk Pass Power Plant	100
North Slope Borough / Atqasuk Power Plant	100
G & K, Inc. / Cold Bay Electric Utility	99
ConocoPhillips Alaska, Inc. / Tarn Development Project	99
ConocoPhillips Alaska, Inc. / Meltwater Development Project (DS 2P)	99
BJ Services Company USA / Prudhoe Bay Generator	92

Table 4.4: Permitted Facilities Located in the North Slope Borough, Grouped by Source Type, Sorted by Total PTE

Owner / Facility (By Source Type)	Total PTE (tpy)*
Aniak Light & Power Company Inc / Aniak Power Plant	91
Eni US Operating Co. Inc. / Oliktok Construction Camp	91
Gwitchyaa Zhee Utilities Company / Gwitchyaa Zhee Utilities Co.	90
Non-classified	**306**
Brooks Range Petroleum Corporation (BRPC) / Deadhorse Liquefaction Facility	156
Fairbanks Natural Gas, LLC dba Polar LNG, LLC / North Shore Development	150
Grand Total	**121,921**

** Total PTE represents the Potential to Emit summed across the following pollutants and pollutant categories (where applicable): carbon monoxide, nitrogen dioxide, nitric oxide, particulates (10 microns or less), fine particulates (2.5 microns or less), total particulates, sulfur dioxide, volatile organic compounds, total hazardous air pollutants, formaldehyde, and hydrochloric acid.*

4.3 DATA GAPS

In general, near-field dispersion models such as AERMOD require surface and upper air meteorological inputs, terrain elevation data, building data when building downwash is a factor, and individual release point parameters such as latitude and longitude, stack height, stack diameter, exit velocity, exit gas temperature, and emission rate. A potential source of data to characterize the individual release points at a facility or site in the North Slope is ADEC's point source emission inventory. The emission inventory is capable of storing information about individual emission units (EUs) such as seasonal throughput, emission factors, and actual annual emissions. In addition, the emission inventory can store parameters for the individual release points that are required for near-field dispersion modeling. As previously mentioned, ADEC develops a complete point source inventory on a 3-year cycle and an abbreviated inventory that includes only the largest sources in the interim years. As of June 2011, the last full inventory completed was for the 2008 calendar year. The 2009 inventory was completed for the larger emitters, and the 2010 inventory was being developed. The next full inventory will be developed for calendar year 2011.

To assess the completeness of ADEC's point source emission inventory and its usefulness as a source for emissions data and release point information required by near-field dispersion models, a review of the inventory was performed against the list of 74 permitted facilities/sites in the North Slope, with an emphasis on the 38 major facilities. The primary goals of this review were to: a) identify major facilities omitted from the emission inventory; b) for those facilities included in the inventory, use current Title V and Title I permits to identify EUs omitted from the inventory; c) identify EUs in the inventory that are not paired with an emission release point; and d) identify release points for which the parameters are not provided in the emission inventory. Secondary goals included: a) identify the meteorology used when modeling was required to obtain a Title V or Title I permit and b) identify the ambient pollutant data used to determine background pollutant concentrations. To perform this review ADEC supplied modeling files, meteorological data, and permits retrieved from the State's AirFacs data system.

During the first phase of the review, the emission inventory was inspected to determine how many of the 74 permitted facilities are represented, ignoring the completeness of the data. Of the 38 major sources, only two were identified that are not represented in ADEC's 2008 or 2009 emission inventory: North Slope Borough Nuiqsut Power Plant and BP Exploration (Alaska), Inc. (BPXA) Crude Oil Topping Unit. These two sources account for only 0.2% of the total potential emissions of the 38 major sources. Of the 36 non-major sources, only two were found to exist in either the 2008 or 2009 emission inventory: Eni US Operating Co. Inc. Nikaitchuq Development and BPXA Transportable Drill Rig Camps. The remaining 34 non-major sources, those not represented in the point source emission inventory, account for 3% of the total potential emissions across all 74 permitted sources. . Given these statistics, ADEC's emission inventory is nearly complete in terms of the representativeness of those facilities with the largest PTE.

The second phase of the emission inventory review focused on the completeness of the emissions data and release point parameters for the 38 major facilities. The meteorological data used for dispersion modeling, when data was provided, was also recorded during this phase of the review.

To determine the completeness of the emissions inventory for the major sources, the most recent Title V permit was reviewed along with all active construction, minor source-specific, and general permits to compile a comprehensive list of EUs for each major source. The EUs for each source were then compared to those included in ADEC's emission inventory. Any EUs not found in the emission inventory were identified, as were any EUs not paired with a release point, with the exception of fixed-roof storage tanks. Though permitted fixed-roof storage tanks are generally included in the emission inventory, rarely are there emissions associated with them, and they are rarely paired with a release point. In addition, release points included in the inventory for which stack parameters are not filled were identified and recorded.

Ignoring fixed roof storage tanks, the review identified 88 EUs from 15 major sources either not found in ADEC's 2008 or 2009 emission inventory or potentially inadequately represented in the inventory, including 12 EUs at the two major sources excluded from the emission inventory altogether. These represent potential data gaps in the emission inventory. APPENDIX C lists those EUs identified during the review that are either: a) excluded from the ADEC's emission inventory, b) included in the emission inventory but not identified with a release point, or c) identified with a release point for which there are no stack parameters provided. It is worth noting that the majority of the EUs listed in APPENDIX C that are represented in the emission inventory may post-date the most recent inventory available based on the actual or estimated construction or start-up date of the EU and/or the date the applicable permit was issued. Where possible, this has been noted. Given the extent of the completeness of the 2008 emission inventory for the major sources, it is anticipated that most of these newer EUs not found in the 2008 or 2009 inventory will become incorporated into the 2011 and subsequent inventories as they are developed. ADEC maintains an inventory of permitted EUs in the AirTools database, an internal data storage and retrieval system. A complete listing of permitted EUs included Alaska's current emission inventory can be made available upon request.

From this review to assess ADEC's point source emission inventory as a data source for dispersion modeling, it is apparent that the more significant data gaps are the 34 non-major sources (e.g., minor, minor synthetic, minor synthetic-80%, and non-classified) that are not included in the emission inventory. As a result, the review was extended to include a third phase to look at those non-major sources whose total PTE is greater than 200 tons per year. Five sources were identified. The five non-major sources reviewed account for 1.4% of the total PTE summed across all 74 permitted sources listed in Table 4.4. The five sources reviewed during this phase, along with the findings, are listed in Table 4.5.

Similar to phase two, active permits, when available, were reviewed during phase three to identify the EUs at each source. Only one of the five sources, Eni US Operating Co. Inc. Nikaitchuq Development, is represented in ADEC's 2008 emission inventory, though no emissions are recorded. Permit AQ0923MSS05, final on December 30, 2010, identifies 95 distinct EUs for this source, each of which is represented in the 2008 emission inventory. The permit indicates the make and model of many of the EUs are still to be determined. While all of the EUs identified from the permit appear to be represented in the emission inventory, only 8 are identified with a release point. It is assumed the operations at this facility represented in the permit post-date the ADEC's most recent emission inventory. Of the four other sources identified for phase three of this review, a permit could not be found for BPXA Milne Point Unit C-PAD.

Table 4.5: Non-major Sources with Total PTE Greater Than 200 Tons Per Year

ADEC Source ID	Owner/Facility Name	Total PTE (tpy)	2008 EI	No. Permitted EUs	Permit	Comments
201	BP Exploration (Alaska) Inc. / Milne Point Unit C-PAD (MPU C-Pad)	232	No	---	---	No permit was found for this source.
305	City of Galena / Galena Airport (formerly USAF, Galena AS)	265	No	9	AQ0305ORL01 (Revision 2)	Permit was final on 1/23/2009.
427	BP Exploration (Alaska) Inc. / Northstar Caribou Crossing Compressor Facility	208	No	2	AQ0427TVP02	Permit issued on 4/19/2010. Construction dates for the 2 EUs was 2000 and 2003.
923	Eni US Operating Co. Inc. / Nikaitchuq Development	741	Yes	95	AQ0923MSS05	Permit was final on 12/30/2010. Only 8 EUs were identified with release points. Operations may post-date most recent emission inventory.
945	ConocoPhillips Alaska, Inc. / Alpine Satellite Drill Pad CD5	277	No	31	AQ0945MSS01 (Revision 2)	Permit was final on 9/17/2009.

4.4 REFERENCES

ADEC, 2011: *2009 Alaska Wildfire Emissions Inventory.* May 2011. < http://fire.ak.blm.gov/content/admin/awfcg_committees/Air%20Quality%20and%20Smoke%20Management/6_2009%20AK%20WF%20EI%20rpt%20050411.pdf >

Andrews, E., R. Stone, J. Ogren, and E. Dutton, 2006: *Long Range Transport to the Arctic: Asian Dust/Air Pollution, Barrow, Alaska – April 2002*. National Oceanic and Atmospheric Administration, Climate Monitoring and Diagnostics Laboratory, Boulder, CO. < http://www.htap.org/meetings/2006/2006_01/posters/Andrews.pdf >

EPA, 2007: *The Plain English Guide to the Clean Air Act.* Office of Air Quality Planning and Standards, Research Triangle Park, NC, 27711. April 2007. < http://www.epa.gov/air/caa/peg>

USGS: *Index of Subjects.* Website. Accessed on August 31, 2011. < http://pubs.usgs.gov/fs/1996/fs-001-96/ >

PrudhoeBay.Com: *Prudhoe Bay Alaska, The North Slope*. Website. Accessed on August 31, 2011. <http://www.prudhoebay.com/>.

Sierra Research, 2007: *Alaska Rural Communities Emission Inventory*. February 2007. < http://www.epa.gov/region10/pdf/tribal/wrap_alaska_communities_final_report.pdf >

5. METEOROLOGY ON THE NORTH SLOPE

In this section, the availability of meteorology on the North Slope, issues associated with the meteorology, and meteorological input requirements required for air dispersion modeling are discussed.

5.1 NATIONAL WEATHER SERVICE AND OTHER HOURLY DATA

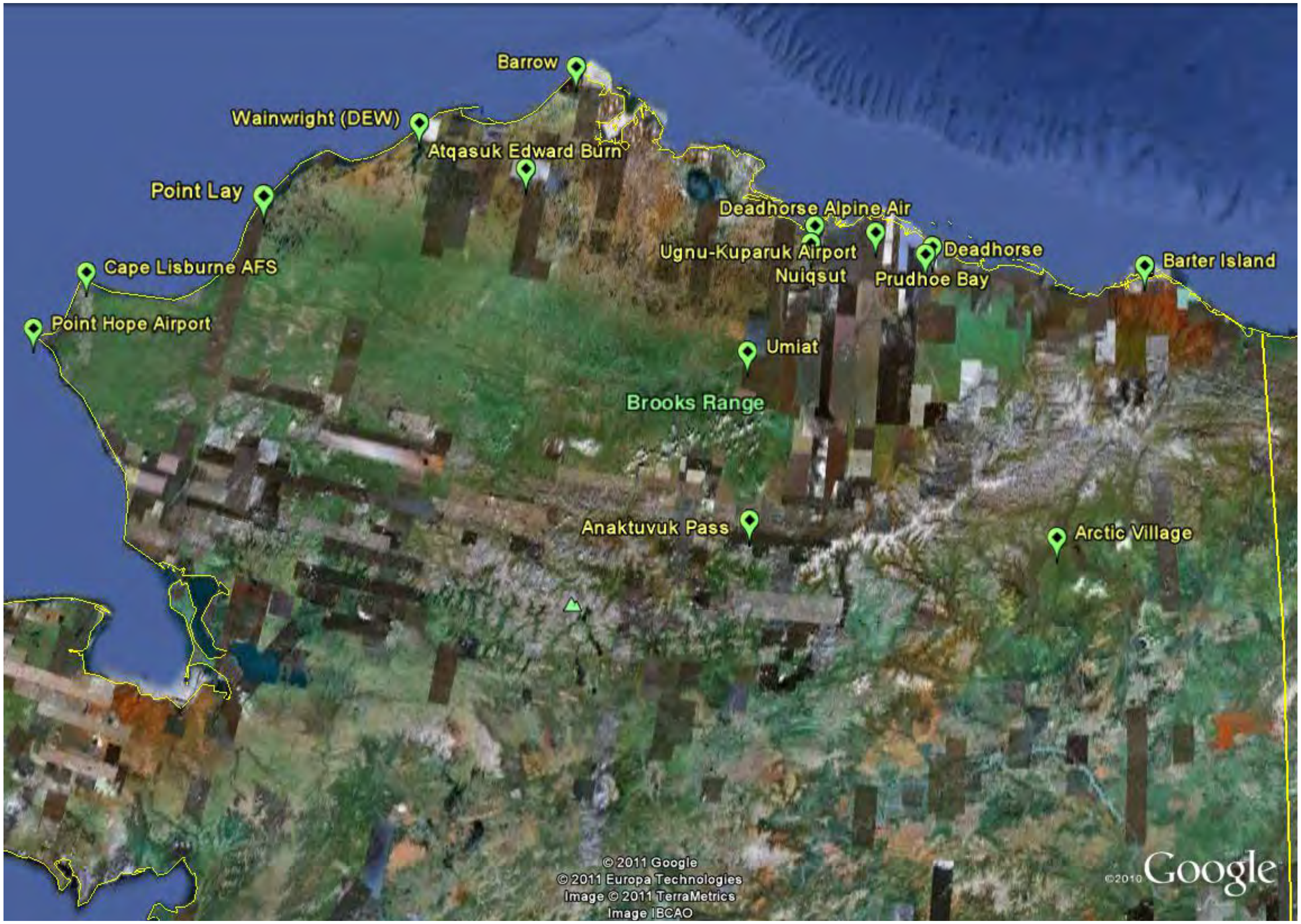
Hourly surface weather observations from the NWS and other public sources are somewhat scarce on the North Slope. The National Climatic Data Center is the repository for hourly surface observations, as well as other atmospheric data, from around the world. Stations with the most complete data available and operated for five or more years are shown in Table 5.1 and Figure 5.1. Stations identified here may also be included in the MMS survey discussed later Section 5.2.1. Several stations have moved slightly or changed World Meteorological Organization (WMO) number and/or Weather Bureau Army-Navy (WBAN) identification number. The WMO number, WBAN number, latitude, and longitude are for the most recent location. The years of operation are not necessarily complete years, particularly the first year of operation. The data completeness for each station will have to be determined if the data are considered for a modeling application. The hourly parameters reported are not readily available without examining the actual data, a time-consuming process that also requires purchase of the data. A listing of the number of observations by station-year-month in the National Climatic Data Center (NCDC) database is available for download at ftp://ftp.ncdc.noaa.gov/pub/data/inventories/ISH-INVENTORY.TXT. The inventory file can serve as an aid to determine, to some extent, if a station records data 24 hours per day. Except where noted, stations that reported fewer than about 700 observations per month are not included since that is a clear indication observations are not taken 24 hours per day.

Table 5.1: Surface Meteorological Data Available from the National Climatic Data Center

Station	WBAN #	WMO #	Call Sign	Latitude	Longitude	Comments
Anaktuvuk Pass	26542	701625	PAKP	68.134	-151.743	1985-present
Arctic Village	46405	701945	PARC	68.115	-145.579	2008-present
Atqasuk Edward Burn	27518	702685	PATQ	70.467	-157.436	2008-present
Barrow	27502	700260	PABR	71.287	-156.763	1920-present
Barter Island	27401	700860	PABA	70.134	-143.577	1947-88; 1997-99; 2010-present
Cape Lisburne AFS	26631	701040	PALU	68.883	-166.117	1952-present
Deadhorse	27406	700637	PASC	70.192	-148.477	1973-present
Deadhorse Alpine Air	27517	702758	PALP	70.344	-150.945	2004-present
Nuiqsut	27515	703644	PAQT	70.212	-151.002	1999-present
Point Hope Airport	26601	701043	PAPO	68.350	-166.800	1943-present
Point Lay	26638	701210	PPIZ	69.817	-162.917	1973-present
Prudhoe Bay	27405	700636	PAUD	70.250	-148.330	1973-76; 1987-99 (daytime only?)
Ugnu-Kuparuk Airport	27408	700634	PAKU	70.331	-149.598	2008-present (daytime only?)
Umiat	26508	701620	PAUM	69.367	-152.133	1946-2154; 1984-2001 (daytime only?)
Wainwright (DEW)	27503	700300	PAWI	70.639	-159.995	1973-present

The nearest station that operates upper air soundings is Barrow, AK. The next nearest sounding station is Kotzebue, AK south of the North Slope on the western coast. Modeling on the North Slope that requires upper air data likely rely on Barrow, whose period of record extends back to the late 1940's.

Figure 5.1: Hourly Meteorological Stations on and Near the North Slope



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5.2 SITE-SPECIFIC METEOROLOGY

Meteorological data that are representative of the location where a dispersion model will be applied is an important issue to consider, as is discussed later in Section 5.4. For this reason, PSD quality site-specific data is preferable for use with refined dispersion models such as AERMOD. Various sources of site-specific data on the North Slope have been identified and their potential for use in dispersion modeling is discussed in the sections that follow.

5.2.1. MMS Nearshore Meteorological Monitoring Project

In 2007, the Minerals Management Service published a report on a 6-year effort to collect and characterize new, existing, and historical nearshore meteorological data for the Beaufort Sea (MMS, 2007). The collection contains data from 34 existing and historical sites for the period 1984-2006 as shown in Table 5.2.

Five primary meteorological monitoring stations, listed in Table 5.2, were established to collect winds, temperature, relative humidity, barometric pressure, and solar radiation. Data collection at Badami, Endicott, Milne Point and Northstar began on January 1, 2001. Collection began at Cottle Island on August 21, 2002. Data was collected under the MMS program at each of the five stations through September 2006.

In addition to the primary sites, 29 existing and historical sites from public and private sources provided supplemental wind data (Figure 5.2). As seen in Table 5.2, several of the supplemental sites ceased data collection in the 1980's and 1990's and many only collected a few months of wind data. The wind data were limited to the region extending from Barrow, Alaska to Herschel Island, Yukon Territories, Canada, approximately 70 kilometers east of the Alaska-Canada border. The data collected for the 34 sites was saved in a Microsoft Access database, resulting in about 1.7 million station-hours of data.

Table 5.2: Meteorological Monitoring Sites in MMS Report (from MMS, 2007)

Name	Latitude	Longitude	Data Start	Data End	Source
PRIMARY STATIONS					
Badami	70.136	-147.009	1/1/01	9/06	
Endicott	70.323	-147.865	1/1/01	9/06	
Milne Point	70.507	-149.662	1/1/01	9/06	
North Star	70.490	-148.698	1/1/01	9/06	
Cottle Island	70.499	-149.093	8/21/02	9/06	
SUPPLEMENTAL STATIONS					
Alpine	70.333	-150.933	6/8/04	9/30/06	NCDC
Aurora Wellsite	70.109	-142.785	9/12/87	9/12/88	Tenneco/MMS
Barrow	71.284	-156.778	1/1/84	12/31/04	NCDC
Barter Island	70.133	-143.633	1/1/84	12/31/04	NCDC
Belcher Wellsite	70.275	-141.513	9/1/88	8/31/89	Amoco/MMS
Betty Pingo	70.280	-148.896	5/27/94	1/1/04	WERC (UAF)
Cabot Wellsite	71.324	-155.216	10/31/91	2/29/92	Arco/MMS
Cross Island	70.490	-147.950	9/7/02	9/18/04	MMS
Deadhorse	70.200	-148.467	1/1/85	12/31/04	NCDC [1]
Diamond Wellsite	71.333	-161.680	8/31/91	10/5/91	Chevron/MMS
Fireweed Wellsite	71.088	-152.603	10/14/90	12/20/90	Arc/MMS
Franklin Bluffs	69.893	-148.770	12/15/86	1/1/05	WERC (UAF)
Galahad Wellsite	70.561	-144.960	9/13/91	10/14/91	Amoco/MMS
Herschel Island, Y.T.	69.567	-138.917	10/16/86	8/11/01	Environment Canada
Komakuk Beach, Y.T.	69.583	-140.183	1/1/85	6/30/93	Environment Canada
Kuparuk Airport	70.317	-149.583	2/4/91	12/31/04	NCDC
Kuparuk DS-1F	70.290	-149.680	1/1/91	6/30/02	ConocoPhillips Alaska
Kuvlum Wellsite #2	70.310	-145.538	7/19/93	8/30/93	Arco/MMS
Kuvlum Wellsite #3	70.327	-145.404	8/31/93	9/30/93	Arco/MMS
Lonely DEW	70.917	-153.233	1/1/85	3/25/88	NCDC
McCovey	70.528	-148.187	11/30/02	2/9/03	MMS
Nuiqsut	70.218	-150.993	4/9/99	12/31/04 [3]	ConocoPhillips Alaska
Oliktok	70.500	-149.883	1/1/85	9/26/95	NCDC
Phoenix Wellsite	70.717	-150.428	9/2/86	9/9/87	Tenneco/MMS
Pt. McIntyre Pad 2	70.717	-148.517	5/17/05	10/1/06	NCDC
Prudhoe Bay	70.250	-148.333	6/3/87	6/14/99	NCDC
Sagwon	69.423	-148.693	10/11/86	1/1/05	WERC (USF)
Wild Weasel Wellsite	70.229	-145.499	9/30/93	11/10/93	WERC (USF)
West Dock	70.381	-148.561	7/14/95	1/1/04	Arco/MMS

1 – NCDC – National Climatic Data Center
2 – WERC (UAF) – Water and Environmental Research Center (University of Alaska Fairbanks)
3 – Continues operating past date end noted here

MMS purports that the meteorological data collected under this program at the primary sites were validated using EPA documents (EPA, 1995; EPA, 2000), and operations were monitored on a regular basis. However, stringent criteria must be met during siting, setup, and the operation of a monitoring site in order for the site meteorological data to be used in a PSD application. For example, data recovery must be at least 90% per quarter year for four (4) consecutive quarters. In addition, there are specific data quality criteria for each monitored parameter, such as acceptable maximum and minimum values and the magnitude of the change in values across specific time periods (EPA, 2000). During the operation of a site, equipment calibration and audits must also be performed on a schedule approved by ADEC with specific recordkeeping and reporting requirements.

ADEC has indicated that some of the data do not meet PSD requirements. In general, the primary stations meet the completeness and quality assurance requirements for wind speed and direction, temperature, and barometric pressure, though not all data and available reports have been rigorously reviewed and approved by ADEC. Of those that have been reviewed, there are known periods in the data record that do not meet PSD requirements. For this reason, it is essential to contact ADEC and discuss the quality of data for the primary sites identified in Table 5.2 before the data are used for regulatory purposes.

Primary stations with known data issues include Northstar and Milne Point. The Northstar facility, an island in the Beaufort Sea, is in a very good location to observe nearshore winds. From January 2001 through August 2001 the wind direction is considered unimpaired. However, beginning in August 2001, a large structure was installed too near the monitoring site that influenced the measured wind direction. As a result, ADEC will not accept wind data recorded after the installation of the Northstar structure in August 2001. In addition, ADEC questions the PSD quality of the wind and temperature data at Milne Point due to potential obstructions from the structure on which the instrumentation is mounted.

Data from the supplemental stations, while possibly useful for comparisons to data from the primary sites or to obtain a general idea of conditions in some areas of the North Slope, cannot be used for regulatory applications. In the 2007 MMS report, winds were analyzed at eight of the supplemental stations (where only wind speed and direction were reported). The data capture is far from being acceptable in most cases, with many of the stations in the 50%-70% range. Also, regular calibrations and audits were not conducted, a requirement for meteorological data to be considered for use in a PSD application.

Figure 5.2: Supplemental Meteorological Monitoring Sites on North Slope/Beaufort Sea

5.2.2. Data Collection by Industry

Several private companies operating in North Slope have set up meteorological monitoring programs at different sites to collect data, primarily for dispersion modeling purposes. At a minimum, these stations usually monitor wind speed and direction at one level (usually near 10 meters), two levels of ambient temperature (usually at 2- and 10-meters), and solar radiation. They may also monitor relative humidity/dew point temperature, barometric pressure, and precipitation. With the two levels of temperature, a temperature difference can be calculated. With temperature difference and solar radiation, atmospheric stability can be determined in AERMOD. Without these values, stability is usually calculated with a representative cloud cover from a nearby station most likely operated by the NWS.

Other parameters that may be collected or calculated include the standard deviation of the horizontal wind direction (σ_θ), vertical wind speed, a second level of wind speed and/or direction, and a redundant set of sensors in the event one of the primary sensors fails. None of these parameters are required for near-field (AERMOD) and far-field (CALPUFF) dispersion modeling.

The data collected under these monitoring programs must be of PSD quality before being approved for modeling for regulatory applications. The facilities are required to submit annual meteorological monitoring reports and the data to ADEC to determine if the data are PSD quality. If the data are determined not to be of PSD quality, then the data should not be used for regulatory modeling. Additional discussion can be found in Section 5.4. Several sources on the North Slope and near the shore of the Bering Sea that collect meteorological data for dispersion modeling include BPXA, Shell Oil (Shell), ConocoPhillips Alaska, Inc. (CPAI), ExxonMobil, and the Alyeska Pipeline Service Company (APSC).

An investigation was performed for this assessment to compile a list of site-specific meteorological data collected by private sources on the North Slope and identify data sets previously approved by ADEC for recent dispersion modeling. This effort included reviewing past Request for Proposals (RFPs) to evaluate data for PSD quality, as well as reviewing current and past operating permits and Technical Analysis Reports to identify data used in past compliance demonstrations.

In addition, ADEC provided archived modeling files previously used to demonstrate compliance with air quality standards for major stationary sources on the North Slope. (Refer to Section 4 for a listing of the major sources.) The number of files provided for a given source varied greatly depending on the source's permit history and the associated modeling requirements. Due to the magnitude of files provided by ADEC (approximately 4GB), the effort was focused on locating the most recent modeling files for each major source and identifying the dispersion model and the meteorological data set(s) used. In many cases, locating the most recent modeling files required a visual inspection of the contents within the model output which contains the time and date the model run was performed. Similarly, it was often necessary to view the model output to determine the meteorology used when not easily identified by the meteorological files themselves and when supplemental files such as README files that described the meteorological data were not provided. This focus on using the most recent modeling files assumed that the more recent modeling utilized the best data available at the time. However, there is the potential that a more detailed assessment in the future could result in additional findings. In addition to the source specific modeling files provided by ADEC, a directory of prior approved AERMOD model-ready meteorological data sets used in past modeling applications was also provided.

Table 5.3: Site-specific Meteorological Data Collected or Used By Private Industry

Site	Latitude[1]	Longitude[1]	Years	Approved for AERMOD?[2]
BPXA/ Badami	70.136	-147.009	2006[3]	Yes
BPXA / Pad A	70.267	-148.753	1991-95	--
			1997-2000	--
			1998-1999	Yes
			2002	--
			2006-2008	Yes
CPAI / DS-1F	70.290	-149.680	11/1/1990-10/31/1992	Yes
			7/1/2001-6/30/2002	Yes
CPAI / Nuiqsut	70.218	-150.993	10/1/01 - 3/31/05	--
APSC / Pump Station 3	68.842	-148.831	3/1/2002-2/28/2003	--
APSC / Pump Station 4	68.422	-149.359	4/1/2002-3/31/2003	Yes
BPXA / Endicott SDI	70.351	-147.964	2001-2005[3]	Yes
BPXA / Milne Point Pad F	70.507	-149.662	1998-1999	--
			2001-2005[3]	Yes
ExxonMobil / Point Thomson Central Pad	70.173	- 146.253	9/1/09 - 8/31/10	--
Shell / Reindeer Island	70.486	-148.331	2009 and 2010 Drilling Season[4]	--
Shell / Point Lay	69.820	-162.920	2009 and 2010 Drilling Season[4]	--

[1] Latitude and longitude are approximate.
[2] "Approved for AERMOD?" indicates AERMOD-ready files were provided by ADEC
[3] Assumed all or a portion of the data was collected as part of the MMS study.
[4] Exact dates of data collection were not provided in the permit documents. Drilling season typically spans from July 1 to November 30.

Table 5.3 is a compilation of the results of this effort to catalogue meteorological data collected by private sources in the North Slope, by site, and identifies those data sets that have been given prior approval for use with AERMOD. Figure 5.3 shows the location of each of the sites on the North Slope. Several of the sites and data listed in Table 5.3 coincide with the sites and data collected for the MMS Nearshore Meteorological Monitoring Project discussed in Section 5.2.1 including Badami, Endicott SDI, and Milne Point Pad F. It is assumed this is the same data collected for the MMS program and has been utilized by private industry for regulatory purposes. For those sites in which ADEC provided prior approved AERMOD-ready meteorological input files, Table 5.4 provides a history of the use of the data by industry for regulatory modeling and identifies the source of upper air used during preprocessing with AERMET.

In addition to the two Shell sites identified in Table 5.3, Shell deployed a buoy in the Beaufort Sea and another in the Chukchi Sea. Shell collected data during periods of open water during the 2009 and 2010 drilling seasons and used the Reindeer Island and Point Lay data identified in Table 5.3 and the buoy data for a compliance demonstration using AERMOD and AERMOD-COARE for activities on the outer continental shelf in the waters off the North Slope.

Figure 5.3: Locations of Site-specific Meteorology Collected or Used By Private Industry

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Table 5.4: Summary of the Historical Use of AERMOD-ready Meteorological Data Files

Site-Specific Data (Owner / Site)	Site-Specific Data Years	Upper Air Site	Applicable Permits
BPXA/ Badami	2006	Barrow (NWS)	AQ1201MSS01
BPXA / Prudhoe Bay Pad A	1998[1]	Barrow (NWS)	AQ0270CPT04, AQ0269CPT01
	1999[1,2]	Barrow (NWS)	AQ0270CPT04, AQ0170CPT01
	2006[1,2]	Barrow (NWS)	AQ0270CPT04
	2007[1]	Barrow (NWS)	AQ0182MSS01
	2008[1]	Barrow (NWS)	AQ0182MSS01
CPAI / DS-1F	11/1/1990-10/31/1992[4]	Barrow (NWS)	AQ0923MSS02, AQ0267MSS03, AQ0923MSS04
	7/1/2001-6/30/2002[1]	Barrow (NWS)	AQ0267MSS03, AQ0923MSS05
APSC / Pump Station 4	4/1/2002-3/31/2003	Barrow (NWS)	AQ0075MSS02
BPXA / Endicott SDI	2001[1]	Barrow (NWS)	AQ0181CPT05, AQ1240MSS01
	2002[1]	Barrow (NWS)	AQ0181CPT05, AQ0181CPT06
	2003[3]	Barrow (NWS)	AQ0181CPT05
	2004[3]	Barrow (NWS)	AQ0181CPT05
	2005[3]	Barrow (NWS)	AQ0181CPT05
BPXA / Milne Point Pad F[4]	2001	Barrow (NWS)	AQ0923MSS04
	2002	Barrow (NWS)	AQ0923MSS05
	2003	Barrow (NWS)	
	2004	Barrow (NWS)	
	2005	Barrow (NWS)	

[1] Missing data substituted with cloud cover from the NWS Deadhorse surface station.
[2] AERMET surface parameters ran prior to January 2008 revision. Data is adequate with EPA's January 2008 revision of AERMOD Implementation Guide.
[3] Missing data substituted with solar radiation and temperature difference measurements at Pad A.
[4] Milne Pt data was used to supplement a minor permit modeling analysis conducted with DS-1F data. The Milne data was used as a surrogate of what the coastal conditions could be near the project site (Oliktok Point). ADEC has not allowed this data to be used stand-alone due to accuracy concerns.

5.3 GRIDDED METEOROLOGICAL DATA

There has been recent interest in the use of gridded meteorological data from numerical models such as MM5 and the Weather Research and Forecasting (WRF) model to drive dispersion models. MM5 was designed to simulate or predict mesoscale and regional-scale atmospheric circulation, developed by Penn State and National Center for Atmospheric Research (NCAR). WRF, designed as the successor to MM5, is a next-generation mesoscale system applicable across scales ranging from meters to thousands of kilometers. The development of WRF was a collaborative effort involving NCAR, the National Oceanic and Atmospheric Administration (NOAA) the National Centers for Environmental Prediction (NCEP), the Forecast Systems Laboratory (FSL), the Air Force Weather Agency (AFWA), the Naval Research Laboratory (NRL), the University of Oklahoma, and the Federal Aviation Administration (FAA)

AERMET cannot directly use gridded meteorological data such as that produced by MM5 and WRF model data. Recently, some progress has been made in developing software tools to convert gridded meteorological data to an AERMOD-ready format and bypassing AERMET. These activities include:

- EPA (Brode, 2008) explored using MM5 data for use in AERMOD by developing a draft tool to convert MM5 output.
- Tennessee Valley Authority developed the WRF-AERMOD tool (Meyers-Cook et al., 2010) to convert WRF data;
- Davis et al. (2008) developed a tool to convert data from the Meteorology-Chemistry Interface Processor (MCIP).
- EPA developed a utility called Mesoscale Model Interface (MMIF) that reads gridded meteorological data.

CALMET, on the other hand, can use MM5 data directly as well as several other formats of gridded meteorology. MM5 data can be used in one of three ways in CALMET (Scire et al., 2000):

- as a spatially variable initial guess field,
- as a replacement for the first step wind field, or
- as 'observations'.

In addition to MM5 data, CALPUFF can interface to other sources of gridded meteorological data: WRF, Rapid Update Cycle (RUC), NAM/Eta, or RAMS models. The MMIF software can also reformat gridded meteorological data to CALPUFF-ready meteorological data.

Developing application-specific gridded meteorology from one of these models is a resource intensive effort. Gridded data have been developed for regions of the country, but the user must accept the options and processing used to develop the data set. New data sets can be ordered from commercial companies for a cost, but it is not inexpensive. For example, the developers of CALPUFF offer a service to develop MM5 data. The cost is $200 per 12km tile. To cover the entire North Slope requires about 40 tiles or $8,000 for one year of MM5 data. Other companies offer similar services.

5.4 METEOROLOGICAL CHALLENGES ON THE NORTH SLOPE

When one thinks about dispersion modeling, the focus is usually on the model. The results that come from a dispersion model are only as good as the data used to drive the model. The dispersive characteristics of the atmosphere are dependent on, among other things, atmospheric stability which relies on temperature and winds. If the meteorology is not valid or representative for the modeling application, the resulting concentration estimates will not be accepted as valid by the regulating authority for modeling applications such as a regulatory compliance determination.

For site data to be used in dispersion modeling on the North Slope, the data must be approved for use by ADEC, which means it must meet certain requirements and determined to be of PSD quality on a quarterly and 12-month annual (but not necessarily a calendar year) basis. Several issues can lead to one or more atmospheric parameters for one or more quarters being deemed not PSD quality, such as:

- not using PSD quality instrumentation (this may be the case if redundant sensors are used),
- not meeting the 90% capture rate,
- missing a scheduled calibration or audit on one or all instruments or not performing the calibration or audit according to standard procedures,
- using improper equipment to perform the calibration or audit (the same equipment used for a calibration must not be used for an audit), and

- the person performing an audit must be independent of the day-to-day operations.

Not meeting the 90% capture rate is often a result of severe or extreme weather conditions, and occasionally due to wildlife (e.g., polar bears and eagles) or other things outside the control of the consultant collecting the data. On the North Slope, temperatures in the winter may, on average, not be much above 0°C, with minimum temperatures around -40°C and lower. As a result, anemometer icing can become a problem. If an anemometer in a remote location ices over and cannot be repaired or replaced quickly, valuable wind data are lost, which may result in data not being of PSD quality for modeling purposes. One option some sites use is a redundant set of instruments. However, these redundant instrument(s) must also be PSD quality before any data substitution is considered.

Models that can use solar radiation, such as AERMOD, have a more serious problem on the North Slope when the sun is low on the horizon and the instrumentation is not capable of recording low radiation values. In these cases, the results of the audits and calibrations are somewhat uncertain. This is a continuing problem in Alaska, especially on the North Slope. The only option when solar radiation is not available or deemed not to meet PSD requirements is to use cloud cover from the nearest site collecting such data, usually an NWS site located at an airport.

Calm and low wind speeds tend to be problematic for steady-state plume models, in part because the equations used to estimate concentration are proportional to 1/U, where U is the wind speed. Thus for lower wind speeds, the concentration increases. In the case where the wind is calm (U = 0), the equations 'blow up', therefore, an estimate cannot be made for that hour. AERMOD treats this effect by estimating the concentration from two limiting states: 1) a coherent plume state that considers lateral diffusive turbulence when the mean wind direction is well defined and 2) a random plume state when the mean wind direction is poorly defined that allows the plume to spread uniformly, about the source, in the x-y plane. The final concentration predicted by AERMOD is a weighted sum of these two bounding concentrations. AERMOD accounts for this issue by including a meander component to dispersion under low-wind speeds. For a non-steady state puff model such as CALPUFF, the low wind speeds do not present this problem since the model tracks puffs across multiple hours. The wind speeds reported by MMS (2007) do not appear to have a large frequency of low-wind conditions.

Additionally, in AERMOD, the winds are assumed to be spatially uniform across the entire domain for the hour being modeled and there is no 'memory' of the state of the atmosphere from the previous hour(s). It is assumed that conditions are unchanged over the period, and the pollutants impact the entire domain even if the distance is greater than the distance a pollutant can be transported in an hour.

In a compliance demonstration, the meteorological data used to drive the model must be representative of the sources and conditions being modeled. The EPA's *Guideline on Air Quality Models* (Guideline) (EPA, 2005) states the meteorological data used in a dispersion model "should be selected on the basis of spatial and climatological (temporal) representativeness as well as the ability of the individual parameters selected to characterize the transport and dispersion conditions in the area of concern", and further states that data representativeness is dependent on:

- Spatial proximity,
- Complexity of the terrain,
- Instrument exposure, and
- Temporal proximity.

All of these points need to be considered when determining if the data are representative, and no one point should be used to make the decision. AERMOD can operate with NWS data solely, as well as a combination of NWS and site data in which NWS data are used to substitute missing parameters, or with site data solely if the parameters needed to develop input requirements for AERMOD are present. Regardless whether NWS and/or site-specific data are used as model input, the Guideline requires that the meteorology be laterally and vertically representative of the transport and dispersion within the analysis domain and free from inappropriate local or microscale influences (EPA, 2005). Data collected in close proximity to the application site, whether NWS data or collected as site-specific data, should be evaluated based on the criteria in the Guideline to determine if the data are truly representative of the application site. This can limit the amount of data that are useful for dispersion modeling for a specific application in the North Slope and thus, contribute to gaps in the North Slope meteorology.

5.5 DATA GAPS IN NORTH SLOPE METEOROLOGY AND FUTURE CONSIDERATIONS

Numerous sources of meteorological data on the North Slope have been identified and discussed in the above sections as well as the challenges to collecting data appropriate for regulatory modeling applications. As discussed previously, the data must be representative of the application site. The Guideline also states that five years of the most recent representative, consecutive data should be used, but at a minimum, one year of site-specific data can be used (EPA, 2005). Five years of site-specific data is preferred; however, it is common to use five years of consecutive surface data collected by the NWS at a nearby airport if at least a single year of site-specific data is not available. When running AERMOD, concurrent twice daily upper air soundings are also required when using NWS surface data or site-specific data that do not include mixing heights.

The geographic coverage of the meteorological data across the North Slope is sparse as is illustrated in Figure 5.1 – Figure 5.3. The majority of data is collected along and near the northern coastline. Little data is collected further inland across most of the North Slope. Data collected by public sources, including the NWS, are sparse though relatively evenly spaced along the coastline while site-specific data collected at industrial sites are concentrated in and around the Prudhoe Bay area and westward to Alpine. Monitoring sites are less numerous as you move westward toward Alpine from Prudhoe Bay. The Prudhoe Bay oilfield is the largest in the U.S. so one would expect there to be significantly more activity in this area. The Trans-Alaska Pipeline System was built to convey oil from the Prudhoe Bay area south to Valdez. It is far more likely that representative data is available around Prudhoe Bay than in any other region of the North Slope due to the density of monitoring sites in this area. Since the public sites are characterized as more coastal, it is less likely these data are representative of application sites more inland. With regard to upper air soundings, the only upper air station on the North Slope is located in Barrow on the northwestern coast.

In areas where representative data is available, modelers must still contend with the quantity of data required, which can be problematic due to the limited collection periods and data quality issues that might affect the use of the data. As indicated previously, the Guideline requires the use of five years of NWS meteorological data or a minimum of one year of site-specific data. While data from public sources such as the NWS generally include a greater period of record than site-specific data collected by private industry, site-specific data are preferred provided the data are representative of the application site and the siting, monitoring, and quality assurance requirements were met. With regard to what data are considered site-specific, the Guideline states: “It should be noted that, while site specific measurements are frequently made ‘on-property’ (i.e., on the source’s premises), acquisition of adequately representative site specific data does not preclude collection of data from a location off property. Conversely, collection of meteorological data on a source’s property does not of itself guarantee adequate representativeness” (EPA, 2005). If data collected at an industrial site as site-specific data are applied at a site other than the one from which the data was collected, even though the data are determined to be representative, the data should be stringently evaluated to ensure it can legitimately be considered site-specific if less than five years of data are used as model input. As Table 5.3 shows, the data available in the North Slope are temporally sparse with very few sites offering five consecutive years of data.

In addition to representativeness and temporal span, the data, as well as the data collection process, must meet the quality assurance criteria published in EPA’s *Meteorological Monitoring Guidance for Regulatory Modeling Applications* (EPA, 2000). In general, these include siting criteria, type of monitoring equipment, maintenance of the equipment during the collection period, and parameter-specific screening criteria applied to the data after they are collected. The stringent requirements of the meteorological data used in dispersion modeling for regulatory applications result in data gaps in the meteorological record on the North Slope. These gaps are realized in both spatial and temporal contexts. The spatial aspect of these gaps refers to the limited geographic coverage which makes finding representative data in many areas of the North Slope a challenge, while the temporal gaps are primarily associated with the period of record of usable data.

Quality assurance screening criteria are applied quarterly. Each quarter must pass the screening criteria separately for the quarter to be deemed PSD quality and usable for regulatory purposes. Parameters pass or fail individually, so a 3-month period of data may include parameters that are acceptable and others that cannot be used. Assuming five consecutive years of data are available, it is rare that all required parameters for each quarter of the data have passed the screening criteria. Table 5.3 and Table 5.4 demonstrate this issue. For this reason, it has been necessary for entities to request prior approval from ADEC to use either abbreviated data sets (i.e., less than five years of data collected off-site) or non-consecutive years when a minimum of a year of site-specific data is not available. Due to the concentration of facilities in the Prudhoe

Bay area with on-going monitoring programs, data is more available in that area of the North Slope. Therefore, it is believed this will be less of an issue for companies established in the Prudhoe Bay area that are expanding or modifying existing operations. However, as exploration continues and expands to other regions of the North Slope, this will become a greater challenge to adequately predict and assess the impact of these activities on the people and the environment.

Filling these gaps and ensuring the integrity of the air quality analysis is a challenge. Currently, missing or unusable site-specific data parameters are substituted using data from NWS sites or other nearby public sources, where available. ADEC approves the methodologies used to meet this challenge on a case-by-case basis. Looking forward to meet these challenges in the future, one possibility when representative data are not available is to interpolate between two or more sites to develop a representative data set. This approach would require significant analysis. Another consideration is the development of a gridded dataset using a prognostic model such as MM5 or WRF. As discussed in Section 5.3, this is an expensive endeavor and the cost would need to be evaluated against the benefits and cost of establishing a new monitoring program.

ADEC reviews annual meteorological data and associated reports for several facilities throughout Alaska. A future endeavor to assist in determining what site data are available and the quality of the data would be, in close discussions with ADEC, develop a database (or spreadsheet) that shows which sites/facilities have collected meteorological data and the quality of those data (and possibly for individual parameters, e.g., wind speed and direction) by quarter. With such information one could more easily check if one year – four consecutive quarters – of data is available for a modeling demonstration.

5.6 REFERENCES

Brode, R., 2008: *MM5-AERMOD Tool*. Presented at the 9th Conference on Air Quality Modeling, U.S. Environmental Protection Agency, Research Triangle Park, NC, October 2008.

Davis, N, S. Arunachalam, and R.Brode, 2008: *MCIP2AERMOD: A Prototype Tool for Preparing Meteorological Inputs for AERMOD.* Presented at the 7th Annual Models-3 CMAS Users Conference, Chapel Hill, NC, October 6-8, 2008.

EPA, 1995: On-site Meteorological Program Guidance for Regulatory Modeling Applications (EPA-450/4-87-013), Office of Air Quality Planning and Standards, Research Triangle Park, NC, Revised August 1995.

EPA, 2000: *Meteorological Monitoring Guidance for Regulatory Modeling Applications* (EPA-454/R-99-005), Office of Air Quality Planning and Standards, Research Triangle Park, NC, February 2000.

EPA, 2005: Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions; Final Rule, 40 CFR, Part 51, Appendix W, November 9, 2005.

MMS, 2007: *Study Final Report for the Nearshore Beaufort Sea Meteorological Monitoring and Data Synthesis Project.* Department of the Interior, OCS Study MMS 2007-011, September 2007.

Meyers-Cook, T., J. Mallard, and Q. Mao, 2010: *Development of a WRF-AERMOD Tool for Regulatory Applications*. 16th Conference on Air Pollution Meteorology, Atlanta, GA, January 2010.

Scire, J, ,2000: *A User's Guide for the CALMET Meteorological Model (Version 5)*. Earth Tech, Concord, MA. January 2000.

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6. AMBIENT MONITORING ON THE NORTH SLOPE

Ambient monitoring on the North Slope is available from industrial/commercial entities, such as BPXA, rather than from local governments. Table 6.1, provided by ADEC, shows the highest monitored concentration, regardless of how the standard is defined, by pollutant for one or more years for North Slope sites. These values are the highest observed values and are not for use in comparisons to the NAAQS for determining attainment. Figure 6.1 shows the location of these sites on the North Slope.

A monitoring station was established in the Village of Point Lay and has been collecting data since June 2010 (EPA, 2011a). EPA Region 10 reviewed the quarterly reports and analyzed the measured air pollutant data and concluded that the data were collected in accordance with the applicable Quality Assurance Project Plans for the monitors and met applicable quality control and quality assurance requirements.

Ambient monitoring data have been collected at Deadhorse beginning in 2010 (EPA, 2011b). The station was sited near gravel roads and pads to measure elevated concentrations for purposes other than collecting ambient data for possible PSD applications. The Deadhorse station is located closer to a road than recommended in EPA's PSD monitoring guidance, and therefore, measures concentrations that are higher than what would typically be found. Placement at this location allowed for higher concentrations to be measured, which was needed for the intended purpose.

Data from Pt. Lay and Deadhorse are not included in the tables below since they are EPA-sponsored sites and the data from those two sites are not included in the ADEC database.

Generally, the ambient monitored values are no more than about half the NAAQS, with the exception of the 1-hr NO_2 standard at Pad A and CCP, where monitored values are greater than the NAAQS values. Since the ambient values reported are maximum values, computing an ambient concentration based on the definition of the standard (e.g., 98^{th} percentile of the 3-yr average) may lower the ambient value to a value less than the NAAQS.

Table 6.1: North Slope Ambient Monitoring Stations and Highest Measured Concentrations in micrograms per cubic meter (µg/m^3)

Pollutant	Averaging Period	NAAQS	Badami		Wainwright		Endicott	
			BPXA	Shell	S&R Site	WPS	SDI	MPI
			1999	8/09 - 12/10	11/08 - 11/09	9/09- 12/10	2007-2008	2009
NO_2	1-hr	188	--	73.3	66.0	60.2	157.9	94.0 [1]
	Annual	100	3.0	--	2.0	--	11.3	--
SO_2	1-hr	196	--	--	--	--	49.7	35.1
	3-hr	1300	9.8	--	17.0	10.5	41.9	34.1
	24-hr	365	7.2	--	10.0	5.2	13.1	28.8
	Annual	80	2.6	--	0.4	--	2.6	2.6
PM-10	24-hr	150	7.9	--	114.0	79.0	--	--
	Annual	50	1.8	--	--		--	--
PM-2.5	24-hr	35	--	12.0	--	35.6 [3]	--	--
	Annual	15	--	--	--	--	--	--
CO	1-hr	40,000	--	--	1,050.0	800.0	1,752.0	--
	8-hr	10,000	--	--	945.0	800.0	1,099.0	--
O_3	1-hr	235	--	--	--	--	--	--
	8-hr [2]		--	--	93.0	--	--	--

1 - The 1-hour NO_2 Endicott MPI value is the maximum value measured within the data set (which is not PSD due to inadequate data capture).

2 – The 8-hr ozone standard is a rolling average.

3 – The maximum measured value is reported here. The concentration has not been computed to represent the ambient concentration based on the definition of the standard (annual mean averaged over three years) and cannot be compared to the NAAQS to determine attainment status.

Table 6.1 (continued): North Slope Ambient Monitoring Stations and Highest Measured Concentrations in micrograms per cubic meter (µg/m³)

			Pad A				CCP		
Pollutant	Averaging Period	NAAQS	2006	2007	2008	2009	2007	2008	2009
NO_2	1-hr	188	293.3 [4]	208.7 [4]	109.2 [5]	135.4	206.8 [4]	193.7 [4]	180.5
	Annual	100	9.4	11.3	--	7.5	18.8	18.8	18.8
SO_2	1-hr	196	52.4	49.7	96.9	10.5	28.8	23.6	23.6
	3-hr	1300	41.9	41.9 [6]	91.7	10.5	28.8	23.6	23.6
	24-hr	365	10.5	34.0 [6]	60.3	5.2	23.5	18.3	20.9
	Annual	80	2.6	2.6 [6]	2.6	2.6	2.6	1.1	5.2
PM-10	24-hr	150	--	--	--	--	55.1 [7]	29.8	25.2
	Annual	50	--	--	--	--	7.5 [7]	--	--
PM-2.5	24-hr	35	--	--	--	--	--	--	--
	Annual	15	--	--	--	--	--	--	--
CO	1-hr	40,000	--	--	--	--	--	--	--
	8-hr	10,000	--	--	--	--	--	--	--
O_3	1-hr	235	--	--	130.0	92.2	--	100.0	100.0
	8-hr		--	--	94.0	86.3	--	94.0	92.2

4 – The maximum measured value is reported here. The concentration has not been computed to represent the ambient concentration based on the definition of the standard (98th percentile, averaged over three years) and cannot be compared to the NAAQS to determine attainment status.

5 – The 1-hour NO_2 value for 2008 A Pad is the maximum value measured within the data set (which is not PSD due to inadequate data capture).

6 – The 2007 3-hr, 24-hr and annual SO_2 values are as reported by AECOM in the September 2008 CCP/CGF H_2S modeling report.

7 – The 2007 CCP PM-10 data is the maximum value measured within the data set (which is not PSD due to inadequate data capture in the 4th qtr).

Table 6.1 (concluded): North Slope Ambient Monitoring Stations and Highest Measured Concentrations in micrograms per cubic meter (µg/m³)

			Nuiqsut				DS-1F	Pt. Thomson
Pollutant	Averaging Period	NAAQS	*2001-2003*	*1/02 - 3/03*	*4/03 - 3/04*	*4/04 - 3/05*	*2001-2002*	*2009-2010*
NO_2	1-hr	188	--	--	88.4	63.9	--	--
	Annual	100	--	--	11.3	3.8	6.0	--
SO_2	1-hr	196	--	7.9	13.1	31.4	--	75.9
	3-hr	1300	--	7.9	10.5	18.3	36.0	65.5
	24-hr	365	--	5.2	5.2	7.9	16.0	23.5
	Annual	80	--	0.0	0.0	0.0	0.0	2.6
PM-10	24-hr	150	33.6 [6]	43.6	31.5	119.4	60.0 [7]	--
	Annual	50	8.5	--	--	--	6.0 [7]	--
PM-2.5	24-hr	35	--	--	--	--	--	--
	Annual	15	--	--	--	--	--	--
CO	1-hr	40,000	--	--	--	--	1,100.0	2.2
	8-hr	10,000	--	--	--	--	600.0	1.3
O_3	1-hr	235	--	--	--	--	--	92.0
	8-hr		--	--	--	80.4	--	84.4

6 - Nuiqsut 24-hr PM-10 impact under similar meteorological conditions (for years 1999-2001).

7 - The DS-1F PM-10 data is an upper bound estimate and should not be interpreted as the actual concentration measured under a Federal Reference Method (FRM)

6.1 DATA GAPS AND FILL PROCEDURES

As seen in Table 6.1, pollutant coverage is good for NO_2 and SO_2. For the PM-10, CO, and ozone, the coverage is likely adequate to estimate background concentrations. However, there is little recent ambient data for PM-2.5. Additionally, PM-2.5 monitoring programs by facilities on the North Slope collect and analyze particulate matter but do not sample for chemical species such as metals and elemental carbon.

There is no lead monitoring on the North Slope. The nearest monitoring is in the Northwest Arctic Borough. The 2008 and 2009 revisions to the NAAQS for lead requires source-oriented monitoring for sources with a potential to emit annual emissions equal to or greater than 1 ton of lead. To comply with this revision, ADEC established a source-oriented monitoring site near the Red Dog mine in the Northwest Arctic Borough. Due to the rugged and uninhabitable location of the Red Dog Mine, ADEC established a population-oriented monitoring site sanctioned by EPA in the Native Village of Noatak in January 2010. The site collects total suspended particulates which are analyzed for lead content. A one-year program to collect data resulting from lead-based fuels still used in some aircraft will begin in late 2011 at the Anchorage Merrill Field airport.

As seen in Figure 6.1, the spatial distribution of ambient air monitoring data is clustered near Prudhoe Bay, with the one site, Wainwright, outside of Prudhoe Bay. Developing background concentrations for facilities in and around Prudhoe Bay becomes a challenge.

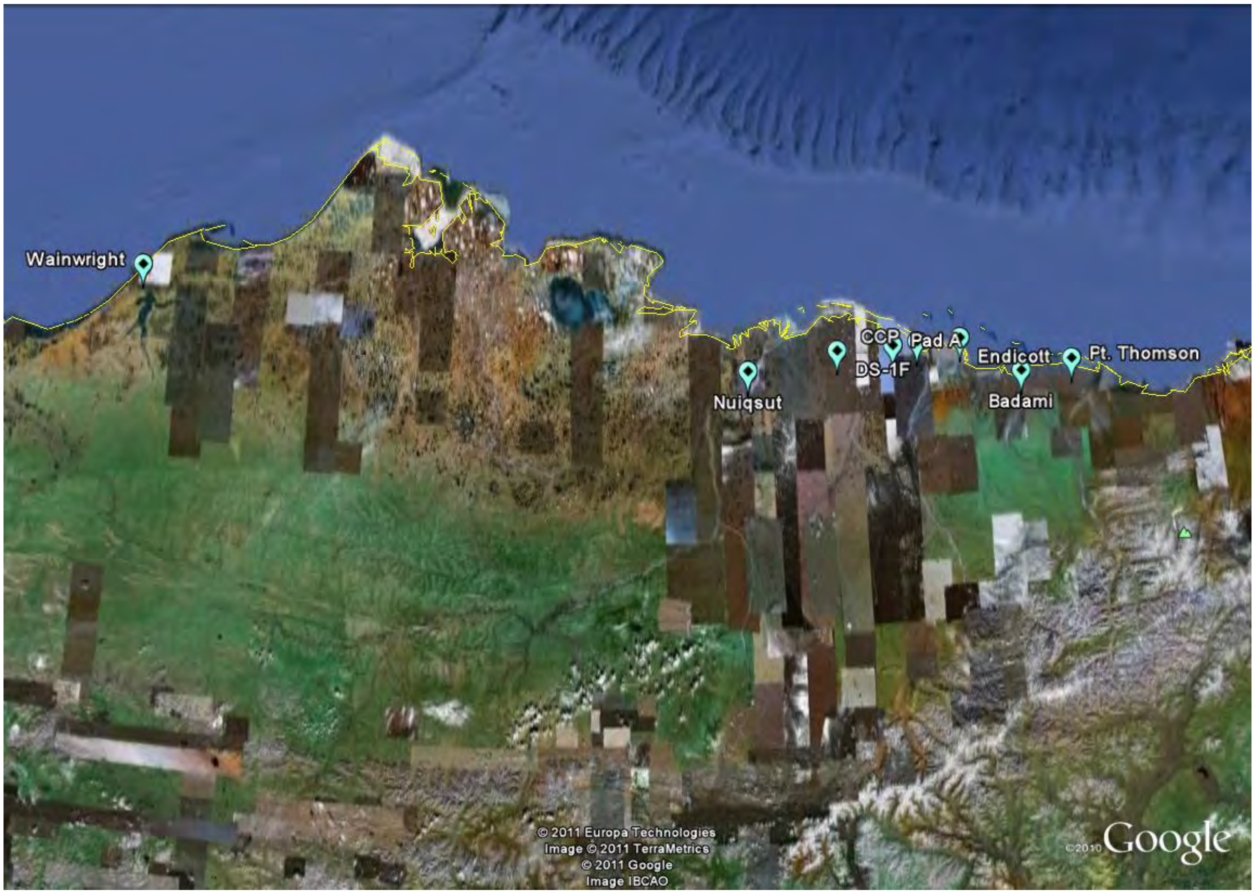
Temporally, there is reasonable amount of data collected in recent years for most stations.

Adding to or filling gaps, spatially, temporally, and for the various pollutants, is challenging considering the climate. ADEC continues to receive quality assurance project plans for ambient air monitoring programs. If the data collected under these programs meets ADEC's and EPA's standards for quality, the pollutant data will eventually fill in. Spatially, additional sites would need to be added to the interior and west coast of the North Slope. This is not likely to happen unless oil and gas companies see a need for such information.

One effort that could be undertaken now, with the results uncertain, is to review technical analysis reports (TARs) from various facilities for any data used in a compliance demonstrations and whether or not it is included in the tables above. The resources required to perform such a review could be extensive due to the volume of files that would need to be examined to locate the TARs.

Another source for ambient information is from programs established to meet EPA requirements. One recent program is for the Outer Continental Shelf PSD construction permit issued by EPA Region 10 to Shell Offshore, Inc. and Shell Gulf of Mexico, Inc. (EPA, 2011). Ambient monitoring was conducted at Wainwright, Pt. lay, and Deadhorse. These stations are outside the purview of ADEC but may provide useful information in adding to State information and filling data gaps.

Figure 6.1: Ambient Monitoring on the North Slope



6.2 REFERENCES

EPA, 2011a: Supplemental Statement of Basis for Proposed Outer Continental Shelf Prevention of Significant Deterioration Permits Noble Discoverer Drillship. EPA Region 10, Seattle WA.

EPA, 2011b: Technical Support Document Review of Shell's Ambient Air Quality Impact Analysis for the Kulluk OCS Permit Application Permit No. R10OCS030000. EPA Region 10, Seattle WA, July 18, 2011.

APPENDIX A

Bibliography

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Table A.1: Bibliography of Potential Data Sources for the North Slope

Name	Reference	Emission	Ambient	Met	Modeling	Description/Comment
Beaufort/Chukchi Seas Mesoscale Meteorology Modeling Study	http://mms-meso.gi.alaska.edu/obs.html http://mms-meso.gi.alaska.edu/			X		Data from nearly 200 locations across the study region, covering the period 1979-2009 and encompassing several different observational networks, have been collected as a part of this study through 2009. Includes general information and maps of the 200 stations. Data was not accessible via this website.
Alaska Outer Continental Shelf Permits - Shell Discoverer Air Permit - Beaufort Sea - Shell Discoverer Air Permit - Chukchi Sea - Shell Kulluk Air Permit - Beaufort Sea - ConocoPhillips Air Permit - Chukchi Sea	http://yosemite.epa.gov/R10/AIRPAGE.NSF/Permits/ocsap	X				Information and access to air permits related to the Outer Continental Shelf. **Shell Discoverer Air Permits - Beaufort Sea and Chukchi Sea:** Modeling performed with ISC-PRIME in screening mode. Worst-case scenario screening meteorology generated using SCREEN3. May contain useful model set up details for ships. Contains list of monitoring sites on the North Slope, and info on possible background concentrations. **Chukchi Sea** application lists all emissions sources which 23 emissions units on the Discoverer (incl. generators, compressors, HPU engines, cranes, winches, cementing units, boilers, and incinerators) as well as support fleets. Support fleets modeled as line and volume sources. Emissions include PM-10, PM-2.5, NO_X, SO_2, CO, VOC, Lead, and HAPS. Ambient background concentrations were determined using BP monitor near Badami facility (1999 only) and Shell/CPAI Wainwright monitor (2008-Present). **Shell Kulluk Air Permit - Beaufort Sea:** Modeling performed with PVMRM chemistry (for NO_2 modeling) and AERMOD without PVMRM chemistry for all other pollutants (e.g., CO, PM, SO_2). Meteorology was prepared using Reindeer Island tower and buoy data, processed with the COARE air-sea flux algorithm and overwater meteorological measurements bypassing AERMET. The Permit Application indicates R10 has encouraged this methodology provided there is no bias toward underestimation and claims this approach is currently be analyzed by EPA. (Additional information is provided in the application regarding this approach as well as the

Table A.1: Bibliography of Potential Data Sources for the North Slope

Name	Reference	Emission	Ambient	Met	Modeling	Description/Comment
						monitoring network in the North Slope operated by Shell - see application dated 2/28/2011.) Not much ambient pollutant, offsite emissions, or PSD met data available from this report. **ConocoPhillips Air Permit - Chukchi Sea:** Initially, the Offshore and Coastal Dispersion model (OCD) was selected because it is the only Guideline model "approved for predicting short-range impacts with the unique ability to simulate over water plume dispersion and transport from emission sources located on an offshore platform." Meteorology was developed from data recorded by research vessels in the vicinity of the project area, five years of recent meteorological data (1999, 2002, 2004, 2005, and 2006) from the Wainwright NWS station, and concurrent mixing heights from the Barrow upper air station. (See AQ Modeling Analysis, Vol. 2, February 2010.) EPA Region 10 requested the use of CALPUFF for future OCS permitting and was used for a subsequent NO_2 analysis. CALPUFF was run with MM5 data and a comparison of predicted met (MM5) to NWS (Wainwright station) was presented. (See ConocoPhillips - Air Permit Application Amendment (PDF)). Background concentrations were based on data collected in Wainwright as part of the Wainwright Near-Term Ambient Air Quality Monitoring Program for which ambient data was collected from November 2008 through October 2009.
ADEC - Regional Haze SIP	http://www.dec.state.ak.us/air/anpms/rh/rhsip.htm	X			X	Contains background parameters which could be used for CALPUFF modeling (especially for visibility).

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Table A.1: Bibliography of Potential Data Sources for the North Slope

Name	Reference	Emission	Ambient	Met	Modeling	Description/Comment
EPA TTN - NEI	http://www.epa.gov/ttn/chief/eiinformation.html	X				There is a significant amount of data for the North Slope, but will require some effort to determine if the data available contains the parameters needed. The 2005 NEI includes about 63 facilities within the North Slope Borough (based on a 02185 FIPS), a significant number of which are located across the northern coast in the areas of special interest. The 2008 NEI includes 72 facilities in the within the North Slope Borough (based on 02185 FIPS) though the 2008 data set did not include lat/long so the exact locations could not be mapped. The 2005 and 2008 point inventories both include a small amount of Tribal data. Tribal data is not identified with a state/co FIPS and must be identified by Tribe. With regard to 2005 mobile data, the only data available is the NMIM county database. Tier summaries are available for criteria pollutants only and does include mobile data. With regard to 2008 mobile data, detailed Onroad and Nonroad data sets can be downloaded separately (very large files).
OCS Study MMS 2005-069 Nearshore Beaufort Sea Meteorological Monitoring and Data Synthesis Project	http://alaska.boemre.gov/reports/2005rpts/2005_069/2005_069.htm			X		This project by Hoefler Consulting Group deployed, maintained, and collected data from five meteorological stations along the Beaufort Sea, Alaska, which began in January 2001. The report describes the project and synthesizes the results from the collection of meteorological data.
WRAP EDMS Emissions Inventory Reports(Western Regional Air Partnership)	http://wrapedms.org/reports.aspx http://vista.cira.colostate.edu/TSS/Results/Emissions.aspx http://www.wrapair2.org/emissions.aspx	X				Can access Area, Dust, Mobile, Point data by state/county and by tribe. Point data offers a Detailed Point Source Report that includes stack parameters. Onroad and Nonroad data is county level by SCC. 2005 point inventory includes 35 distinct plant IDs in North Slope Borough (based on 02185 FIPS).
Detailed AQS Data	http://www.epa.gov/ttn/airs/airsaqs/detaildata/downloadaqsdata.htm		X			Download last 10 years of raw AQS data by pollutant from EPA via the Technology Transfer Network. **No evidence there are AQS monitors in the Northern Slope.**
Alaska Air Monitoring Network	https://fortress.wa.gov/ecy/aaqm/Default.htm		X			**No evidence ADEC operates any monitors in the North Slope.**

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Table A.1: Bibliography of Potential Data Sources for the North Slope

Name	Reference	Emission	Ambient	Met	Modeling	Description/Comment
ADEC Permit Program	http://www.dec.state.ak.us/air/ap/perlist.htm	X				Access to Alaska Permits: Proposed, Pending, Final, General
ADEC Permit Program	https://myalaska.state.ak.us/dec/air/airtoolsWeb/PublicPermitListings.aspx	X				Access to Alaska Permits: Proposed, Pending, Final, General
EPA AirData	http://www.epa.gov/air/data/info.html	X	X			Emissions (NEI) and ambient (AQS) data summaries.
A Critical Review of Four Types of Air Quality Models Pertinent to MMS Regulatory and Environmental Assessment Missions	http://www.gomr.boemre.gov/PI/PDFImages/ESPIS/3/3269.pdf				X	
Model Clearinghouse Review of AERMOD-COARE as an Alternative Model for Application in an Arctic Marine Ice Free Environment	http://www.epa.gov/ttn/scram/guidance/mch/new_mch/Model%20Clearinghouse%20Review%20of%20AERMOD-COARE.pdf				X	
NCDC Station Locator	http://www.ncdc.noaa.gov/oa/climate/stationlocator.html			X		NCDC offers various mechanisms to search for stations and data of different types. Three different methods were used to research North Slope stations (Station Locator, MMS, and the GIS Services web page. See the NCDC Surface Station worksheets for tables of surface stations that are potential sources of post-1990 hourly surface data. (Of significance - only about 7 of the stations located in the North Slope are ASOS/AWOS stations.)
Multi-Network Metadata System (MMS)	https://mi3.ncdc.noaa.gov/mi3qry/login.cfm					
NCDC GIS Services	http://gis.ncdc.noaa.gov/map/isd/					
Water and Environmental Research Center (WERC) at the University of Alaska Fairbanks - North Slope Hydrology Research Projects	http://ine.uaf.edu/werc/projects/NorthSlope/upper_kuparuk/uk_met/current.html			X		Real-time met data from 6 met stations in the North Slope operated by WERC. Parameters reported include T, Td, RH, Ws, Wd and Precip.
NOAA/ESRL Radiosonde Database	http://www.esrl.noaa.gov/raobs/			X		NOAA Radiosonde (Upper Air) database (Point Barrow is the only upper air station within the North Slope. Kotzebue is on the west coast not too far to the south of the North Slope.)
Western Governor's Association	http://www.westgov.org/					Could not find any evidence of data access from this site.

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Table A.1: Bibliography of Potential Data Sources for the North Slope

Name	Reference	Emission	Ambient	Met	Modeling	Description/Comment
Arctic Long Term Ecological Research (ARC LTER) - Toolik Lake Met Data	http://ecosystems.mbl.edu/arc/weather/weatherdefault.html			X		Weather data has been collected at Toolik Lake (68 degrees 38'N, 149 degrees 36'W) since June 1988 to present time. Data collected includes air temperature, relative humidity and wind speed at 1 and 5 meters, wind direction at 5 meters, global solar radiation, photosynthetically active radiation, barometric pressure, precipitation, soil temperatures, lake temperature, lake depth, and evaporation pan depth and pan water temperature. Most sensors are read every minute and then averaged or totaled every hour. *Use of the dataset will be restricted to academic, research, educational, government, recreational, or other not-for-profit professional purposes.* (See reference for more information related to use of this data.)
Toxics Release Inventory (TRI) Program	http://www.epa.gov/tri/tridata/current_data/index.html	X				The 2009 TRI, the most recent data available on the website, does not include any North Slope facilities with the exception of the Red Dog Operations just across the southern border of the North Slope Borough.
Alaska Rural Communities Emission Inventory	http://www.epa.gov/region10/pdf/tribal/wrap_alaska_communities_final_report.pdf	X				Rural communities emission inventories (excludes point sources). Can be used for estimates of emissions from area and mobile sources in rural areas like those found on the North Slope.
2009 Alaska Wildfire Emissions Inventory	http://fire.ak.blm.gov/content/admin/awfcg_committees/Air%20Quality%20and%20Smoke%20Management/6_2009%20AK%20WF%20EI%20rpt%20050411.pdf	X				"Fire activity during the 2009 season was not usual. Early season fire potential predictions were for lower than average burned acres. However, due to changing weather patterns, the month of May in the Fairbanks area was the driest in over 80 years, and Fairbanks' driest July on record also had the high temperature record. The McGrath area also was hotter and drier than normal. The summer was the smokiest since 2005. Smoke blanketed the northern half of the state at the end of July and the beginning of August from Deadhorse and Barrow, to Kotzebue and Nome, south to the Alaska Range, and east into Canada."
National Data Buoy Center	http://www.ndbc.noaa.gov/			X		Buoy Data for (Prudhoe Bay 2005-2010) and (Red Dog Dock near North Slope 2006-2010)

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APPENDIX B

General Air Quality Analysis Approaches
Memorandum of Understanding, June 2011

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Table B.1: June 2011 Memorandum of Understanding, Appendix Table A

Table A. Consult this table when:		
A reasonably foreseeable number of oil or gas wells and associated emission inventory has been developed, utilizing limited or general information; the reasonably foreseeable number of wells and associated emissions are expressed as a range (*e.g.,* low, medium, high).		
Long Range Transport Assessment Approach	'Add-on' Photochemical Approach	Local Assessment Approach
When: Actions that contain single (or small group) source scenarios. Conducive to providing regional assessments of cumulative and incremental impacts. Transport distances greater than 50km.	*When:* Actions that contain large scale source scenarios. Conducive to providing regional assessments of cumulative and incremental impacts.	*When:* Actions likely to result in local air quality impacts. Transport distances less than 50km.
Description: Conduct modeling with estimates of emissions and estimated meteorological and geographic information for single or small groups of sources. This analysis may be used for new projects or proposals that lack specific development information but contain source scenarios that warrant additional review. This approach utilizes EPA guideline approved models for near (local) and far-field analysis. Models tend to be specific to an AQ pollutant, approved purpose, and regulatory application. Impact estimates are generated for ambient concentration, atmospheric deposition, and AQRVs. *Note:* Additional narrative may be necessary to describe how uncertainties affect air quality impact estimates.	*Description:* Conduct regional scale modeling with estimates of emissions and estimated meteorological and geographic information with complex photochemical processes. This analysis may be used for new projects or proposals that lack specific development information but contain large scale or complex photochemical source scenarios that warrant additional review. For this approach, reasonable estimates of incremental emissions are reentered into an existing photochemical modeling system to fully assess impacts based on reasonably foreseeable scenarios. *Note:* Additional narrative may be necessary to describe how uncertainties affect air quality impact estimates.	*Description:* Conduct local scale modeling analysis with emission estimates, meteorological, and geographic information for single sources. May be used when local AQ impact potential is great. Must consider the uncertainties associated with running near-field models with limited or general information. *Note:* Additional narrative is likely to be needed to describe air quality issues, emission uncertainties, and their affects on estimated impacts. Commitment to complete additional analysis may be necessary when requisite information becomes available.
*Models**: Long range transport models such as CALPUFF, SCIPUFF	*Models** Photochemical models such as CMAQ, CAMX	*Models**: AERMOD / AERSCREEN, VISCREEN, PLUVUE II, CALPUFF
Maximizing resources, time, and costs: Lead Agencies are encouraged to develop and utilize modeling methods that promote optimal resource efficiencies. Early planning often can result in datasets (meteorology, emissions, etc…), modeling systems, and analysis outputs that can be applied to a broad range of agency actions requiring air quality models. Reusing aspects of air quality modeling results in substantial time and cost savings, especially with repetitive similar applications. Early modeling considerations substantially reduce modeling development requirements in all subsequent project development phases. Modeling systems that evaluate varied growth patterns (expressed in the form of low, medium, and high) offers reuse potential for both results and modeling systems. An example of a Reusable Modeling Framework (RMF) with emphasis on growth patterns using a complex photochemical model is found in the RMF example attached to this Appendix. The RMF concept could be applied to additional models, domains, and agency actions. MOU Section V.E.4.b describes criteria to eliminate air quality modeling requirements based on availability of existing modeling.		

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Table B.2: June 2011 Memorandum of Understanding, Appendix Table B

Table B: Consult this Table When	
A reasonably foreseeable number of oil or gas wells (*e.g.,* specific number and location) and associated emission inventory has been developed.	
Dispersion Model Approach	'Add on' Photochemical Approach
When: For criteria pollutants, toxics/HAPs, AQRVs (FLAG), small-medium scale & number of sources, EPA guideline (regulatory), screening & refined modeling options.	*When:* Projects or plans with large geographic extent, large number of sources, or present complex issues with ozone and secondary particulate impacts.
Description: Conduct modeling with project specific emission, meteorological, and geographic information. This approach recommends EPA guideline models, or alternative models that meet Appendix W guidelines on model applications for near (local) and far-field analysis. Models tend to be specific to an AQ pollutant, approved purpose, and regulatory application. Impact estimates are generated for ambient concentration, atmospheric deposition, and AQRVs. Although these models make up the primary air quality modeling tool chest, most do not handle complex scenarios, advanced chemical reactivity, or large numbers of sources commonly associated with regional scale oil & gas development. This modeling approach is the current state-of-practice and is likely for most project specific AQ impact assessments. Re-use of domains, meteorology, and file configuration minimizes resources and costs.	*Description:* Conduct regional scale modeling with project specific emission, meteorological, and geographic information with complex photochemical processes. This approach utilizes a regional scale „one atmosphere" simulation of a wide variety of AQ pollutants with a large geographic extent. Emissions are gridded, allow for chemical transformation, and offer a variety of transportation mechanisms to address near and far-field transport. Impact estimates are generated for ambient concentration, atmospheric deposition, and AQRVs. „Add on" means to insert project specific incremental emission estimates into an existing regional scale modeling system. Re-use of existing baseline inventories, meteorology, and model setup greatly reduce resources necessary for model application. The „Add on" photochemical approach is anticipated to become the state-of-practice in coming years.
Models:* AERMOD / AERSCREEN, VISCREEN, PLUVUE II, CALPUFF, SCIPUFF	*Models*:* CMAQ, CAMX
Maximizing resources, time, and costs: Lead Agencies are encouraged to develop and utilize modeling methods that promote optimal resource efficiencies. Early planning often can result in datasets (meteorology, emissions, etc…), modeling systems, and analysis outputs that can be applied to a broad range of agency actions requiring air quality models. Reusing aspects of air quality modeling results in substantial time and cost savings, especially with repetitive similar applications. Early modeling considerations substantially reduce modeling development requirements in all subsequent project development phases. Modeling systems that evaluate varied growth patterns (expressed in the form of low, medium, and high) offers reuse potential for both results and modeling systems. An example of a Reusable Modeling Framework (RMF) with emphasis on growth patterns using a complex photochemical model is found in the RMF example attached to this Appendix. The RMF concept could be applied to additional models, domains, and agency actions. MOU Section V.E.4.b describes criteria to eliminate air quality modeling requirements based on availability of existing modeling.	

APPENDIX C

Data Gaps in the ADEC Emission Inventory
for Major Sources on the North Slope

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Table C.1: Data Gaps in the ADEC Emission Inventory for Major Sources on the North Slope

ADEC Source ID	Owner	Facility Name	EU ID	EU Description	Permit ID	Comment
181	BP Exploration (Alaska) Inc.	Endicott Production Facility	49	Drilling Main Engine, CAT G3520C IM	AQ0181CPT06-R5	Not included in emission inventory. EU may post-date most recent emission inventory. CPT06-R5, final on 2/14/2011, indicates estimated installation date in 2009.
181	BP Exploration (Alaska) Inc.	Endicott Production Facility	50	Drilling Main Engine, CAT G3520C IM	AQ0181CPT06-R5	Not included in emission inventory. EU may post-date most recent emission inventory. CPT06-R5, final on 2/14/2011, indicates estimated installation date in 2009.
181	BP Exploration (Alaska) Inc.	Endicott Production Facility	51	Drilling Main Engine, CAT G3520C IM	AQ0181CPT06-R5	Not included in emission inventory. EU may post-date most recent emission inventory. CPT06-R5, final on 2/14/2011, indicates estimated installation date in 2009.
181	BP Exploration (Alaska) Inc.	Endicott Production Facility	52	Drilling Main Engine, CAT G3520C IM	AQ0181CPT06-R5	Not included in emission inventory. EU may post-date most recent emission inventory. CPT06-R5, final on 2/14/2011, indicates estimated installation date in 2009.
181	BP Exploration (Alaska) Inc.	Endicott Production Facility	53	Drilling Main Engine, CAT G3520C IM	AQ0181CPT06-R5	Not included in emission inventory. EU may post-date most recent emission inventory. CPT06-R5, final on 2/14/2011, indicates estimated installation date in 2009.
181	BP Exploration (Alaska) Inc.	Endicott Production Facility	54	Drilling Main Engine, CAT G3520C IM	AQ0181CPT06-R5	Not included in emission inventory. EU may post-date most recent emission inventory. CPT06-R5, final on 2/14/2011, indicates estimated installation date in 2009.
181	BP Exploration (Alaska) Inc.	Endicott Production Facility	55	Drilling Main Engine, CAT G3520C IM	AQ0181CPT06-R5	Not included in emission inventory. EU may post-date most recent emission inventory. CPT06-R5, final on 2/14/2011, indicates estimated installation date in 2009.
181	BP Exploration (Alaska) Inc.	Endicott Production Facility	56	Drilling Main Engine, CAT G3520C IM	AQ0181CPT06-R5	Not included in emission inventory. EU may post-date most recent emission inventory. CPT06-R5, final on 2/14/2011, indicates estimated installation date in 2009.
181	BP Exploration (Alaska) Inc.	Endicott Production Facility	57	Auxiliary Generator, CAT C32	AQ0181CPT06-R5	Not included in emission inventory. EU may post-date most recent emission inventory. CPT06-R5, final on 2/14/2011, indicates estimated installation date in 2009.
181	BP Exploration (Alaska) Inc.	Endicott Production Facility	58	Camp Engine 3, CAT C27	AQ0181CPT06-R5	Not included in emission inventory. EU may post-date most recent emission inventory. CPT06-R5, final on 2/14/2011, indicates estimated installation date in 2009.

Table C.1: Data Gaps in the ADEC Emission Inventory for Major Sources on the North Slope

ADEC Source ID	Owner	Facility Name	EU ID	EU Description	Permit ID	Comment
181	BP Exploration (Alaska) Inc.	Endicott Production Facility	59	Fire Water Pump, Hatz 4M41Z	AQ0181CPT06-R5	Not included in emission inventory. EU may post-date most recent emission inventory. CPT06-R5, final on 2/14/2011, indicates estimated installation date in 2009.
181	BP Exploration (Alaska) Inc.	Endicott Production Facility	61	Boiler	AQ0181CPT06-R5	Not included in emission inventory. EU may post-date most recent emission inventory. CPT06-R5, final on 2/14/2011, indicates estimated installation date in 2009.
181	BP Exploration (Alaska) Inc.	Endicott Production Facility	62	Boiler	AQ0181CPT06-R5	Not included in emission inventory. EU may post-date most recent emission inventory. CPT06-R5, final on 2/14/2011, indicates estimated installation date in 2009.
181	BP Exploration (Alaska) Inc.	Endicott Production Facility	63	Bulk Mud Boiler	AQ0181CPT06-R5	Not included in emission inventory. EU may post-date most recent emission inventory. CPT06-R5, final on 2/14/2011, indicates estimated installation date in 2009.
181	BP Exploration (Alaska) Inc.	Endicott Production Facility	64	MAC Heater	AQ0181CPT06-R5	Not included in emission inventory. EU may post-date most recent emission inventory. CPT06-R5, final on 2/14/2011, indicates estimated installation date in 2009.
181	BP Exploration (Alaska) Inc.	Endicott Production Facility	65	MAC Heater Pipe Barn 1	AQ0181CPT06-R5	Not included in emission inventory. EU may post-date most recent emission inventory. CPT06-R5, final on 2/14/2011, indicates estimated installation date in 2009.
181	BP Exploration (Alaska) Inc.	Endicott Production Facility	66	MAC Heater Pipe Barn 2	AQ0181CPT06-R5	Not included in emission inventory. EU may post-date most recent emission inventory. CPT06-R5, final on 2/14/2011, indicates estimated installation date in 2009.
181	BP Exploration (Alaska) Inc.	Endicott Production Facility	69	Transportable Drill Rig Heater, 100hp	AQ0181MSS04	Not included in emission inventory. EU may post-date most recent emission inventory. MSS04, final on 3/3/2009, indicates EU installation in 2009.
181	BP Exploration (Alaska) Inc.	Endicott Production Facility	70	Transportable Drill Rig Heater, 100hp	AQ0181MSS04	Not included in emission inventory. EU may post-date most recent emission inventory. MSS04, final on 3/3/2009, indicates EU installation in 2009.
181	BP Exploration (Alaska) Inc.	Endicott Production Facility	71	Transportable Drill Rig Heater, 100hp	AQ0181MSS04	Not included in emission inventory. EU may post-date most recent emission inventory. MSS04, final on 3/3/2009, indicates EU installation in 2009.

Table C.1: Data Gaps in the ADEC Emission Inventory for Major Sources on the North Slope

ADEC Source ID	Owner	Facility Name	EU ID	EU Description	Permit ID	Comment
181	BP Exploration (Alaska) Inc.	Endicott Production Facility	72	Transportable Drill Rig Heater, 100hp	AQ0181MSS04	Not included in emission inventory. EU may post-date most recent emission inventory. MSS04, final on 3/3/2009, indicates EU installation in 2009.
181	BP Exploration (Alaska) Inc.	Endicott Production Facility	73	Transportable Drill Rig Heater, 100hp	AQ0181MSS04	Not included in emission inventory. EU may post-date most recent emission inventory. MSS04, final on 3/3/2009, indicates EU installation in 2009.
181	BP Exploration (Alaska) Inc.	Endicott Production Facility	74	Transportable Drill Rig Heater, 4 MM Btu/hr	AQ0181MSS04	Not included in emission inventory. EU may post-date most recent emission inventory. MSS04, final on 3/3/2009, indicates EU installation in 2009.
181	BP Exploration (Alaska) Inc.	Endicott Production Facility	10A	Turbine, Solar Taurus	AQ0181CPT06-R5	Not included in emission inventory. Estimated installation date 2012-2013, CPT06-R5 final on 2/14/2011
186	BP Exploration (Alaska) Inc.	PBU Central Power Station (CPS)	15	GRSD-17-1101, Black Start Engine for GTRB-17-1101	AQ0186TVP02P	Not included in emission inventory. EU may post-date most recent emission inventory. TVP02, issued on 12/28/2010, indicates emissions are negligible based on operating schedule (< 3 hrs/yr).
186	BP Exploration (Alaska) Inc.	PBU Central Power Station (CPS)	16	GTSD-17-2101, Black Start Engine for GTRB-17-2101	AQ0186TVP02P	Not included in emission inventory. EU may post-date most recent emission inventory. TVP02, issued on 12/28/2010, indicates emissions are negligible based on operating schedule (< 3 hrs/yr).
186	BP Exploration (Alaska) Inc.	PBU Central Power Station (CPS)	17	GTSD-17-0602, Black Start Engine for GTRB-17-3101	AQ0186TVP02P	Not included in emission inventory. EU may post-date most recent emission inventory. TVP02, issued on 12/28/2010, indicates emissions are negligible based on operating schedule (< 3 hrs/yr).
186	BP Exploration (Alaska) Inc.	PBU Central Power Station (CPS)	18	GTSD-17-4101, Black Start Engine for GTRB-17-4101	AQ0186TVP02P	Not included in emission inventory. EU may post-date most recent emission inventory. TVP02, issued on 12/28/2010, indicates emissions are negligible based on operating schedule (< 3 hrs/yr).
267	ConocoPhillips Alaska, Inc.	CPF 1, Kuparuk Central Production Facility #1	57	Kuparuk Unit Topping Plant (KUTP)	AQ0267TVP01	Included in emission inventory, not paired with a release point. No emissions reported. TVP01 indicates construction was in 1983.
267	ConocoPhillips Alaska, Inc.	CPF 1, Kuparuk Central Production Facility #1	?	P-1E02, Diesel Fired Equip. 240 hp	AQ0267CPT01	Omitted from inventory. CPT01 dates back to 2003. May not be in use.

Table C.1: Data Gaps in the ADEC Emission Inventory for Major Sources on the North Slope

ADEC Source ID	Owner	Facility Name	EU ID	EU Description	Permit ID	Comment
269	BP Exploration (Alaska) Inc.	Flow Station #3 (FS 3)	20	Horizontal Flare	AQ0269TVP01P	Included in emission inventory, not paired with a release point. TVP01 (expired) indicates the construction date is unknown.
183	BP Exploration (Alaska) Inc.	Gathering Center #2 (GC 2)	26	FL-02-0002, KALDAIR LP/HP Vertical Emergency Flares	AQ0183TVP01-R1	Included in emission inventory, paired with a release as fugitive emissions but no stack parameters provided. No emissions reported. TVP01 indicates construction was approximately 1977.
200	BP Exploration (Alaska) Inc.	Milne Point Production Facility (MPU)	21	B-Pad Process Vent	AQ0200TVP01	Included in emission inventory, not paired with a release point. No emissions reported. TVP01 indicates install date was 1985.
227	TDX North Slope Generating, Inc.	North Slope Generating Power Plant	11	Turbine Generator No. 2 Solar Taurus T-60 Turbine (Natural gas)	AQ0227TVP02, AQ0227MSS05	Included in emission inventory, not paired with a release point. EU may post-date most recent emission inventory. First appears in MSS05 final on 9/7/2010.
227	TDX North Slope Generating, Inc.	North Slope Generating Power Plant	12	Emergency Generator No. 1 Cummins GTA-28 (Natural gas)	AQ0227TVP02, AQ0227MSS05	Included in emission inventory, not paired with a release point. EU may post-date most recent emission inventory. First appears in MSS05 final on 9/7/2010.
227	TDX North Slope Generating, Inc.	North Slope Generating Power Plant	13	Emergency Generator No. 2 Cummins NTA-855 (Diesel)	AQ0227TVP02, AQ0227MSS05	Included in emission inventory, not paired with a release point. EU may post-date most recent emission inventory. First appears in MSS05 final on 9/7/2010.
244	Alaska Interstate Construction, LLC	Deadhorse Soil Remediation Unit	2	Backup generator, Cat-G353, 350 kW	AQ0244TVP02	Included in emission inventory, not paired with a release point. No emissions reported. TVP02, issued on 5/27/2009, indicates construction date was in 1991.
244	Alaska Interstate Construction, LLC	Deadhorse Soil Remediation Unit	3	Rock crusher	AQ0244TVP02	Included in emission inventory, not paired with a release point. No emissions reported. TVP02, issued on 5/27/2009 indicates EU is a future install.
265	BP Exploration (Alaska) Inc.	Crude Oil Topping Unit (COTU)	F1	Overhead Gas Flare; McGill, air-assist; 250,000 SCF/day	AQ0265TVP02	Facility not in emission inventory.
265	BP Exploration (Alaska) Inc.	Crude Oil Topping Unit (COTU)	F2	Emergency Flare; McGill (pilot/purge rating); 9,000 SCF/day	AQ0265TVP02	Facility not in emission inventory.

Table C.1: Data Gaps in the ADEC Emission Inventory for Major Sources on the North Slope

ADEC Source ID	Owner	Facility Name	EU ID	EU Description	Permit ID	Comment
265	BP Exploration (Alaska) Inc.	Crude Oil Topping Unit (COTU)	H1	Gas-Fired Heater; Econotherm Crude Heater; 22.7 MMBtu/hr^3	AQ0265TVP02	Facility not in emission inventory.
265	BP Exploration (Alaska) Inc.	Crude Oil Topping Unit (COTU)	H2	Gas-Fired Heater; Radco Crude Heater; 22.7 MMBtu/hr^3	AQ0265TVP02	Facility not in emission inventory.
265	BP Exploration (Alaska) Inc.	Crude Oil Topping Unit (COTU)	H4	Gas-Fired Heater; Broach Glycol Heater; 7.5 MMBtu/hr^3	AQ0265TVP02	Facility not in emission inventory.
265	BP Exploration (Alaska) Inc.	Crude Oil Topping Unit (COTU)	TK1	83-F-1 Storage Tank; Residual Crude & Naphtha Storage; 1,500 bbls	AQ0265TVP02	Facility not in emission inventory.
274	BP Exploration (Alaska) Inc.	Prudhoe Bay Operations Center / Main Construction Camp (PBOC/MCC)	20	9401; Diesel-Fired Cummins Emergency Electric Generator (Caterpillar 3512DITA), Tarmac camp, s/n 3YF00469	AQ0274TVP02	Included in emission inventory, not paired with a release point. No emissions reported. Permit indicates NSPS Subpart IIII is not applicable to this EU.
274	BP Exploration (Alaska) Inc.	Prudhoe Bay Operations Center / Main Construction Camp (PBOC/MCC)	21	74-4901-231; Rapid Engineering Gas-Fired MUA Heater, PBOC	AQ0274TVP02	Not included in emission inventory. Install/modification date 1978.
295	Halliburton Energy Services, Inc.	Deadhorse Facility	10	High Pressure Washer #1; 325,000 Btu/hr	AQ0295MSS01-R1	Included in emission inventory, not paired with a release point. No emissions reported. May post-date most recent inventory. Appears in MSS01 Revision 1 final on 5/24/2011.
295	Halliburton Energy Services, Inc.	Deadhorse Facility	11	High Pressure Washer #2; 170,000 Btu/hr	AQ0295MSS01-R1	Included in emission inventory, not paired with a release point. No emissions reported. May post-date most recent inventory. Appears in MSS01 Revision 1 final on 5/24/2011.
295	Halliburton Energy Services, Inc.	Deadhorse Facility	12	High Pressure Washer #3; 580,000 Btu/hr	AQ0295MSS01-R1	Included in emission inventory, not paired with a release point. No emissions reported. May post-date most recent inventory. Appears in MSS01 Revision 1 final on 5/24/2011.

Table C.1: Data Gaps in the ADEC Emission Inventory for Major Sources on the North Slope

ADEC Source ID	Owner	Facility Name	EU ID	EU Description	Permit ID	Comment
295	Halliburton Energy Services, Inc.	Deadhorse Facility	13	High Pressure Washer #4; 580,000 Btu/hr	AQ0295MSS01-R1	Included in emission inventory, not paired with a release point. No emissions reported. May post-date most recent inventory. Appears in MSS01 Revision 1 final on 5/24/2011.
295	Halliburton Energy Services, Inc.	Deadhorse Facility	14	Solid Fuel Incinerator, Consumat, 170 lb/hr	AQ0295MSS01-R1	Included in emission inventory, not paired with a release point. No emissions reported. May post-date most recent inventory. Appears in MSS01 Revision 1 final on 5/24/2011.
295	Halliburton Energy Services, Inc.	Deadhorse Facility	15	Used Oil Burner, 400 gal/month	AQ0295MSS01-R1	Included in emission inventory, not paired with a release point. No emissions reported. May post-date most recent inventory. Appears in MSS01 Revision 1 final on 5/24/2011.
295	Halliburton Energy Services, Inc.	Deadhorse Facility	17	Building Combustors (2); 302,000 Btu	AQ0295MSS01-R1	Included in emission inventory, not paired with a release point. No emissions reported. May post-date most recent inventory. Appears in MSS01 Revision 1 final on 5/24/2011.
295	Halliburton Energy Services, Inc.	Deadhorse Facility	7A	Natural Gas Generator, Caterpillar 3516LE, 1148hp, 820 ekW	AQ0295MSS01-R1	Included in emission inventory, not paired with a release point. No emissions reported. May post-date most recent inventory. Appears in MSS01 Revision 1 final on 5/24/2011.
295	Halliburton Energy Services, Inc.	Deadhorse Facility	7A	Natural Gas Generator, Caterpillar 3516LE, 1148hp, 820 ekW	AQ0295MSS01-R1	Included in emission inventory, not paired with a release point. No emissions reported. May post-date most recent inventory. Appears in MSS01 Revision 1 final on 5/24/2011.
352	North Slope Borough	Nuiqsut Power Plant	1	Generator, CAT 3512/67Z01688, 910Kw	AQ0352MSS01	Facility not in emission inventory.
352	North Slope Borough	Nuiqsut Power Plant	2	Generator, CAT 3512/67Z01658, 910Kw	AQ0352MSS01	Facility not in emission inventory.
352	North Slope Borough	Nuiqsut Power Plant	3	Generator, CAT 3508/70Z01007, 455Kw	AQ0352MSS01	Facility not in emission inventory.
352	North Slope Borough	Nuiqsut Power Plant	4	Generator, CAT 3508/70Z01008, 455Kw	AQ0352MSS01	Facility not in emission inventory.
352	North Slope Borough	Nuiqsut Power Plant	5	Generator, CAT G3516/ZBA00281, 1148bhp	AQ0352MSS01	Facility not in emission inventory.

Table C.1: Data Gaps in the ADEC Emission Inventory for Major Sources on the North Slope

ADEC Source ID	Owner	Facility Name	EU ID	EU Description	Permit ID	Comment
352	North Slope Borough	Nuiqsut Power Plant	6	Generator, CAT G3516/ZBA00305, 1148bhp	AQ0352MSS01	Facility not in emission inventory.
417	BP Exploration (Alaska) Inc.	Badami Development Facility	421a	Generator, Cummins QSK50-G4, 1971hp	AQ0417MSS03	Included in emission inventory, not paired with a release point. No emissions reported. May post-date most recent inventory. MSS03 final on 10/20/2010.
74	Alyeska Pipeline Service Company	TAPS Pump Station 03	27	Reciprocating Internal Combustion Engine, MTU Detroit, Diesel, 800 kWe	AQ0074MSS02	Included in emission inventory, not paired with a release point. No emissions reported. May post-date most recent emission inventory. MSS02 final on 9/30/2010.
75	Alyeska Pipeline Service Company	TAPS Pump Station 04	22	34-GEN-4401, MTU Detroit 16V 2000G45TB	AQ0075MSS03, AQ0075TVP02	Included in emission inventory, not paired with a release point. No emissions reported. EU may post-date most recent emission inventory. Appears in TVP02 issued on 2/17/2011. Indicates construction commenced in 2010.
911	Pioneer Natural Resources Alaska, Inc.	Ooguruk Development Project	I-11	John Deere JW6HUF60; Diesel Firewater Pump Engine, s/n RG6081H178379	AQ0911TVP01	Included in emission inventory, not paired with a release point. EU may post-date most recent inventory. TVP01 and MSS04 were both Final in 2011.
911	Pioneer Natural Resources Alaska, Inc.	Ooguruk Development Project	I-12	Cement Storage and Blending Equipment	AQ0911TVP01	Included in emission inventory, not paired with a release point. EU may post-date most recent inventory. TVP01 and MSS04 were both Final in 2011.
911	Pioneer Natural Resources Alaska, Inc.	Ooguruk Development Project	I-2a	Diesel Rig Steam Boilers	AQ0911TVP01	Included in emission inventory, not paired with a release point. EU may post-date most recent inventory. TVP01 and MSS04 were both Final in 2011.
911	Pioneer Natural Resources Alaska, Inc.	Ooguruk Development Project	NR-2	Front-end Loader 1 CAT 966G II	AQ0911MSS04	Included in emission inventory, not paired with a release point. EU may post-date most recent inventory. TVP01 and MSS04 were both Final in 2011.
911	Pioneer Natural Resources Alaska, Inc.	Ooguruk Development Project	I-2b	Diesel Rig Steam Boilers	AQ0911TVP01	Included in emission inventory, not paired with a release point. EU may post-date most recent inventory. TVP01 and MSS04 were both Final in 2011.
911	Pioneer Natural Resources Alaska, Inc.	Ooguruk Development Project	I-3	Diesel Rig Steam Boilers	AQ0911TVP01	Included in emission inventory, not paired with a release point. EU may post-date most recent inventory. TVP01 and MSS04 were both Final in 2011.

Table C.1: Data Gaps in the ADEC Emission Inventory for Major Sources on the North Slope

ADEC Source ID	Owner	Facility Name	EU ID	EU Description	Permit ID	Comment
911	Pioneer Natural Resources Alaska, Inc.	Oooguruk Development Project	I-4	Diesel Rig Steam Boilers	AQ0911TVP01	Included in emission inventory, not paired with a release point. EU may post-date most recent inventory. TVP01 and MSS04 were both Final in 2011.
911	Pioneer Natural Resources Alaska, Inc.	Oooguruk Development Project	I-5	Pennram E-55 Incinerator; Incinerator, s/n 205229	AQ0911TVP01	Included in emission inventory, not paired with a release point. EU may post-date most recent inventory. TVP01 and MSS04 were both Final in 2011.
911	Pioneer Natural Resources Alaska, Inc.	Oooguruk Development Project	I-7	Rig Support Boilers (3 units)	AQ0911MSS04	Included in emission inventory, not paired with a release point. EU may post-date most recent inventory. TVP01 and MSS04 were both Final in 2011.
911	Pioneer Natural Resources Alaska, Inc.	Oooguruk Development Project	I-8	Portable Heaters (7 units)	AQ0911MSS04	Included in emission inventory, not paired with a release point. EU may post-date most recent inventory. TVP01 and MSS04 were both Final in 2011.
911	Pioneer Natural Resources Alaska, Inc.	Oooguruk Development Project	NR-1a	Cummins DFHD Diesel Primary Generator	AQ0911TVP01	Included in emission inventory, not paired with a release point. EU may post-date most recent inventory. TVP01 and MSS04 were both Final in 2011.
911	Pioneer Natural Resources Alaska, Inc.	Oooguruk Development Project	NR-1b	Cummins DFHD Diesel Primary Generator	AQ0911TVP01	Included in emission inventory, not paired with a release point. EU may post-date most recent inventory. TVP01 and MSS04 were both Final in 2011.
911	Pioneer Natural Resources Alaska, Inc.	Oooguruk Development Project	NR-1c	Cummins DFHD Diesel Primary Generator	AQ0911TVP01	Included in emission inventory, not paired with a release point. EU may post-date most recent inventory. TVP01 and MSS04 were both Final in 2011.
911	Pioneer Natural Resources Alaska, Inc.	Oooguruk Development Project	NR-3	Front-end Loader 2 Volvo 180E	AQ0911MSS04	Included in emission inventory, not paired with a release point. EU may post-date most recent inventory. TVP01 and MSS04 were both Final in 2011.
911	Pioneer Natural Resources Alaska, Inc.	Oooguruk Development Project	NR-4	Crane CAT 966G II	AQ0911MSS04	Included in emission inventory, not paired with a release point. EU may post-date most recent inventory. TVP01 and MSS04 were both Final in 2011.
911	Pioneer Natural Resources Alaska, Inc.	Oooguruk Development Project	NR-5	Forklift CAT TH330B	AQ0911MSS04	Included in emission inventory, not paired with a release point. EU may post-date most recent inventory. TVP01 and MSS04 were both Final in 2011.

Table C.1: Data Gaps in the ADEC Emission Inventory for Major Sources on the North Slope

ADEC Source ID	Owner	Facility Name	EU ID	EU Description	Permit ID	Comment
911	Pioneer Natural Resources Alaska, Inc.	Oooguruk Development Project	NR-6	Light Plants (6 units)	AQ0911MSS04	Included in emission inventory, not paired with a release point. EU may post-date most recent inventory. TVP01 and MSS04 were both Final in 2011.
911	Pioneer Natural Resources Alaska, Inc.	Oooguruk Development Project	NR-7	Diesel Mud Module Standby Generator	AQ0911TVP01	Included in emission inventory, not paired with a release point. EU may post-date most recent inventory. TVP01 and MSS04 were both Final in 2011.
911	Pioneer Natural Resources Alaska, Inc.	Oooguruk Development Project	NR-8	Diesel Casing Standby Generator	AQ0911TVP01	Included in emission inventory, not paired with a release point. EU may post-date most recent inventory. TVP01 and MSS04 were both Final in 2011.
911	Pioneer Natural Resources Alaska, Inc.	Oooguruk Development Project	NR-9a	Escape Vehicle	AQ0911MSS04	Included in emission inventory, not paired with a release point. EU may post-date most recent inventory. TVP01 and MSS04 were both Final in 2011.
911	Pioneer Natural Resources Alaska, Inc.	Oooguruk Development Project	NR-9b	Escape Vehicle	AQ0911MSS04	Included in emission inventory, not paired with a release point. EU may post-date most recent inventory. TVP01 and MSS04 were both Final in 2011.
911	Pioneer Natural Resources Alaska, Inc.	Oooguruk Development Project	S-3	Portable Heaters (3 units)	AQ0911MSS04	Included in emission inventory, not paired with a release point. EU may post-date most recent inventory. TVP01 and MSS04 were both Final in 2011.
911	Pioneer Natural Resources Alaska, Inc.	Oooguruk Development Project	S-5	Construction Camp Propane Heaters	AQ0911MSS04	Included in emission inventory, not paired with a release point. EU may post-date most recent inventory. TVP01 and MSS04 were both Final in 2011.
911	Pioneer Natural Resources Alaska, Inc.	Oooguruk Development Project	S-6	Westland CY-2050-FA; Construction Camp Incinerator	AQ0911TVP01	Included in emission inventory, not paired with a release point. EU may post-date most recent inventory. TVP01 and MSS04 were both Final in 2011.